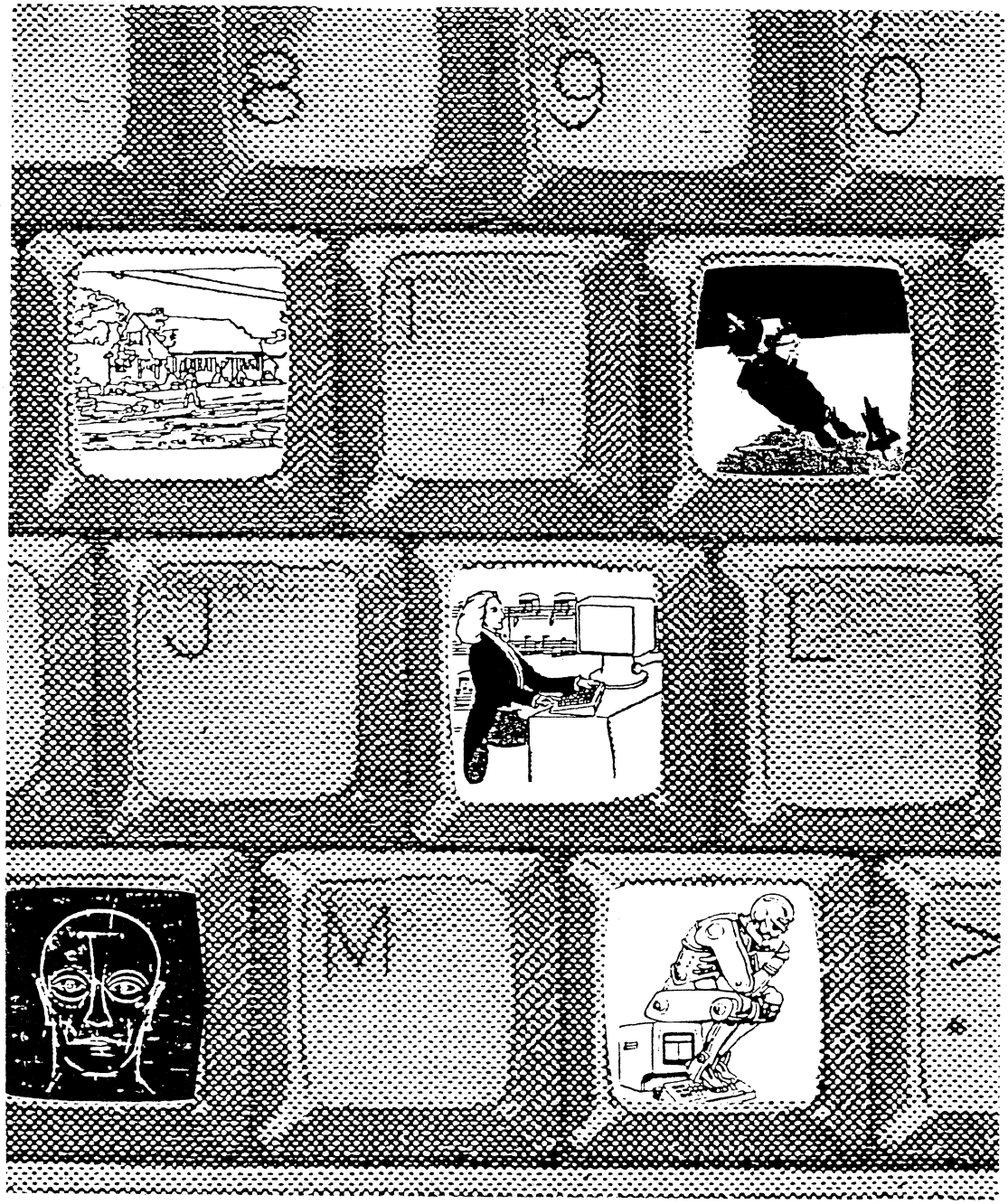
For AI Professionals, Students, Businessmen, Entrepreneurs, Investors, and Newcomers

WHO'S WHO IN ARTIFICIAL INTELLIGENCE

THE AI GUIDE TO PEOPLE, PRODUCTS, COMPANIES, RESOURCES, SCHOOLS AND JOBS



By Alan Kernoff, Published by WWAI™ in association with Tom Schwartz Assoc.

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In the preparation of this book, one could not help but be moved by the great achievements of the researchers described herein, and their ongoing contributions to the art and science of Artificial Intelligence.

Foreword

There are four issues often raised in and about the AI community:

- Is the AI professional an armchair professor whose ideas are merely dreams, not practical inventions with practical, everyday value?
- Will AI create jobs or destroy jobs in the labor market?
- Will AI bring about a new era of information and resource sharing to improve the lot of mankind, or not?
- Will AI be used for war or peace?

Throughout this book there is expressed no bias on these issues. Rather, this book is to give an in-depth view of an exciting and new technology. And to pay tribute to those who place all of us on the threshold of a new technological era.

Preface

For purposes of categorization, we may subdivide the field of AI into several groupings:

- Expert Systems
- Natural Languages
- Visual Recognition
- Voice Recognition
- Robotics
- Supercomputers
- Tools

Expert systems give you the knowledge of experts to help you make the right decisions.

Natural language allows you to program computers with simple, everyday words.

Visual recognition allows machines to recognize and interpret visual patterns, and ultimately to see.

Voice recognition allows machines to hear, and to speak.

Robotics includes assembly line machines such as those used in the automotive industry to sort bolts or to weld car frames together automatically. It also includes autonomous, individual machines with options of voice and sight recognition.

Supercomputers are new generation computers that are ten to 100 times faster and more powerful than existing computers. Supercomputers, unlike traditional computers, do not process data in a linear, consecutive manner. Instead, supercomputers have many processing centers and process many problems simultaneously.

Tools include computer languages such as Franz Lisp, Proust, FORTH, etc.

To summarize, expert systems encode the knowledge of experts into executable rules to help you make the best decisions. Natural language makes writing with computer languages more like writing human languages. Sight and voice recognition make machines sentient. Robots do routine or complex tasks, such as sorting thousands of bolts per minute, also military scouting applications. Supercomputers are AI specific and tools include special AI software.

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Overview of AI and Brief Guide to AI Companies

EXECUTIVE SUMMARY

Artificial Intelligence (AI) refers to computer-based systems that endow machines with human-like intelligence — reasoning and sensing abilities.

To gain an overview of AI in America, one can look at activities in AI laboratories, AI companies, AI schools, and the work of those in AI.

For companies and institutions, AI products and services enhance productivity and bottom-line profits. For individuals, AI aids complex decision making and conflict resolution, and provides expert guidance.

For American society, AI signals the dawning of a more advanced technological age.

Artificial intelligence was postulated in the thirties, and since World War II has received mixed attention in university and private research labs. The mid-1980s are very alive with AI at the corporate, institutional, and home enthusiast levels. There are many recent developments:

- Raymond Kurzweil of Kurzweil Applied Intelligence (Waltham, MA) is developing a typewriter that takes dictation, with a 10,000-word vocabulary. Also, he has brought to market optical scanners that read books to the blind.
- Dr. William Meisel, President of Speech Systems Incorporated (Tarzana, CA), is developing a "talkwriter" — a large-vocabulary, continuous speech recognition system to transcribe dictation in an office environment.
- Dr. Bisiani and Dr. Reddy, Department of Computer Science, Carnegie-Mellon University, under the ARPA Strategic Computing Program, have a goal of building a 10,000-word vocabulary, speaker-independent, speech recognition system capable of taking dictation. This would involve a multiprocessor implementation of VAXs and PERQs.
- Functionoids, robotic surveillance assistants, from Odetics (Anaheim, CA) are six-legged mobile prototype units operated by remote control. They can assume different postures from a 78-inch-high stance, to a 36-inch squat. They have a stepping height of 30 inches, level ground speed of 1.5 mph, and payload lift capacity of 2,090 pounds.
- Dr. John Hollerback, Faculty, Artificial Intelligence Laboratory, Massachusetts Institute of Technology, is co-designer and builder of a multiprocessor system for robotic hands, where each finger and its eight robotic tendons are controlled by one microprocessor; and robotic fingertip touch monitoring is by a large-array tactile sensor system based on capacitance sensors, with robotic fingertips defined by conductive strips screened onto thin rubber sheets, and a special electronic circuit detecting capacitance change between conductive strips from pressure deformation, for touch identification.
- The United States Department of Defense has outlined its space power strategy. This 20-year plan calls for AI defense systems on land, on sea, in the air, and in space.
- DARPA is funding supercomputer projects to support space power computing project implementations.
- CAT, a project involving Dr. John McDermott, Department of Computer Science, Carnegie-Mellon University, is a system to monitor and assess threats to the nuclear aircraft carrier USS Carl Vinson and recommend possible actions to counter those threats.
- Pilot Decision-Making project is headed by R. Schvaneveldt and T. Goldsmith, Computing Research Laboratory (CRL), New Mexico State University. Prototype I, an Air Force funded project, is a computer system that displays the state of two fighter aircraft in computer graphic displays and selects appropriate fighter maneuvers given position, heading, and speed of the aircraft; dynamic flight equations, mapping of the maneuvers onto the inputs of the flight equations; updating of airspace as a result of decisions, displaying new airspace; ongoing decision support and logistical airspace mapping.
- Hughes Aircraft has started developing space power defense systems at a facility in Calabasas, California.

- Personal computers and supercomputers and software designed for AI development are being brought to market by the Japanese, French, English, and Americans.
- Microelectronics and Computer Technology Corporation (MCC), Austin, TX, is a private sector joint research and development venture composed of 21 major U.S. companies. MCC was created to help maintain U.S. technological preeminence and international competitiveness in microelectronics and computers.

Companies actively recruiting AI personnel include:

Arco	3M
Atari	McDonnell Douglas
AT&T	Martin-Marietta
Bell Labs	Mitre
Boeing	Motorola
Burroughs	Nixdorf
Data General	NCR
DEC	Olivetti
Eaton	RCA
General Electric	Rockwell
General Motors	Siemens
Gould	Sperry
GTE	Schlumberger/Fairchild
Harris	Standard Oil
Hewlett-Packard	Texas Instruments
Hughes Aircraft	TRW
IBM	United Technologies
Kodak	Wang
Lockheed	Xerox

Attention has been actively focused on AI in recent years, and recent months, for several reasons. The price of computing has gone down and memory storage capacity has gone up. New LISP AI workstations are being brought to market in increasing numbers. New software programs allow non-expert programmers and systems designers to become involved in AI. AI success stories from the AI pioneering schools — Stanford, Carnegie-Mellon, and MIT — have influenced the opening of additional academic research centers at a growing number of colleges and universities. Universities with AI laboratories include:

- Brown
- Clarkson
- Georgia Institute of Technology
- University of Maryland
- MIT
- Ohio State University
- Purdue
- Rochester Institute of Technology
- Stanford
- Syracuse University
- Yale
- New Mexico State University
- Rutgers University
- Carnegie-Mellon
- Colgate
- University of Illinois
- University of Massachusetts
- University of Miami
- University of Pennsylvania
- Rensselaer Polytechnic
- Rutgers
- University of Texas
- Vanderbilt
- New York State University at Buffalo

Japan has a dedicated fifth-generation computer program of AI research and development aimed at increasing productivity in all industries from automotive to shipbuilding, thus making Japan more competitive in the world marketplace.

In response to the Japanese AI effort, the United States Department of Defense (DOD) has dedicated major budget dollars to develop and implement state-of-the-art AI weapons systems, including autonomous search and destroy machines for land, sea, air, and space use, to automate warfare and, in some cases, remove the need for front-line involvement of U.S. personnel in combat situations.

(MCC, Austin, TX was also formed in response to Japanese AI activity.)

Venture monies are fluidly available for new AI projects, specifically in financial, insurance, aerospace, and petrochemical applications.

Original equipment manufacturers (OEMs) are sprouting up to develop vertical market niches for AI products, ranging from mainframe business applications, such as insurance systems, to management and sales psychology expert systems such as Xerox's and Thoughtware's Sell Sell Sell, and knowledge-based novelties such as Human Edge's party game, Mindprober, that run on microcomputers such as the IBM PC.

AI EXPERT SYSTEMS

AI expert systems offer the user the power to make accurate decisions and to take appropriate action in new or unknown areas. The basic requirements that need to be met to qualify an expert system are:

- Knowledge base
- Inference engine
- Ability to document its own decisions
- Ability to learn.

The knowledge base is a body or collection of bodies of expert information. The inference engine is the computer program that allows the machine to draw conclusions and to make judgments — to consult. The system should dump (display on the screen or print-out) its own reasoning rules upon request, and answer user queries. The ability to learn allows the user to input additional information that the system may incorporate into its "brain" and draw conclusions from. In addition to expert systems, there are available expert systems shells. These are composed of an inference engine and a framework to hold a knowledge base. The user installs a knowledge base.

Inference engines allow repetitious and logical tasks to be reduced to executable rules. With the "boss in the machine" (that is, the knowledge base), the subordinate may consult the "boss" when necessary to make the correct decision. Repetitious tasks may be delegated to subordinates for execution and implementation — such as credit checking.

Presently, expert systems offer the following solutions:

- Decision support systems
- Diagnostic systems
- Strategic command and control military systems

For example, decision systems may support stock market analysis and other investment portfolio decisions, or may be used to make better insurance underwriting decisions. Diagnostic systems may support automobile, or medical diagnostics. And strategic command and control systems may support and/or semi-automate the design of military strategic planning and implementation of real-time conflict resolution.

Expert systems used in teaching or executive training applications can quickly determine a user's knowledge level and orientation. Then instantly and automatically design an instruction curriculum for that person, based on their ability to learn.

Medical expert systems include MYCIN, developed at Stanford Heuristics Department, to help doctors diagnose meningitis. EMYCIN was created by removing the knowledge base from MYCIN to leave the shell and inference engine for custom applications.

Diagnostic expert systems used to configure VAX computers were developed by Digital Equipment Corporation (DEC) and Carnegie-Mellon University. R1 has replaced 35 people who did the system configuration and reportedly saved DEC several hundred thousand dollars.

Geologists' expert system, DIPMETER ADVISOR, developed by Schlumberger, guides geologists.

First-wave companies (pre-1984) include Teknowledge (Palo Alto, CA); Intellicorp (Menlo Park, CA); McDonnell Douglas/Tymshare (Cupertino, CA); General Research Corporation (Santa Barbara, CA); Inference Corporation (Los Angeles, CA); Smart Systems Technology (Alexandria, VA); Software A&E (Arlington, VA); Human Edge Software (Palo Alto, CA); Thoughtware (FL); Expert Ease (England); Computer*Thought (Plano, TX). Also Digital Equipment Corporation and Texas Instruments.

Second-wave companies (1985 and post-1985) include large companies such as IBM, AT&T, Xerox Learning Systems, and small companies such as AI Mentor (Palo Alto, CA).

(Expert systems products that run on IBM PCs are included in the table on the following page.

A PARTIAL LIST OF EXPERT SYSTEMS COMPANIES

AI Mentor
AI Research Group
Advanced Information & Decision Systems
Applied Expert Systems (APEX)
Artelligence
Brattle Research
Carnegie Group
California Intelligence
Computer*Thought
Digital Equipment Corporation (DEC)
Expertelligence
Expert-Knowledge Systems
Expert Systems International
General Research
Human Edge Software
Iconics

Table of Expert System Companies and their Products

Acronym	Product	Company	Mainframe/Mini	IBM PC	Comments
ART	Automatic Reasoning Tool	Inference Corporation	LISP-based machines		
	The Sales Edge	Human Edge		IBM PC (Apple)	Business strategy products
	EXSYS	California Intelligence		IBM PC	Expert shell
KEE	Knowledge Engineering Environment	IntelliCorp	LISP-based machines		
KES	Knowledge Engineering System	Software Architecture and Engineering	LISP, VAX	IBM PCXT	
M.1		Teknowledge		IBM PC	
S.1		Teknowledge	VAX		
	RuleMaster	Radian	VAX	IBM PC	
	SAVVY PC	Excalibur Technologies		IBM PC	
	Sell Sell Sell	Thoughtware		IBM PC	
	Trigger	Thoughtware		IBM PC	
TESS	Helix	Software Arts	IBM PC		

Inference Corporation
Intellicorp
Intelligent Software
Jeffrey Perrone & Associates
Migent Software
Palladian
Perceptronics
Production Systems Technologies
Radian
Reasoning Systems
Schlumberger
Smart Systems Technology
Software Architecture & Engineering
Software Arts
Syntelligence
Systems Control Technology
Teknowledge
Texas Instruments
Verac
Xerox

NATURAL LANGUAGE

Natural language products are designed to make it easier for non-computer people to use computers. Rather than having to learn command languages to communicate with a database, everyday American words are typed into the console: Natural language sentences conform to rules of syntax, and also to semantic connotations and denotations.

Several companies market natural language front ends that attach to mainframes, minis and micros for database query and integrating to other software applications such as graphics or spreadsheets. The user does not have to learn numerous command languages for several different programs, but can simply type in everyday American.

Artificial Intelligence Corporation (Waltham, MA) brought INTELLECT to market in 1981, and uses everyday American to query the database. INTELLECT fits on top of IBM mainframes to interface with databases. It costs $50,000. A micro to mainframe link has been announced for micros. And a micro version (just for micros) is planned.

Cognitive Systems (New Haven, CT) is at work merging an expert system with a natural language invoked database in such a way as to query the user about the nature and environmental setting of his requests in terms of desired results expected from the system.

Symantec (Sunnyvale, CA) has a PC-based natural language product in process.

Texas Instruments (Austin, TX) has NaturaLink software tools to build natural language applications for the TI micro, available for $8,000. TI has a natural language interface to Dow Jones News Retrieval Service now on the market.

Micorim (Bellevue, WA) has CLOUT available for micros, including IBM PC. CLOUT fits on Micorim's database product, RBase. CLOUT sells for $195.

Safeguard Business Systems has announced PC-based natural language front-end accounting software.

Mathematica Products Group (Princeton, NJ) has RAMIS II English natural language front end to its database management system, RAMIS II. The total package sells for $15,000 to $100,000, depending on the exact system ordered.

Natural Language Companies and their Products

Company	Product
Artificial Intelligence Corporation	INTELLECT
Bolt, Beranek and Newman	Irus
Cognitive Systems	Easytalk
Excalibur Technologies	Savvy PC
Frey Associates	Themis
GMIS	
Information Builders	Tabletalk
McDonnell Douglas/Infotym	Reveal
Logical Business Machines	Diplomat
Logos Corporation	
Mathematica Products Group	English/RAMIS II
Microdata	Natural Language
Micorim	CLOUT
Relational Technology	
Silogic	
Symantec	
Texas Instruments	NaturalLink

VOICE RECOGNITION

Voice recognition systems are the spoken equivalent of the written natural language products. A voice recognition system allows the user to address the machine in spoken language. These systems are now coming to the market for microcomputer-based products. The portable Apricot micro from ACT Ltd. (England), has a built-in vocabulary of about 30 words, supplied by Dragon.

Voice Recognition Companies and their Products

Company	Product	Cost ($)	Vocabulary (Words)	Type
Dragon	Mark II	500	30–300	Syllables
	PC Eval	3,000	30–Up (Memory limited)	Phrases
Kurzweil Applied Intelligence				
Interstate Voice Products	Vocalink	1,600	240	Syllables
Microphonics Technology Corporation				
NEC	SR100	2,000	120	Phrases
	DP200	15,000	150	Phrases
Scott Instruments				
Speech Systems				
Tecmar	Voice recognition board	99	100–200	Syllables
Texas Instruments	Speech command	2,600	50	Syllables
Verbex	V3000	20,000	120	Phrases
Voice Connection				
Voice Control				
Votan	VPC2000	24,000	64	Phrases

VISUAL RECOGNITION

Machine vision is perceived by a video camera, light scanner, or other sensor. It is then digitized and interpreted to control and propagate robotic movement.

Perceived data is decomposed into pixels, and the computer measures the dimensions of each pixel. The characteristics are then read into memory for identification.

VISUAL RECOGNITION COMPANIES

Applied Intelligent Systems
Asea
Automation Intelligence
Automation Systems
Automatix
Cognex
Contrex
Control Automation
Cybatech
Diffracto Ltd
Electro-Optical Information
Everett/Charles
Forster-Miller
General Electric
Ham Industries
Intelledex
Interactive Video Systems
International Robomation
Integration Automation
Itran
Key Image Systems
Machine Intelligence
Machine Intelligence International
Object Recognition Systems
Octek/Foxboro
Opcon
Pennsylvania Video
Perception
Recognition Concepts
Robotic Vision Systems
Silma
Synthetic Vision Systems
View Engineering
Vuebotics

LIStPROCESSING (LISP) MACHINES

The LISP (LIStProcessing) language was developed around 1960, specifically to handle relationships between mathematical expressions, words, and other symbols. In that way, it is different from other computer languages which are designed not for relationships between symbols, but for the adding and subtracting of numbers.

Until a few years ago, LISP applications were run only on non-specialized mainframe computers.

Because of their complexity, LISP programs used great amounts of computer memory and time. Now, specialized LISP workstations are available to develop AI applications. LISP machines have processors especially designed to run LISP. That is, the hardware chips are designed for LISP and not for other computer languages.

As AI development is expanding away from university centers and specialized private research and development facilties out into the commercial marketplace, and due to the lower-priced availability of powerful computers, LISP machines are in greater demand.

LISP machines are specialized and are not to be confused with LISP applications that can be run on mainframes or micros.

Xerox (Palo Alto, CA), Symbolics (Cambridge, MA), and Lisp Machine (Cambridge, MA and Los Angeles, CA) supply LISP machines. The machines sell for $25,000 to $160,000 each. Approximately half of the machines sold go to commercial enterprises and half go to the military.

Xerox sells three LISP machines:

- Dolphin (Model 1100)
- Dorado (Model 1132)
- Dandelion (Model 1108)

Symbolics (Cambridge, MA) began by licensing the MIT-developed CADR processor.

Symbolics sells several machines:

- LM-2 (about 40 installations)
- 3600 (about 400 installations) $100,000
- 3670
- 3640 $ 60,000

Symbolics sold 40 machines to the Microelectronics and Computer Technology Corporation (MCC) (see Thinktank section).

Lisp Machine Incorporated (LMI) also began by licensing MIT's CADR processor. Having recruited a senior officer from Texas Instruments, LMI has built its system around the NuMachine bus component manufactured by Texas Instruments (TI).

LMI sells:

- Lambda
- 2X2 $110,000
- 2X2 Plus (Unix-based)
- Lambda S

Also:

- LM-PROLOG

Texas Instruments (Dallas, TX) has Explorer.

Apollo Computer (Chelmsford, MA) and Perq Systems Corporation (Pittsburgh, PA) sell supercomputer workstations that support LISP. Hewlett-Packard (Palo Alto, CA) and Tektronix (Klamath Falls, OR) are entering this market.

Digital Equipment Corporation (Maynard, MA) has LISP on its VAX superminicomputers and VAXstation 100.

IBM has new versions for LISP for IBM mainframes.

Fujitsu markets ALPHA, a LISP processor.

Gold Hill Computers (Cambridge, MA), Soft Warehouse (Honolulu, HI), and Norell Data Systems (Los Angeles, CA) all market LISP software for the IBM PC.

Silogic (Los Angeles, CA) sells PROLOG interpreters.

The following companies are involved in AI computer hardware components and systems:

- Apollo Computer
- Flexible Computer Corp.
- Perq
- Technology Industries
- Convex
- Hewlett-Packard
- Prime
- Texas Instruments
- Data General
- IBM
- Sun Computer
- Tektronix
- Digital Equipment Corporation
- Lisp Machine Incorporated
- Symbolics
- Xerox

SUPERCOMPUTERS (Parallel Processors)

- MIPS — millions of instructions per second
- BIPS — billions of instructions per second
- LIPS — logical inferences per second
  (1 LIPS = 1,000 instructions/sec)

While suited to AI, LISP machines, like other computers, are single, powerful processors that accomplish work objectives sequentially, one after another.

DEC's supercomputer being implemented at Carnegie-Mellon calls for up to 64 to 1,000 processors. In a supercomputer, each processor does a different part of the same job at the same time — simultaneously.

Some of the most powerful mainframes now run at 44 millions of instructions per second. The Defense Advanced Research Projects Agency (DARPA) and the Pentagon have requested a supercomputer that will run at a rate of 10 billion instructions per second.

According to DARPA figures, available LIPS rates for the mid-80s are approximately 10,000 to 100,000 LIPS — 10 million to 100 million instructions per second. However, DARPA and Pentagon request that by the end of the 1980s and beginning of the 1990s, the rate of LIPS is 100,000,000 to 100,000,000,000 LIPS — 100 billion to 1,000 billion instructions per second.

This rate of LIPS is also the Japanese supercomputer goal. (See section on Japanese AI.)

In America, Digital Equipment Corporation, IBM, and AT&T may be working on such supercomputer projects.

Thinking Machines Incorporated (Waltham, MA) is building a CONNECTION MACHINE, a supercomputer with 64,000 parallel processors.

LISP and PROLOG Language Tools

LISP and PROLOG are special AI languages designed to process relationships between math expressions, symbols and words.

LISP and PROLOG Language Companies and their Products

Company	Software	Mainframe/Mini	IBM PC	Cost
Apollo Computers	Domain Lisp	X		
Delphia, France	D-Prolog	X		
Digital Equipment Corporation	VAX Lisp	X		
ExperTelligence	ExperLisp		(Mac)	
Gold Hill Computers	Golden Common Lisp		X	$495
IBM	LISP/VM	X		
IBM	PSC PROLOG	X		
Integral Quality Incorporated	IQLisp		X	175
Levien Instrument Company	BYSO LISP		X	195
Logicware	M PROLOG		X	800
MIT*	LISP	X		
MIT	MacLisp	X		
Norell Data Systems	LISP/88		X	50
PCD Systems	PCD LISP		X	100
Programming Logic Systems	micro-PROLOG		X	295
Prologica	PROLOG		X	395
Soft Warehouse	muLISP-83		X	250
Symbolics	Symbolics PROLOG	X		
Symbolics/LISP Machine, Inc.	ZetaLisp	X		
Texas Instruments	TI Lisp	X		
UC Berkeley	Franz Lisp	X		
University of Marseilles, France*	PROLOG	X		
Upsala University, Sweden	LM PROLOG	X		
Xerox	InterLisp-D	X		

*The original LISP and PROLOG.

Note: The above languages are mainframe- and minicomputer-oriented, except where indicated for IBM PC.

U.S. MILITARY SPACE POWER AND EARTH SECURITY APPLICATIONS

The Department of Defense (DOD) wants American and NATO forces to have AI-based weapons systems in order to fight against large armies, so that fewer American and NATO personnel have to be deployed. Smart weapons will reduce the amount of allied manpower necessary, make sophisticated weapons easier for personnel to deploy, allow greater tactical and strategic battle command, and establish greater military force through superior weaponry.

At a conference presentation in 1985 at the Palo Alto Hyatt, the assistant director of the Defense Advanced Research Projects Agency's (DARPA) Strategic Computing Initiative proposed spending $600 million through 1990 to develop machine intelligence technology for DARPA.

DARPA is interested in autonomous vehicles for use as weapons carriers to seek out and destroy adversary machines, such as a tank-hunting machine that goes out to intelligently hunt and stalk tanks, and then perform evasive maneuvers in order to escape detection.

Stanford University researchers are currently working on high-speed peripherals under a DARPA strategic computing contract.

DARPA wants autonomous land vehicles, a pilot's associate to assist fighter pilots, and a battle management system for use by naval aircraft carrier groups. Instead of fielding guided missiles or remotely piloted vehicles, autonomous land, sea air, and space vehicles capable of complex, far-ranging reconnaissance and attack missions could be deployed.

Funding for autonomous land vehicles that can act without remote guidance is available by the Army Engineer Topographical Labs, Fort Belvoir, VA, as part of a DARPA program. Overall AI strategic operations planning hardware and software applications are sought. Electronic Warfare (EW) applications, Command, Control, Communications and Intelligence (C3I) applications, autonomous robot-soldier-with-visual-recognition applications, robot sentry, robot reconnaissance, robot counter-mine, and robot airborne surveillance applications and hardware are sought, as well as AI expert systems, diagnostic systems, and medical expert systems. Also sought is a battalion information management system for situational assessment, planning, and decision support systems that are capable of generating "what-if" scenario and topographical mapping, and strategic planning, and can issue orders.

The Air Force wants intelligent reentry vehicles capable of targeting and tracking and guiding movements. Real-time pilot-aid applications are requested. Joint Chiefs of Staff, space command and space power programs call for AI defensive weaponry in space. The Air Force Rome Air Development Center is managing expert systems, heuristics (best guess reasoning), improved inferencing systems, and supercomputer multi- and parallel-processing contracts.

The Ada language has been chosen as the official programming language of the U.S. Government, in an effort to minimize the proliferation of software languages used. Ada was developed under the DOD. The Air Force Wright-Patterson Base Language Control Facility has been designated by the Ada Joint Program Office of the DOD to validate Ada language applications. However, other languages may be used (that more efficiently process equations and relationships between equations in supercomputer mode).

The U.S. Navy wants real-time battle management systems for naval carrier groups. CAT, a project involving Dr. John McDermott, Department of Computer Science, Carnegie-Mellon University, is a system that will monitor and assess threats to the aircraft carrier USS Carl Vinson, and recommend possible actions to counter those threats. (See section on AI Schools, Carnegie-Mellon, re: ZOG project.) The Navy also seeks expert systems and intelligent software-assistant applications to design other feasibility, risk, and productivity management softwares.

Overall, AI usage in military applications aims at developing superior weaponry, streamlining weapon deployment training, and minimizing loss of life.

Space Power and Earth Security Companies and their Products

Company/Research Lab	Product	Military Branch
Advanced Information & Decision Systems	Target Visual Recognition	Navy
Bolt, Beranek & Newman	Natural Language	
Bolt, Beranek & Newman	Computer-Assisted Instruction	Navy
Carnegie-Mellon University	Expert System	Air Force
Denelcor	Supercomputer	DARPA
Honeywell	Target Visual Recognition	Army
Hughes	Autonomous Vehicle	DARPA
Lockheed	Natural Language	DARPA
Lockheed	Target Visual Recognition	
Mitre	Expert Systems	
MIT	Supercomputer	DARPA
Robot Defense Systems	Autonomous Tank	Army
TRW	Satellite Visual Recognition	DARPA

Other companies and labs involved include Control Data, Data General, Digital Equipment, Harris/Telesoft, Intermetrics, Irvine Computer Science Corporation, New York University, Rolm, Science Applications, and SofTech.

JAPANESE AI

To an extent we can thank the Japanese for fueling American DARPA and American private enterprise AI enthusiasm.

In 1980, The Japanese Information Processing Development Center (JIPDEC), Tokyo released its "Interim Report on Study and Research on Fifth Generation Computers."

In Tokyo, The Institute for New Generation Computer Technology (ICOT) employs about 50 AI researchers borrowed from leading Japanese AI firms. Several hundred AI professionals are involved, from such companies as Mitsubishi, Hitachi, NEC, Fujitsu, Oki Electric, Sharp, and Toshiba.

The Japanese are building supercomputers, perhaps with portable hand-held interfaces to the supercomputer's advanced inferencing capabilities, parallel processing architectures, knowledge-based management systems, with natural language front ends. It is reasonable to assume a variety of built-in real-time voice recognition driven spoken-language translation programs as well.

The Ministry of International Trade and Industry (MITI) funds ICOT. MITI has allocated about $400 million of its money for the development effort — not counting private Japanese business funds. ICOT contracts work out to AI vendors.

To ICOT, Mitsubishi recently released the Personal Sequential Inferencing Machine; and Toshiba, Hitachi, and Oki released the Delta, a relational database machine.

It is interesting to note cooperative supercomputer efforts with United States and Japanese companies. Fujitsu with Amdahl; NEC with Honeywell; Hitachi with National Advanced Systems.

The published Japanese philosophy publicly promoting the Fifth Generation Computing Project, includes the strategy of introducing expert systems into homes and small businesses as well as into scientific and corporate applications, and to improve the quality of life while simultaneously increasing productivity. The target year for realization of the project is 1990.

Very large scale integration (VLSI) is the foundation of the project. One goal is a processor with one million transistors per chip, leading to a development of 10 million transistors per chip. Multichip processors are considered. Another goal is a personal computer with 32 processors, and a special high-speed machine with up to 10,000 processors. Some of the VLSI processors would operate at about 10 million instructions per second, each.

Such a machine is not so much a traditional computer at all, but a computer complex. Hardware subsystems with different architectures for different purposes would require very high level interfaces. For example, experimental machines with microcode installations of PROLOG are being built, which would optimally be reduced to a single circuit.

Very large expert system knowledge bases are planned with natural language, voice recognition, visual recognition, and graphics interfaces and applications.

Additional goals include typewriters that take dictation, and machines that talk back to the user in natural conversations.

Simultaneously, the same circuit boards used in powerful personal computers described above would make effective controllers for robots.

EUROPEAN ESPRIT PROGRAM

The European Strategic Program for Research Information Technologies (ESPRIT), funded by the ten-country EEC, has a $1.5 billion dollar budget, to give Europe a fifth generation project of its own. The European countries involved hope that the project will prevent domination of the European AI market by Japan and the United States.

A computer network, much like the DARPA network in the U.S. that ties together related researchers from different geographical locations, has been installed, tying together researchers in several different European countries.

Targeted AI research areas include:

- Computer-controlled manufacturing
- Very large scale integration (VLSI)
- AI software language applications
- Information processing architectures
- Office automation

Some European companies are involved in cooperative efforts with Japanese and U.S. companies, in an effort to remain competitive in the quickly changing computer (and consequently AI) marketplace.

Britain has a $500 million fifth generation computing project also, the Alvey project. There is a great deal of small company start-up activity in England. Expert-Ease, the first expert system for IBM PC in America, came from Donald Michie in the United Kingdom.

France and Germany have small projects funded by their governments.

ICL, Compagnie de Machines Bull, and Siemens have opened an AI lab in Bavaria.

IBM, DEC, TI

- International Business Machines
- Digital Equipment Corporation
- Texas Instruments

AI has been quietly alive and well in university research laboratories, such as MIT and Stanford, and Carnegie-Mellon, and at companies such as Digital Equipment Corporation, Xerox, IBM, TI, and Schlumberger, for many years. Lately, with the appearance of IBM PC-based products, and prices dropping on AI workstations, the media has made a mild uproar over AI.

DEC has the Artificial Intelligence Technology Center (Hudson, MA), a West Coast AI Laboratory (Palo Alto, CA), and an AI Marketing Group (Sacramento, CA). It is a member of the Microelectronics and Computer Technology Corporation thinktank.

IBM has natural language research underway at Thomas J. Watson Research Center (Yorktown Heights, NY), an AI Federal Systems Division (Oswego, NY), the AI San Jose Laboratory (San Jose, CA), and the AI Palo Alto Scientific Center Laboratory (Palo Alto, CA).

IBM supports university research, recently providing a mainframe, minis, micros and terminals to an AI research team at Syracuse University, New York; funding a parallel processor of IBM design at MIT; and funding Stanford to build an expert system to diagnose computer circuit design and implementation problems. IBM has recently entered the robotics field.

(For a complete discussion about AI at TI, please see the special feature on Texas Instruments in the AI Company Omnibus section.)

The following table describes selected IBM and DEC AI products:

Selected IBM and DEC Products

System	Comments	Hardware	Software	Company
VAX		X		DEC
VAX LISP			X	DEC
VAXstation 100	AI specialized workstation	X		DEC
OPS5	For expert system development on VAX systems		X	DEC
XCON	Expert system that configures VAX computers		X	DEC
XSEL	Expert system for computer salespeople		X	DEC
ISA	Ordering against inventory program		X	DEC
XSITE	Computer site location configuration system		X	DEC
KBS	Circuit board configuration and assembly station		X	DEC
Callisto	Large project management system		X	DEC
PTRANS	Factory management system		X	DEC
SPEARS	Drive diagnostic system		X	DEC
INET	Corporate analysis simulation system		X	DEC
XCALIBUR	Natural language front end to expert systems/databases		X	DEC
Intellect	Natural language front end to mainframe dbms marketed by IBM		X	AI Corp.
TQA*	Natural language to query databases		X	IBM
Prism	Expert system speculated to be in development		X	IBM
LISP/370	LISP for IBM 370 mainframe		X	IBM
LISP/VM	Recent product of LISP for mainframe timesharing		X	IBM
OPS5	DEC's popularized AI language now implemented on IBM 370s		X	IBM
308X PROLOG	Version of PROLOG to run on a 308X mainframe		X	IBM

Selected IBM and DEC Products (Continued)

System	Comments	Hardware	Software	Company
Epistle	A system to read and summarize text, and check grammar for publishers		X	IBM
AML	Programming language for robots, availability-mainframes, IBM PC		X	IBM
YES/MVS	Yorktown expert system for MVS systems, maintains mainframe efficiency		X	IBM
SCRATCHPAD II	Algebraic formula manipulation language		X	IBM
PSC PROLOG	PROLOG version from IBM's Paris Scientific Center		X	IBM
HANDY	Development of interactive education applications; IBM PC-based		X	IBM

*TQA = Transformational Question-Answering

APPENDIX: ROBOTICS

To acquaint the reader with some of the issues involved in robotics, and at the same time to describe some of the current research in the field, current work at selected robotics laboratories is described below. (Also refer to the WWAI — Robotics section, and the overview section entitled U.S. Military Space Power and Earth Security Applications, about autonomous vehicles and robots.)

THE ADVANCED AUTOMATION AND SPEECH RECOGNITION LABORATORY IN THE SCHOOL OF ELECTRICAL ENGINEERING AT PURDUE UNIVERSITY

A laboratory for advanced automation research (AARL), involving the control of trainable manipulators, robotic systems, and prosthetic devices, has been established within the School of Electrical Engineering, Purdue University.

TRAINABLE MECHANICAL MANIPULATOR

Application of discrete word speech recognition, linguistic task organization and control, and hardware parameter adaptive, self-organizing control has been used in order to drive a general-purpose, trainable, mechanical manipulator to execute tasks to assist paralyzed persons.

This research is divided into three parts:

- The Voice Input and Speech Recognition Project
- The Linguistic Task Organizer with Trainable Capabilities
- The Self-Organizing Trainable Controller

This work is being implemented by a mechanical arm, a Perceptronics interface, and the PDP 11/45 computer of the AARL. Various signal codes to be used for electronic signals generating commands to drive a bionic arm are also being studied. Current research is directed toward the development of codes compatible with typical neural and muscular signals which are easily detectable by pattern recognition schemes.

PRACTICAL TASKS FOR INDUSTRIAL APPLICATIONS

When a robot is expected to perform practical tasks for industrial applications, it must have a capability of online decision-making in complex environments. One possible approach is the development of a team of robots, each of them having a definite assignment and each interacting with others through a central command post so that a command goal can be achieved.

This scheme falls into the category of team-decision theory in that the team has a common goal, and each member does not memorize the complete history of the tasks that it has accomplished; each member does not have the same information about the overall situation. The control branch of the team involves decision-making for mapping overall strategy and optimization techniques for detailed plans of each robotic member's action.

Mass production, typified by the assembly line and hard automation, has produced yearly increases in labor productivity. But its potential for additional significant productivity increases appears limited. Few areas now exist where mass production can be

economically applied. In fact, due to rapid product changes — a consequence of increased international competition — mass production is no longer applicable in areas where it once was used. An increasing amount of manufacturing is now performed in batch production. Here, neither assembly line techniques nor hard automation are applicable.

Techniques of robotics can be applied to the area of batch production to obtain continuing productivity increases.

SUMMARY

The objective of the type of research described above is to increase the flexibility and extend the usefulness of current industrial robots. Also, to provide a solid base for future advanced systems based on computer control techniques and dynamic manipulator models. The mode of solution is based on a dynamic and kinetic model of a manipulator which provides a solid base on which to build a manipulator control system.

Compliant tasks, in which the manipulator adapts dynamically, are described in terms of degrees of freedom in a working coordinate system. In this work, joint torque sensing is employed to provide the required compliance.

The speed of operation of the manipulator can be optimized in terms of the model. This work can be integrated into a manipulator machine language, resembling a computer machine language.

The primitive instructions must be carefully chosen to provide a consistent language to facilitate programming, and as a target output language for future high-level languages.

This manipulator machine language must account for the dynamics of the manipulator and provide optimized and compliant motion. (Faculty involved in the above projects at Purdue are: King-Sun Fu; Johnson Luh; Rangasami Kashyap; and Antti Koivo.)

ROBOTICS ACTIVITY AT THE ARTIFICIAL INTELLIGENCE LABORATORY AT MIT

Touch

(Also see AI Schools, MIT.) Dr. John Hollerback has co-designed and built a multiprocessor system based on the Motorola 68000 and multibus, where each finger and its eight tendons are controlled by one microprocessor; also co-designed a large-array tactile sensors system based on capacitance sensors, defined by conductive strips screened onto thin rubber sheets, for fingertip touch identification, with a special electronic circuit detecting capacitance change due to decreased distance between conductive strips from pressure deformation.

COMPUTER AND INFORMATION SCIENCE DEPARTMENT, UNIVERSITY OF MASSACHUSETTS AT AMHERST

More Touch

Dr. Overton of MIT has developed an elastomer-based tactile array sensor that allows monitoring an array of gray-level "forcels" to aid object recognition and to obtain feedback about position of the object relative to the gripper. The tactile array is very robust, and provides 25 tactile transducers in one square inch of sensor surface.

Odetics (Anaheim, CA)

Functionoids, robotic surveillance assistants, from Odetics (Anaheim, CA) are six-legged mobile prototype units operated by remote control. They can assume different postures from a 78-inch-high stance to a 36-inch squat. They have a stepping height of 30 inches, level ground speed of 1.5 mph, and payload lift capacity of 2,090 pounds.

Who's Who in Artificial Intelligence

Who's Who in Artificial Intelligence

WWAI INDEX KEY

a) AI Research; AI Tools; General
b) Expert Systems
c) Automatic Theorem Proving; Automatic Programming
d) Knowledge Representation
e) Programming Languages and Software
f) Learning; Knowledge Acquisition
g) Natural Language
h) Voice Recognition
i) Robotics; Machine Learning
j) Visual Recognition
k) Cognitive Modeling
l) Heuristics; Inference; Reasoning
m) Specialized Architectures
Very Large System Integration (VLSI)
Distributed Computation
Parallel Processing
Parallel Algorithms
Concurrent Processing
n) AI Workstations; AI Hardware
o) Supercomputers
p) Networks

Acock, Dr. Malcolm	d	Borgida, Dr. Alexander	a	Cuny, Dr. Janice E.	m
Ahmed, Dr. Wissam W.	h	Brachman, Dr. Ronald J.	a	Davidson, Dr. Susan	m
Aikins, Dr. Janice	b	Bradshaw, Gary L.	a	Davis, Dr. Randall	b
Allebach, Dr. Jan P.	j	Brady, Dr. J. Michael	i	De Mori, Dr. Renato	b
Allen, J.	h	Bramer, Dr. M. A.	b	Dyksen, Dr. Wayne R.	b
Amarel, Dr. Saul	d	Bratko, I.	b	Deken, Dr. Joseph	i
An, Chae Hun	i	Brooking, Annie G.	b	Denning, Dr. Peter J.	m
Anderson, Dr. John	k	Brooks, Dr. Rodney	i	Dertouzos, M.	m
Andrews, Dr. Peter	c	Brouillet, Jean-Luc	b	Dietterich, Thomas G.	i
Apostolico, Dr. Alberto	m	Brown, Dennis P.	d	Ding-Yi, Tan	l
Arib, Dr. Michael A.	i	Brown, Dr. John Seely	b	Djaferis, R.	i
Arvind, Dr.	m	Brutlag, Dr. Douglas L.	b	Donald, Bruce R.	i
Ashok, Mahalakshmi	g	Buchanan, Dr. Bruce G.	a	Doyle, Dr. Jon	l
Atallah, Dr. Mikhail J.	m	Buneman, Dr. Peter	d	Drinan, Ann L.	g
Atkeson Christopher G.	i	Cadiou, Philippe	b	Elliott, Howard	j
Badler, Dr. Norman	j	Carbonell, Jaime	g	Ellison, Dr. Robert	e
Baird, Dr. Michael	j	Carleton, David	n	Erdmann, Michael	i
Bajcsy, Dr. Ruzena	j	Carlson, David A.	a	Erman, Dr. Lee D.	b
Baker, Dr. James D.	b	Carr III, Dr. John W.	f	Eshelman, Dr. Larry	d
Banerji, Dr. Ranan B.	l	Chambers, Michael G.	d	Fagan, Dr. Lawrence M.	d
Barber, Dr. Gerald	m	Chandrasekaran, Dr. B.	j	Fahlman, Dr. Scott	m
Barr, Avron	a	Clancey, Dr. William J.	b	Feigenbaum, Dr. Edward	b
Barstow, Dr. David	c	Clark, Dr. K. L.	e	Ferrentino, Andred B.	b
Barto, Dr. Andrew G.	i	Clarke, Dr. Lori A.	e	Fikes, Dr. Richard	d
Bates, Dr. Madeleine	g	Cobb, Judy	j	Finegold, Aryeh	n
Berlinger, Dr. Hans	d	Cohen, Dr. Paul R.	l	Finin, Dr. Timothy	g
Berwick, Dr. Robert C.	g	Comer, Dr. Douglas E.	p	Forgy, Dr. Charles	e
Bhargava, Dr. Bharat	m	Corkhill, Dr. Daniel D.	a	Forsyth Richard	b
Binford, Dr. Thomas	j	Cox, Phil	b	Foster, Dr. Caxton C.	m
Bisiani, Dr. Roberto	h	Creeger, Morris J.	n	Fox, Dr. David	g
Bloch, Carl J.	j	Crocker, Dr. Stephen D.	b	Fox, Dr. John	b
Bollay, Denison	b	Croft, Dr. W. Bruce	a	Fox, Mark	b

AI Research, AI Tools, General

AI Research, Robotics, Expert Systems, AI Software Languages

BARR, Avron

Founder
Aldo Ventures

Co-founder
MicroKinetics,Inc.

M.S., Computer Science, Stanford University, 1981; A.B., Mathematics/Physics (with honors), Cornell University, 1971.

Consultant and writer. Founder of Aldo Ventures, a consulting business.

Co-editor of the *Handbook of Artificial Intelligence* as a Research Associate in the Department of Computer Science at Stanford University (1981–1982); Research Assistant, Stanford University (1976–1981); Research Associate, Institute for Mathematical Studies in the Social Sciences at Stanford University (1973–1976); Scientific Programmer, Institute for Mathematical Studies in the Social Sciences (1972–1973). Programming languages: ALGOL, SAIL, LISP, BASIC, FORTRAN, TUTOR, COURSEWRITER, and PDP-10 assembler language.

Co-founder of MicroKinetics, Inc., a robotics firm (1984); partner in AI publications firm (1980–1985); co-founder of Teknowledge, Inc., an applied AI expert systems firm (1981). Consultant in AI for numerous firms, including Framentec, Inc., Monte Carlo (1984); EFS, Inc., Vienna; Computer*Thought Corporation (development of advanced programming environments and tutors, 1981–1983); Hewlett-Packard Computer Science Research Laboratory (knowledge representation and AI applications, 1981–1982); Texas Instruments, Inc. (computer-assisted instruction in programming, 1980–1981); Cybernetics Technology Office, Defense Advanced Research Projects Agency (DARPA) (AI applications in computer-assisted instruction, 1978–1979); Xerox/Ginn Publishing Company, Xerox PARC; U.S. Army Research Institute; Computer Curriculum Corporation. Reviewer, relations of theoretical and applied AI to the interdisciplinary study of cognition, Princeton University Department of Economics (1981–1982).

Research interests include: AI research, expert systems, AI software language, and AI tools. Publications include *The Handbook of Artificial Intelligence*, with co-editor Dr. E. Feigenbaum (Kaufmann, 1982), and several papers, centering on AI topics (see bibliography).

AI Research

BORGIDA, Dr. Alexander

Ph.D., Toronto. Faculty, Purdue State University at New Brunswick, New Jersey, 1985.

Research interests include: AI research and information systems.

AI Research, Knowledge Representation

BRACHMAN, Dr. Ronald J.

Ph.D., Applied Mathematics, Harvard University, 1977; M.S., Applied Mathematics, Harvard University, 1972; B.S. (summa cum laude), Electrical Engineering, Princeton University, 1971.

Dr. Brachman is Senior Computer Scientist at AT&T Bell Laboratories. He was Senior Computer Scientist at Schlumberger CAS Research (1981–1984), where he also managed the Knowledge Representation and Reasoning Group (1981–1983) and the Cognition Group (1983). Computer Scientist at Bolt Beranek and Newman Inc. (1972–1981); Simulation Programmer, Formation, Inc. (1972); Manager, Princeton Student Data Service (1969–1971).

He has served on the editorial boards of *Journal of Automated Reasoning* and *American Journal of Computational Linguistics*. Professional activities include participation in several AI conferences, lecturing, doctoral thesis committee member and appraiser (Harvard University, 1980–1981; University of Toronto, 1981), teaching courses and individual classes at Stanford University (Computational Approaches to the Semantics of Natural Language), Syracuse University. Teaching fellow at Harvard for one year. Dr. Brachman has served on the Executive Council of the American Association for Artificial Intelligence, and is presently Vice-Chairman of the Association for Computing Machinery SIGART, and a member of Association for Computational Linguistics, and Cognitive Science Society. He is a member of the IntelliCorp Scientific Advisory Board. Author and co-author of numerous books and reports, including an award-winning paper on the tractability of subsumption in frame-based description languages (see bibliography).

Research interests include: AI research and knowledge representation.

AI Research, Cognitive Psychology, Cognitive Science

BRADSHAW, Gary L.

M.A., Psychology, University of Missouri, Columbia; B.A., Psychology, University of Missouri, Columbia.

Mr. Bradshaw is currently doing research in the Department of Psychology at Carnegie-Mellon University in psychological investigations of human inference processes and memory retrieval phenomena, learning and discovery mechanisms in machine speech recognition, and computational models of scientific discovery. Contributing author, *Machine Learning, An Artificial Intelligence Approach* (Tioga, 1983).

Research interests include: AI research, cognitive psychology, and cognitive science.

AI Research, Expert Systems, AI Tools

Founding Board Member
AAAI

Co-founder
Teknowledge

BUCHANAN, Prof. Bruce G.

Ph.D., Philosophy, Michigan State University, 1966; M.A., Philosophy, Michigan State University; B.A. (with honors), Mathematics, Ohio State University, 1961.

Professor of Computer Research at Stanford University. Co-principal investigator of the Heuristic Programming Project at Stanford (now the Knowledge Systems Laboratory), founding board member and membership chairman of AAAI.

Professor Buchanan is a founder and past president of Teknowledge, Inc. and currently a consulting senior scientist there. He is co-author (with R. Lindsay, E. A. Feigenbaum and J. Lederberg) of *Applications of Artificial Intelligence for Organic Chemistry: The Dendral Project*, and (with

E. H. Shortliffe) of *Rule-Based Expert Systems: The MYCIN Experiments of the Stanford Heuristic Programming Project.* He has published numerous technical papers and review articles, including an overview of AI in the Encyclopedia Britannica 1985 Science Yearbook.

On the editorial boards of *Artificial Intelligence: An International Journal*; *Journal of Automated Reasoning*; MIT Press Series on AI; Addison-Wesley Press Series on Expert Systems. Advisory board, IEEE Transactions on Pattern Analysis and Machine Intelligence; Comtex Scientific Corporation, Scientific Advisory Board.

Memberships include: AAAI and American Association for the Advancement of Science. (See bibliography.)

Research interests include: expert systems, diagnostic and troubleshooting systems; data interpretation, medical decision making, knowledge representation, knowledge acquisition and machine learning, hypothesis formation, induction and theory formation.

AI Resources

CARLSON, David A.

AI Researcher, Department of Electrical and Computer Engineering, University of Massachusetts at Amherst.

Research interests include: analysis of resource tradeoffs in order to provide bounds on the simultaneous resource requirements for both computational problems and machine models, performance limits of algorithms solving a given problem, and development of framework for design of multi-resource efficient algorithms.

Current investigations concern time-space tradeoffs for serial algorithms, area-time tradeoffs in VLSI, and time-processor tradeoffs in parallel processing environments.

AI Research, AI Software Languages, AI Tools, Distributed AI

CORKHILL, Dr. Daniel D.

Ph.D., Computer and Information Science, University of Massachusetts, 1983; M.S., Computer Science, University of Nebraska, 1976; B.S., Computer Science, University of Nebraska, 1975.

Dr. Corkhill is a Research Computer Scientist in the Computer and Information Sciences Department at the University of Massachusetts at Amherst.

As Research Computer Scientist at the University of Massachusetts, he has performed basic research in cooperative distributed problem-solving and meta-level control. Previously, he was Research Assistant in the Computer and Information Sciences Department and Programmer at the University of Nebraska Computer Network (1973–1974), Bendix Corporation (1984), General Electric Corporation (1984), GTE Laboratories (1984, 1985), and Texas Instruments (1985).

Dr. Corkhill developed and taught a course on programming methodology at the University of Nebraska and was previously a teaching assistant in data structures and operating systems courses. Since then he has taught several seminars. Author and co-author of numerous publications (see bibliography).

Research interests include: AI research, AI software languages, AI tools, coordination in distributed problem-solving networks, planning and control in large AI systems, design and programming methodologies for constructing large AI systems, and hardware and software support for AI systems.

AI Research, Document Retrieval Systems, Office Information Systems

CROFT, Dr. W. Bruce

Ph.D. Assistant Professor, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: AI research, document retrieval systems, and office information systems.

Licensing, Financing, Proprietary Rights for AI Concerns

Law Partner
Blanc, Gilburne, Peters, Williams and Johnson

GILBURNE, Miles

J.D., Harvard Law School.

Partner in the law firm of Blanc, Gilburne, Peters, Williams and Johnson. Represents legal AI concerns. Member of the Board of Directors of The Computer Association; Editor-in-Chief, *The Computer Lawyer*.

AI Research, Software Development Environments, Operting Systems

GRAHAM, Dr. Robert M.

Ph.D. Professr, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: software development environments, operating systems, programming methodology, and programming languages.

Training and Education, Expert Systems, AI Tools, AI Software

President
Harmon Associates

HARMON, Paul

President, Harmon Associates, San Francisco, California.

Mr. Harmon is a management consultant who has spent the past 15 years helping large corporations deal with human performance problems.

Designed and developed a training program to teach managers and programmers about artificial intelligence and expert systems, Teknowledge (1983). Later, he helped Teknowledge develop its training course for M.1, a small expert system building tool designed to run on an IBM PC. Mr. Harmon has developed a 3-day overview of AI and expert systems (recently presented at Texas Instruments) and plans to introduce a 5-day workshop to teach non-programmers to develop small expert systems, and he is planning to introduce a newsletter that will provide information to individuals who are concerned with developing expert systems.

Co-author, *Expert Systems: Artificial Intelligence in Business* (Macmillan, 1984), selected as book-of-the-month by Macmillan's Science Book Club. Mr. Harmon is working on a second book on expert systems that will focus on applications that have been implemented in the field and the practical problems encountered by companies developing those systems.

Research interests include: training and education, expert systems, AI tools, and AI software languages.

AI Research

HEDRICK, Dr. Charles

Ph.D., Carnegie-Mellon University. Faculty, Rutgers State University at New Brunswick, New Jersey, 1985.

Research interests include: AI research and distributed information systems.

AI Research

Vice President
Atari

Co-founder
Xerox PARC Learning Group

KAY, Dr. Alan

Ph.D., Computer Science, University of Utah; M.S., Computer Science and Physiology, University of Utah; B.S., Mathematics and Molecular Biology, University of Colorado, Boulder.

Dr. Kay is Chief Scientist and Vice President of Atari Corporation, where he is responsible for advanced research activities. Co-founder of the Xerox Palo Alto Research Center Learning Research Group.

Dr. Kay designed SMALLTALK, a programming language for the non-programmer, and co-designed several Xerox PARC personal computers. Publications — see bibliography.

Research interests include: AI research and natural language.

AI Research, Computer Vision

KITCHEN, Leslie

AI Researcher, Computer and Information Sciences, University of Massachusetts at Amherst.

Research interests include: parallel processes for high-level computer vision.

AI Research, Expert Systems, AI Management, AI Languages, Tools

Director
Information Processing Systems
RAND Corporation

KLAHR, Dr. Philip

Ph.D., Computer Sciences (specializing in artificial intelligence), University of Wisconsin, 1975; M.S., Computer Sciences, University of Wisconsin, 1969; B.S., Mathematics, University of Michigan, 1967.

Dr. Klahr is presently the Director of Information Processing Systems at the RAND Corporation in Santa Monica, California (1984–present). He is responsible for managing multimillion-dollar research programs involving projects developing artificial intelligence techniques, expert system tools and applications, computerized problem-solving and planning methods, applications of artificial intelligence to simulation, and human-engineered interfaces.

Senior Computer Scientist at RAND (1978–1984). Principal investigator and leader of research project involved in improving military simulations through the application of artificial intelligence and expert systems. Designed the ROSS object-oriented simulation language, the SWIRL strategic simulation, and the TWIRL tactical simulation. Coordinated development of a color graphics facility to display simulations, an explanation facility to explain simulation events, and a parallel processing system to enhance simulation speed. Also involved in projects on machine learning and programming by example.

Previously Senior Computer Analyst, System Development Corporation, Santa Monica, California (1972–1978). Designed and implemented a complete deductive data management system built upon the notion of "proof planning." The system includes a rule-based parser, a theorem prover, an expert system, a relational data management system, an explanation facility, a plausibility reasoning mechanism, and natural language I/O.

Dr. Klahr has also been a Visiting Professor at Oregon State University, teaching graduate-level courses in Artificial Intelligence. And as a consultant (1972), designed and implemented a deductive/inference system for the CONVERSE natural-language, question-answering system. As a Research Assistant, Computer Sciences Department, University of Wisconsin (1967–1972), researched new methods for inferential question-answering; developed resolution-based theorem prover and interactive list processing system.

Professional activities include: Association for Computing Machinery (ACM); ACM Special Interest Group on Artificial Intelligence (SIGART); American Association for Artificial Intelligence (AAAI); Cognitive Science Society; Reviewer, *Journal of the ACM.*

See bibliography for publications.

AI Research, Computer Aids for the Disabled

KULIKOWSKI, Stanley

AI Researcher, Computer and Information Sciences Department, University of Michigan.

Research interests include: AI research, computer aids for the disabled, communication prosthesis software, and networks for communication.

AI Research, AI Hardware, Problem-Solving

KUMAR, Dr. Vipin

Ph.D., Computer Science, University of Maryland, College Park, 1982.

Dr. Kumar is Assistant Professor of Computer Science at the AI Laboratory, University of Texas, Austin, where he teaches courses in artificial intelligence and computer architecture. Developed unified approach to search procedures used in AI and operations research; developed parallel branch-and-bound formulations of AND/OR graph search.

Author and co-author of a number of papers (see bibliography). Member of ACM, SIGART, SIGOPS, IEEE, AAAI, and Sigma Xi.

Research interests include: problem-solving, parallel architectures for AI applications, AI research, and AI hardware.

AI Research, Expert Systems, Perception

LEVINSON, Dr. Robert

Ph.D., Computer Science, University of Texas, Austin, 1985; B.A., Mathematics and Computer Science, University of Minnesota, 1981.

Assistant Professor, Board of Studies in Computer and Information Sciences, University of California, Santa Cruz.

Thesis is "A Self-Organizing Retrieval System for Graphs." Domain-specific contributions of the dissertation: A system for generating synthetic precursors of organic molecules that "learns by example"; a method of discovering generalizations of organic chemical reactions; a more powerful retrieval method for molecules and reactions; a method of classification and concept discovery for chess positions. Additional contributions of the dissertation: A data base organization for graphs based on a multi-level partial ordering; a simple and powerful retrieval algorithm for data that has been placed in a partial ordering by more-general-than; ability to use a partial ordering by more-general-than for multiple purposes — conceptual clustering, situation comprehension, retrieval and generalization. Interests include adaptive knowledge bases. (See bibliography for papers and abstracts.)

AI Research, AI Software Languages, AI Tools, Expert Systems

MARTINS, Dr. Joao P.

Ph.D., Artificial Intelligence, State University of New York, Buffalo, 1983; M.S., Computer Science, State University of New York, Buffalo, 1979.

Dr. Martins is Assistant Professor, Departamento de Engenharia Mecanica, Instituto Superior Tecnico, Lisbon, Portugal, and Vice President of the University Computing Services. Visiting Assistant Professor, Department of Computer Science, State University of New York, Buffalo

(1985) and Visiting Instructor (1982–1983), Research Assistant (1980–1982), and Teaching Assistant, State University of New York, Buffalo (1979–190).

Member of Association for Computing Machinery, SIGART/ACM special interest group in Artificial Intelligence, and American Association for Artificial Intelligence. Author and co-author of journal articles and technical reports (see bibliography).

Research interests include: AI research, AI software languages, AI tools, expert systems, belief revision, deduction, and knowledge representation.

AI Research

McCARTHY, Dr. John

Ph.D., Princeton, 1951. Professor of Computer Science, Department of Computer Science, Stanford University.

Research interests include: AI research, mathematical theory of computation, and computing with symbolic expressions.

AI Research, Legal Reasoning

McCARTY, Dr. L. Throne

J.D., Harvard. Faculty, Rutgers State University at New Brunswick, New Jersey, 1985.

Research interests include: AI research and legal reasoning systems.

AI Research, Expert Systems, AI Tools/Software, Natural Language

McCUNE, Dr. Brian P.

Co-founder
Advanced Information & Decision Systems (AI&DS)

Vice President and *Manager*
User Aids Program (AI&DS)

Ph.D., Computer Science, Stanford University, 1979.

Co-founder AI&DS. Vice President and Manager, User Aids Program, Advanced Information & Decision Systems, Mountain View, California (1985).

Professional interests include: knowledge-based and expert systems; software systems, especially environments for software and knowledge engineering; decision support systems; and distributed systems.

Since 1980 he has led research and development of interactive software systems to support decision makers such as battlefield commanders, managers, planners, analysts, system designers, and programmers. Dr. McCune is currently designing and creating knowledge bases for expert systems for signal analysis and database alerting. He is also supervising work on knowledge-based assistants for terrain analysis, geological analysis, radar-system analysis, distributed database access, textual information retrieval, software documentation, Ada program editing, and problem diagnosis and performance maintenance in distributed computing systems.

In other professional activities, Dr. McCune is on the Editorial Advisory Board of *Defense Electronics* and the Advisory Board of *The Artificial Intelligence Report*. Previously, he was an Associate Editor of *The AI Magazine*, published by AAAI; member of the User Environment Subgroup of International Federation of Information Processing Working Group 6.5 on Computer Message Systems; and reporter for the *SIGART Newsletter*. Dr. McCune has been referee for publications of the Association for Computing Machinery and for artificial intelligence conferences, and reviewer of proposals for federal agencies.

In prior work at AI&DS, Dr. McCune led the design of the Air Force's first advanced-development artificial intelligence system, a constraint-based planner for tactical missions. He led a project that studied software maintenance problems in the Air Force and designed a number of

knowledge-based systems to deal with these problems in the Ada Programming Environment of the future. He also helped develop a taxonomy of knowledge-based hypothesis formation systems, as the first step toward providing guidance on when a new problem is amenable to current approaches and which approach or combination of approaches is best. Dr. McCune has also worked on distributed decision-making environments and the architecture of computer networks for electric power utilities. He served as Computer Facilities Manager during 1980–1984.

During 1978–1980, Dr. McCune was Computer Scientist and Acting Deputy Program Manager of the Computer Science Department of Systems Control, Inc., where he was involved in AI research. He led a project that developed approaches to semiautomatic specification, coding, and modification of operating systems in response to changing application requirements, host hardware, and network configuration. He contributed to the design of the CHI knowledge-based programming environment. In addition, as Computer Facilities Manager of the Defense Division, he installed the first Foonly F2 Computer (a cost-effective PDP-10 emulator) as an ARPA Network Host for AI research.

During 1973–1978, Dr. McCune was Research Assistant in the PSI group at the Stanford University Artificial Intelligence Laboratory, participating in the design and implementation of various systems for automatic program acquisition and coding, including initial specification and design of the PSI Program Model Builder. He was also ARPA Network Technical Liaison. During 1973–1975, he was a Teaching Assistant for Computer Science Department Courses: Introduction to Computing, Models of Though Processes, and Survey of Automatic Programming.

During 1969–1972, Dr. McCune was, successively, Computer Operator, Programmer, and Senior Programmer at the Milne Computer Center of Oregon State University. In these positions he was responsible for analysis and programming of a wide variety of business and scientific application systems. In 1969 he was employed by the OSU Mathematics Department as Laboratory Instruction in Programming Digital Computers.

Dr. McCune has consulted for the Artificial Intelligence Center, SRI International; Network Information Center; and BIT Computer Systems. Dr. McCune's graduate fellowships included National Science Foundation Graduate; International Business Machines Graduate; Josephine de Karman, Phi Kappa Phi Edwin L. Sparks Memorial (Honorary); and Phi Eta Sigma Founder's Fund. He received a Blue Key Dubach Award as one of the five outstanding male graduates of Oregon State University in 1972.

Dr. McCune is a member of the honor societies of Sigma Xi, Phi Kappa Phi, Blue Key, Phi Eta Sigma, and Iota Delta Pi. His professional societies include AAAI, ACM, and IEEE. (See bibliography.)

AI Research Data Structures and Algorithms, Database Management

ORNSTEIN, Dr. Jack A.

Ph.D. Assistant Professor, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: AI research, data structures and logarithms, and database management.

AI Research, Expert Systems

POLITOWSKI, George

Ph.D. Computer Science (in progress), University of California, Santa Cruz, 1986; M.S., Computer and Information Sciences, University of California, Santa Cruz, 1984.

Dissertation on establishing a methodology for the development of heuristics for specific problem domains.

Research interests include: AI research, expert systems, and heuristics.

AI Research, Computational Linguistics

RAPAPORT, Dr. William J.

Ph.D., Indiana University.

Assistant Professor, New York State University at Buffalo.

Research interests include: computational linguistics.

AI Research, Software Engineering, Program Testing

RICHARDSON, Debra

AI Researcher, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: AI research, software engineering, program testing, program verification, software development environments, specification languages, and specification testing.

Artificial Intelligence, all aspects of

President
Artificial Intelligence Publications

Founder
American Association of Artificial Intelligence

ROBINSON, Louis G.

Mr. Robinson is President of Artificial Intelligence Publications and Editor of The Artificial Intelligence Report.

He was the Founder of the American Association for Artificial Intelligence, and served as the first Executive Director and first Executive Editor. Formerly the Head of Public Relations at Lawrence Berkeley National Laboratory, University of California.

Research interests include: expert systems, natural language, voice recognition, visual recognition, AI software languages, AI workstations, AI hardware, AI resources, AI tools, AI research, and robotics.

AI Tools, Expert Systems, AI Research

RUSSINOFF, Dr. David

Ph.D., Mathematics, New York University, 1978; M.S., Mathematics, New York University, 1977; M.A., Computer Science, University of Texas, 1983.
MTS, Artificial Intelligence, Microelectronics and Computer Technology Corporation (MCC), Austin, Texas.

Taught mathematics, numerical analysis, and LISP at University of Texas. Developed Proteus, a nonmonotonic inference system, at Microelectronics and Computer Technology Corporation.

Research interests include: AI tools, expert systems, and AI research.

AI Research

SAFIR, Dr. Arin

M.D., New York University, 1954.

Trained in Ophthalmology, New York Eye and Ear Infirmary, 1956–1959. Studied Physiological Optics, University of Cambridge, England, 1962.

AI Research

SAMUEL, Dr. Arthur

S.M., S.B., MIT, 1926; B.A., College of Emporia, 1923.

Professor Emeritus of Research in Computer Science, Department of Computer Science, Stanford University.

Research interests include: artificial intelligence.

AI Research, Expert Systems, Natural Language

SCHWARTZ, Dr. Daniel

Ph.D., Systems Science, Portland State University, 1981; M.S., Mathematics, Simon Fraser University, British Columbia, Canada, 1973; B.A., Mathematics, Portland State University, 1969.

Assistant Professor of Computer Science, Florida State University.

Research interests include: Fuzzy logic and approximate reasoning, knowledge representation, logic programming, automated problem solving, expert systems, natural language, and AI research.

(See bibliography.)

AI Research, Expert Systems, Natural Language

Chairman
Computer Science Dept.
University of Wisconsin

Director
Graduate Group in
Cognitive Sciences
University of Wisconsin

SHAPIRO, Dr. Stuart C.

Ph.D., Computer Sciences, University of Wisconsin, 1971; M.S., Computer Sciences, University of Wisconsin, 1968; S.B., Mathematics, Massachusetts Institute of Technology, 1966.

Dr. Shapiro is a professor and Chairman of the Computer Science Department, State University of New York, Buffalo. He is Director of the Graduate Group in Cognitive Sciences. Assistant Professor, Indiana University, Bloomington (1971–1978); Teaching Assistant and Research Assistant, University of Wisconsin (1966–1970).

Artificial intelligence consultant, XMCO Inc. (1985); principal lecturer and consultant, Smart Systems Technology, McLean, Virginia (1983–1985); consultant on applicability of artificial intelligence systems to avionics systems (1983); consultant on applicability of artificial intelligence to communications system control, Rome Air Development Center, Griffiss Air Force Base, New York; consultant, Linguistics Group, RAND Corporation — designed the knowledge representation part of the MIND natural language processing system (1968–1971). Dr. Shapro is a member of the Association for Computing Machinery (special interest groups in AI, computer science education, and programming languages); Association for Computational Linguistics; Cognitive Science Society, American Association for Artificial Intelligence, IEEE, Computer Society, and Systems, Man, and Cybernetics Society.

Dr. Shapiro is the author of numerous journal articles, chapters in books, and technical papers (see bibliography). He is the author of three books: *Techniques of Artificial Intelligence* (D. Van Nostrand, New York, 1979), *LISP: An Interactive Approach* (Computer Science Press, Rockville, Maryland, in press), and *Encyclopedia of Artificial Intelligence* (John Wiley & Sons, Inc., New York, to be published).

Reviewed books, articles, and manuscripts for numerous publishers. Associate editor for AI in *Cognition and Brain Theory* (1979–198) and Editorial Board Member, *American Journal of Computational Linguistics* (1980–1982). Panelist and council service for N.S.F. Graduate Fellowship Evaluation Panel in Computer Science, National Research Council (1984–1985); N.S.F. Local Course Improvement Program Review Panel; Curriculum Advising Council, Computer Science Department, SUNY; review panel for the Adaptive Network Research Program of the System

Avionics Division of Wright-Patterson Air Force Base, Air Force Studies Board, National Research Council; Computer Science Curriculum Advisory Countil, Erie Community Collect; N.S.F. Graduate Fellowship Evaluation Panel in Applications of Mathematics, National Research Council.

Research interests include: AI research, expert systems, natural language, cognitive science, computational linguistics, knowledge representation, reasoning, logic programming, semantic networks, belief systems, expert systems for medical diagnosis, and expert systems for maintenance.

AI Research, Expert Systems, AI Tools

Director
Artificial Intelligence Center
FMC Corporation

THORNDYKE, Dr. Perry W.

Ph.D., Cognitive Psychology, Stanford University, 1975; B.A., Computer and Information Sciences, Yale University, 1971.

Director, Artificial Intelligence Center, Electronics Engineering and Computer Science, FMC Corporation, Central Engineering Laboratories. Dr. Thorndyke has a technical background in artificial intelligence, expert systems for planning and decision making, computer-based training technology, intelligent human-machine interfaces, cognitive modeling, spatial reasoning, and distributed intelligence.

Director, Knowledge Systems Branch, Perceptronics, Inc. (1981–1984); Computer Scientist, Information Sciences Department, RAND Corporation (1975–1981); Adjunct Assistant Professor, University of California, Los Angeles (1975–1981); Research Associate, Computer Sciences Laboratory, Xerox Palo Alto Research Center (1973–1975); Research Assistant, AI Group, Stanford Research Institute (1971–1972).

Dr. Thorndyke was advisor to the Air Force Human Resources Laboratory on technology and automation requirements for tactical decision-making facilities (1983), and advisor to the Army Research Institute on program planning for artificial intelligence initiative (1982). He was invited to address the American Education Research Association Meetings (1981) and he organized and chaired the RAND Team Performance Workshop (1980). He is on the Editorial Board of the *Journal of Educational Psychology* (1978–1985). Contributor to *AI Handbook* (Barr and Feigenbaum, Eds., 1976–1977). Dr. Thorndyke is a reviewer for more than 10 professional journals in computer science and psychology, and he is the author of more than 30 journal publications, book chapters, and technical reports in the areas of artificial intelligence, instruction, and modeling of complex human performance (1974–1983). He has presented more than 100 conference papers, colloquia, and management and technical briefings. (See bibliography.)

AI Research, Cognitive Psychology, Expert Systems, Legal Applications

WATERMAN, Dr. Donald A.

Ph.D., Computer Science, Stanford University; M.S., Computer Science, Stanford University; B.S., Electrical Engineering, Iowa State University.

Dr. Waterman is a Senior Computer Scientist at RAND Corporation, Santa Monica, California.

Research interests include: AI research, cognitive psychology, and applications of expert systems in government and industry, including the design and development of tools for building expert systems and the development of legal decision systems.

AI Research, Natural Language

Director
Computer Research Laboratory
New Mexico State University

WILKS, Dr. Yorick

Ph.D., Mathematics and Philosophy, Pembroke College, Cambridge, UK, 1968; M.A., B.A., Mathematic and Philosophy, Pembroke College, Cambridge, UC, 1965, 1963.

Dr. Wilks is Director of the Computing Research Laboratory at New Mexico State University.

Dr. Wilks was Professor of Computer Science at University of Essex, UK (1983–1985); Visiting Professor, Commonwealth of Australia (1983); Professor of Linquistics, University of Essex, UK (1978–1983); Reader in Linguistics, University of Essex, UK (1976–1978); Senior Visiting Fellow, Department of Artificial Intelligence, University of Edinburgh, Scotland (1975–1976); Senior Research Fellow, Institute for Semantic and Cognitive Studies, Castagnola, Switzerland (1974–1975); Research Associate and Lecturer, Artificial Intelligence Laboratory, Stanford University (1970–1974); Consultant, O.N.R. Contract, Stanford University (1969–1971); Lecturer, University of Nairobi, Kenya (1969); Principal Investigator, A.F.O.S.R. Contract in Language Processing Systems Development Corporation (1966–1967); Research Associate, Cambridge Language Research Unit, Cambridge, UK (1963–1966).

Honors and awards include: External Examiner; M.S. in Epistemics, University of Edinburgh (1982–1984); Royal Society Travel Fellowship (1983); Visiting Sloan Fellow, University of California, Berkeley (1981); Participant, Nobel Symposium on Language (1980); NATO Senior Scientist Fellowship (1979); Visiting Sloan Fellow, Yale University (1979); and SRC Senior Visiting Fellowship, University of Edinburgh. Extensive publications (see bibliography).

Research interests include: AI research and natural language.

AI Research, Software Validation, Software Development

ZEIL, Dr. Steven J.

Ph.D. Assistant Professor, Computer Science and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: AI research, software validation and testing, software development environments, and methodologies.

Expert Systems

Expert Systems

AIKINS, Dr. Janice

Ph.D., Computer Science, Stanford University. Research Scientist at IBM's Palo Alto Scientific Center.

Research interests include: knowledge control in expert systems.

Expert Systems, AI Research, AI Tools

Manager
Schlumberger Austin Research Center

BAKER, Dr. James D.

Ph.D., Mathematics, Johns Hopkins University; M.A., Mathematics; B.A., Mathematics.

Dr. Baker is Manager of the Schlumberger Austin Engineering Center. He has worked in operations research, pattern recognition, image processing, math representation of systems, and methodologies for developing complex systems. Directed the development of artificial intelligence techniques and their application to industrial problems at Schlumberger Doll Research, including the DIPMETER ADVISOR, an expert system for oil field log interpretation. Previously at Honeywell, Texas Instruments, and the Johns Hopkins University Applied Physics Laboratory. (For publications, see bibliography.)

Research interests include: expert systems, AI research, AI tools, operations research, pattern recognition, image processing, math modeling, and systems development methodologies.

Expert Systems, AI Workstations, AI Software Languages, AI Tools

Chairman of the Board and *President*
ExperTelligence

BOLLAY, Denison
B.A., Engineering, Harvey Mudd College, 1974.

Mr. Bollay is President and Chairman of the Board of ExperTelligence (1985), Santa Barbara, a public company (EXPR) specializing in AI products for microcomputers.

Directed and participated in the ExperTelligence team that created the first compiled LOGO and LISP for microprocessors, ExperLisp and ExperLogo. ExperOPS was the first fully-up implementation of OPS5. The products run on Apple's Macintosh microcomputer.

Mr. Bollay pioneered with Frank Lehan the adaptation of Bayes and Markov techniques to signal processing (1977–1980). Also developed a real-time rule-based expert system related to stock options.

Expert Systems

BRAMER, Dr. M. A.
Ph.D., Computer Science; B.Sc., Mathematics.

Lecturer in Computer Science, Mathematics Faculty, Open University, United Kingdom. Committee Member, Newsletter Editor of the British Computer Society Specialist Group on Expert Systems; Features Editor of *AISB Quarterly* (The Journal of the Society for the Study of Artificial Intelligence and Simulation of Behavior).

Research interests include: expert systems and game playing.

Expert Systems, Heuristic Problem Solving Methods

BRATKO, I.
Faculty, Department of Electrical Engineering, E. Jardelj University, Yugoslavia; AI Researcher, J. Stefan Institute, Ljubljana, Yugoslavia; also, Researcher, Machine Intelligence Research Unit, University of Edinburgh, UK.

Research interests include: expert system tools, heuristic methods for problem solving, information system implementation, combinational optimization problems, and computer chess.

Intelligent Knowledge-Based Systems

Founder and *Director*
Knowledge Based Systems Center
Polytechnic, South Bank, London

BROOKING, Annie G.
Founder and Director of Knowledge Based Systems Center, at Polytechnic, South Bank, London. The Knowledge Based Systems Center is one of Europe's leading centers for intelligent knowledge-based systems.

Research interests include: methodology of systems design and intelligent knowledge-based systems.

Expert Systems, AI Software Languages, AI Tools

BROUILLET, Jean-Luc
M.S., Computer Science (Artificial Intelligence), Stanford University, 1985.

Mr. Brouillet is a Knowledge Engineer at Teknowledge.

Research interests include: expert systems, AI software languages, and AI tools.

Director
Intelligent Systems Laboratory
Xerox PARC

Robust Expert Systems

BROWN, Dr. John Seely

Director and Principal Scientist, Intelligent Systems Laboratory, Xerox Palo Alto Research Center (PARC), Palo Alto, California.

Previously a faculty member at the University of California at Irvine in the Department of Information and Computer Science and the Department of Cognitive Psychology. Formerly a Principal Scientist at Bolt, Beranek and Newman, researching intelligent tutoring systems.

Currently at Xerox PARC, directing a cognitive science research group. At PARC, his research is concerned with showing how cross-disciplinary basic research can enable major theoretical and pragmatic advances.

Dr. Brown's group created INTERLISP-D and the associated Xerox 100 line of LISP machines.

Research interests include: team problem-solving, experimental learning, diagnostic systems to trace systematic errors in user performance, and expert systems frameworks for intuitive next-generation expert systems.

Expert Systems, AI Tools, AI Workstations

BRUTLAG, Dr. Douglas L.

Ph.D. (with distinction), Biochemistry, Stanford University, 1972; B.S. (with honors), Biology, California Institute of Technology, 1968. George W. Green Award for Creative Scholarship and NSF Predoctoral Fellowship.

Dr. Brutlag is Associate Professor of Biochemistry at Stanford Medical School and co-investigator of NUH BIONET Resource. He has taught in the Department of Biochemistry at Stanford since 1974, taking a sabbatical at the Institut Pasteur in Paris, France (1981–1982). Previously, he was Research Scientist at the Commonwealth Scientific and Industrial Research Organization.

Dr. Brutlag's professional honors include an NIH Senior Fogarty International Fellowship, a Henry and Camille Dreyfus Teacher-Scholar Grant, a Basil O'Connor National Foundation Young Investigator's Award, membership in the American Society of Biological Chemists, election to the Federation of American Societies for Experimental Biology, and an Andrew W. Mellon Foundation Fellowship. Public service includes participation in the National Institute of Health study and research sections in Cell Biology, Molecular Cytology, Genetics, and Small Business Innovation.

Author and co-author of extensive publications (see bibliography) and presentations.

Research interests include: expert systems, AI tools, and AI workstations.

Expert Systems, AI Tools, AI Software Languages, AI Research

CADIOU, Philippe

M.S., Computer Science, Stanford University, 1978; Engineer Ecole Centrale de Paris, 1976.

Knowledge Engineer, Knowledge Engineering Services, Teknowledge, Inc., Palo Alto, California. Design and development of expert systems applications. Design of knowledge representation schemes and knowledge base coding. Implemented an explanation module for an expert system in computer configuration (1983). Designed and implemented a constraint checking system for an intelligent editor. Currently designing a quality assurance tester for a manufactured product. Mr. Cadiou was a member of the CII-Honeywell-Bull research center AI team in Paris. He implemented an object-oriented tool for knowledge representation (KOOL), which was

used to develop a prototype expert system for a computer configuration application.

His background includes research on automatic translation (1978–1979) and a master's project on the PSI automatic programming system at Stanford University with Dr. Cordell Green.

Research interests include: expert systems, AI tools, AI software languages, and AI research.

Expert Systems

Co-director
GUIDON/NEOMYCIN Tutoring Project
Knowledge Systems Laboratory
Stanford University

Founding Consultant and *Director*
Teknowledge

CLANCEY, Dr. William J.
Ph.D., Computer Science, Stanford University, 1979.

Research Associate in Computer Science at the Knowledge Systems Laboratory (formerly the Heuristic Programming Project) of Stanford University. An active member of the expert systems community since he joined the MYCIN project in 1975, for which he was co-developer of antibiotic therapy and question-answering programs. Now co-director of the GUIDON/NEOMYCIN tutoring project, his interests lie in computational modeling of problem-solving and the design of architectures for expert systems to facilitate their construction explanation, and multiple use.

Dr. Clancey has published widely on tutoring and expert system methodology, and is the editor (with E. H. Shortliffe) of *Readings in Medical Artificial Intelligence: The First Decade*. He has given tutorials on expert systems for Teknowledge, Inc. and WICS, as well as panel presentations at numerous conferences. At AAAI-84, he helped present a tutorial on Applications of AI to Training and Education, and his paper on the nature of problem-solving in expert systems was nominated for the Publisher's Prize. Dr. Clancey is also a founding consultant and Director of Teknowledge.

Expert Systems, Micro Shell Designer for

COX, Phil
Technical Director of ISIS Systems. Developed Micro Expert, expert systems shell for microcomputers.

Expert Systems, AI Research, AI Software Languages

Director
Computer Science Laboratory
Aerospace Corporation

CROCKER, Dr. Stephen B.
Ph.D., Computer Science, University of California, Los Angeles, 1977; B.A., Mathematics, University of California, Los Angeles, 1968.

Dr. Crocker is Director of the Computer Science Laboratory at Aerospace Corporation in Los Angeles. Previously Project Leader in program verification system design and development at the University of Southern California Information Sciences Institute (1974–1981); and Research and Development Program Manager for DARPA/IPTO (1971–1974). Managed research funding in DARPA's AI, automatic programming, and speech understanding programs. Developed arm control program at Massachusetts AI Laboratory. Author and co-author (see bibliography).

Research interests include: expert systems, AI research, AI software languages, natural language, AI workstations, and program analysis, synthesis and verification.

Expert Systems

Co-founder
Applied Expert Systems

Founding Consultant
Teknowledge

DAVIS, Dr. Randall

Active in work on expert systems since his early involvement with the MYCIN system and his development of the TEIRESIAS system for knowledge acquisition. After receiving a Ph.D. from Stanford in 1976, he spent two more years there as a Chaim Weizmann Postdoctoral Scholar. He went to MIT in 1978, and from 1979 to 1981 was the holder of a Harold and Ester Edgerton Endowed Chair. Currently an Associate Professor at MIT, he has published widely on expert systems, and serves on the editorial board of the *Artificial Intelligence Journal* and *New Generation Computing*. His current research on expert systems explores the use of reasoning from first principles, relying on descriptions of structures and function. His paper describing this work was nominated for the Publisher's Prize at AAAI-83. Davis is an experienced lecturer on the topic of expert systems, a founding consultant of Teknowledge and a co-founder of Applied Expert Systems.

Expert Systems, Voice Recognition

Chairman
Computer Science Department
Concordia University
Montreal, Canada

DE MORI, Dr. Renato

Ph.D., Electronic Engineering, Politecnico di Torino, Italy, 1967.

Dr. De Mori is Professor and Chairman of the Computer Science Department of Concordia University in Montreal, Canada.

Before joining the Computer Science Department at Concordia University, he was Professor and Chairman of the Institute for Computer Science at the University of Torino (1976–1982); Assistant and Associate Professor at Politecnico di Torino (1969–1976).

Author of two books — *Computer Models of Speech Using Fuzzy Algorithms* (Plenum, 1983) and *Computer Models for Vision and Speech Perception*, 2 vols. (CRC Press, 1982) — and more than 100 papers, primarily published in international journals and proceedings of international conferences in computer systems, pattern recognition, and AI. Associated Editor of *Signal Processing*, *Speech Communication*, and *Pattern Recognition Letters*. Chairman of the Technical Committee on Automatic Speech Recognition of the International Association for Pattern Recognition, and General Chairman of the Canadian Conference in Artificial Intelligence (Montreal, 1986).

Dr. De Mori is a member of AAAI, IEEE-CS, ACM, and EURASIP. He is on the Board of Directors of Centre De Recherche en Informatique de Montreal (CRIM) and on the Scientific Council of Centre National d'Etudes de Telecommunications (CNET) I, Lannion-A, France.

Research interests include: expert systems and voice recognition.

Expert System for Partial Differential Equations

DYKSEN, Dr. Wayne R.

Ph.D., Applied Mathematics, Purdue University, 1982; M.S., Applied Mathematics, Purdue University, 1979; B.A., Mathematics, Calvin College, 1977.

Assistant Professor of Computer Sciences, Purdue University, 1984.

Dr. Dyksen's research interests are in numerical analysis, especially the solution of partial differential equations. His current work is focused on three main areas: developing iterative methods for three-dimensional elliptic problems, deriving vector and parallel algorithms, and building an expert system for partial differential equations. (See bibliography.)

Expert Systems, AI Research, AI Tools

Founding Member
AAAI

ERMAN, Dr. Lee D.

Ph.D., Computer Science, Stanford University, 1974; M.S., Computer Science, Stanford University, 1968; B.S. (with distinction), Mathematics, University of Michigan, 1966.

Dr. Erman is Principal Scientist in Research and Advanced Development at Teknowledge, Inc. Previously, he was a research project leader and computer scientist at the University of California's Information Sciences Institute (ISI) (1978–1982) and an Assistant Professor of Computer Science at Carnegie-Mellon University (1976–1978), as well as a researcher (1970–1976). He was a teaching and research assistant at Stanford University (1966–1970), and a research programmer with the Logic of Computers Group at the University of Michigan (1966). Dr. Erman worked with Dr. Raj Reddy at Stanford University and at Carnegie-Mellon University in speech understanding systems.

Designer and chief implementor of the HEARSAY-I systems and in charge of the HEARSAY-II ARPA speech understanding project. Design and development at ISI of HEARSAY-III, which provides architecture for an expert problem-solver for a chosen domain. Principal developer of Teknowledge's S.1 knowledge-engineering tool product. Primary responsibility at Teknowledge is tools for building knowledge systems. Author and co-author (see bibliography), and lecturer.

Founding member of the American Association for Artificial Intelligence (AAAI). Editorial board member, Addison-Wesley and *Artificial Intelligence Journal*. Professional associations include AAAI, Association for Computing Machinery, IEEE, and USC/ISI.

Research interests include: AI tools, expert systems, AI research, and structure of knowledge-based expert systems.

Knowledge-Based Systems for Personal Financial Planning (PFP)

ESHELMAN, Dr. Larry

Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Research interests include: developing a knowledge-based system whose domain of expertise is personal financial planning (PFP). Given a client's financial goals and an initial set of client data, PFP uses its financial expertise and additional information solicited from the client to explore opportunities that will help the client to achieve financial goals.

Expert Systems, AI Software Languages, AI Workstations, Natural Languages

President
Software Architecture and Engineering, Inc.

FERRENTINO, Andrew B.

M.S., Mathematics, Lehigh University, 1964; B.A., Mathematics, Middlebury College, 1962.

President of Software Architecture and Engineering, Inc.

Transformed Software Architecture and Engineering, Inc. (SA&E) from a software engineering advanced technology company into one of the leading small companies in the AI marketplace. Developed and carried out the AI product strategy leading to the popular Knowledge Engineering System product and the current research and development activities underway at SA&E. Initiated contracts with the United States Government through the combination of software engineering techniques, 4th generation, and 5th generation technologies.

Expert Systems, Microcomputer Expert Shell Developer

Founder
Warm Boot, Ltd.
London

FORSYTH, Richard

M.Sc., Computer Science, City University, 1980; B.A., Psychology, Sheffield University, UK, 1970.

Founder Warm Boot, Limited, a software house selling machine-intelligence applications. Lecturer, then Senior Lecturer, Polytechnic, North London (1979–1984).

Expert Systems, Medical Applications

Director
Biomedical Computing Unit
Imperial Cancer Research Fund Laboratories
London

FOX, Dr. John

Originally trained in psychology at Durham and Cambridge University. Postdoctoral Fellow at Carnegie-Mellon and Cornell Universities, studying the application of production system techniques in modeling pattern recognition and image interpretation (1973–1975). Since 1975, Dr. Fox's research has centered on decision-making. This has involved designing, installing and evaluating several decision support systems in medicine.

Primary theoretical interest: development of a knowledge-based theory of decision-making to complement classical statistical theory.

Lectured widely in Europe to academic and industrial groups; advisor to UK Department of Industry's ALVEY Project. Program Chairman of the British Computer Society's Expert Systems (1983); he was editor of Pergamon's *State of the Art Report on Expert Systems*, currently editor of *Knowledge Engineering Review*.

Dr. Fox became the Director of the Biomedical Computing Unit at the Imperial Cancer Research Fund Laboratories in London (1981), developing knowledge-based techniques for applications in molecular biology and in medicine, using LISP and PROLOG. The group was responsible for the design and implementation of the PROPS expert systems package, and is active in theoretical AI research.

Expert Systems, Knowledge Representation

Co-founder
Carnegie Group, Inc.

Director
Intelligent Systems Laboratory
Robotics Institute
Carnegie-Mellon University

FOX, Mark

Co-founder of Carnegie Group, Inc. Ph.D., Director of the Intelligent Systems Laboratory at Carnegie-Mellon University's Robotics Institute, one of the leading laboratories for research in AI and manufacturing. He was Project Leader for the development of several powerful AI tools and systems, including SRL, a prototype of Knowledge Craft, and ISIS, a constraint-directed factory scheduling system.

Expert Systems, Natural Language, AI Research, AI Resources

President, *CEO*, and *Technical Director*
Frey Associates, Inc.

FREY, Eric D.

Electrical Engineering, Massachusetts Institute of Technology, 1963; Universite des Roches, Bluche sur Sierre, Valais, Switzerland.

Mr. Frey is President, CEO, and Technical Director of Frey Associates, Inc. in Amherst, New Hampshire.

Conceived and implemented architecture of Frey Associates' generic expert systems; conceived and implemented the AI architecture upon which THEMIS, a natural language query product, was based; currently designing and implementing a 32-bit microprocessor-based version of the natural language-understanding component of THEMIS. Design and development of CYBOS; design, development, and programming of CAPIDYNE-OS; design and development of IBM/360 emulation monitor for IBM/1401 operations; NEACP.

Project member; technical consultant to financial institutions.

Research interests include: expert systems, natural language, AI research, AI software languages, AI research, and robotics.

Expert Systems, Vision Systems

GASCHNIG, Dr. J.

Ph.D., Computer Science, Carnegie-Mellon; B.S., Electrical Engineering and Computer Science, MIT.

Computer Scientist, Stanford Research Institute International, Menlo Park, California.

Research interests include: design and implementation of visual texture description systems; Prospector; and performance evaluation and codification of model design techniques.

Expert Systems, AI Software Languages, Natural Language

President and *CEO*
Carnegie Group, Inc.

GEISEL, Larry K.

MSE, Arizona State University, 1965.

Mr. Geisel is President and Chief Executive Officer of Carnegie Group, Inc. He has 22 years of business experience and technical management. Prior to joining Carnegie Group, Mr. Geisel founded Summit Information Systems Corporation, a successful systems company serving the banking industry, and served as Vice President with Applied Theory Associates and Corporate MIS Director at Pullman, Inc. He is a frequent speaker at conferences.

Research interests include: expert systems, AI software languages, natural language, and forecasting trends for commercial AI growth.

Expert Systems

GENESERETH, Dr. Michael

Ph.D., M.A., Harvard; B.S., MIT. Assistant Professor of Computer Science, Stanford University.

AI tool design for building expert systems. Program Chairman, 1983 AAAI Conference on AI. Dr. Genesereth is on the Editorial Board of the *Artificial Intelligence Journal.*

Research interests include: knowledge representations, learning, problem solving, automated tutoring, automated consultation, and software engineering.

Expert Systems, Medical Applications in

Vice President
Institutional Development
Baylor College of Medicine

GORRY, Dr. G. Anthony

Ph.D., Computer Science, MIT, 1967.

Vice President for Institutional Development at Baylor College of Medicine. Associate Professor, Sloan School of Management and Faculty, Department of Computer Science, MIT (1967–1975). At MIT his research included use of computers for medical decision-making.

Research interests include: clinical cognition and health policy analysis.

Expert Systems

Vice President
Software Engineering
Applied Expert Systems, Inc.

GREENFELD, Dr. Norton

Ph.D., Information Sciences, California Institute of Technology, 1972; M.S., Information Sciences, California Institute of Technology, 1968; B.S., Mathematics, California Institute of Technology, 1967.

Dr. Greenfeld is Vice President of Software Engineering at Applied Expert Systems, Inc. His work and research include: expert systems, knowledge representations, and English database query systems.

Previously at Bolt, Beranek and Newman as Principal Investigator of a project to develop an advanced information presentation system, a knowledge-based display management system; Manager of development of a personal computer system (Jericho); and Principal Investigator for a contract with Lister Hill National Center for Biomedical Communications (National Library of Medicine).

Dr. Greenfeld has done research at California Institute of Technology in all aspects of the REL project, at Information Sciences Institute (ISI), at the University of Southern California in automatic programming systems and applications of artificial intelligence technology to command-and-control systems (for DARPA), and at Massachusetts Institute of Technology, where he was part of the OWL knowledge-based expert systems group. Author of numerous publications and reports (see bibliography).

Expert Systems

HARDT, Dr. Shoshana

Ph.D., Weizmann Institute of Science, Israel.

Assistant Professor, New York State University at Buffalo.

Research interests include: expert systems.

Expert Systems, AI Research

Founder
Syntelligence

Founding Director
Schlumberger/Fairchild Laboratory for Artificial Intelligence Research

HART, Dr. Peter E.

Ph.D. 1966, M.S. 1963, Stanford University; B.E.E. 1962, Rensselaer Polytechnic Institute.

Fellow, Institute of Electrical and Electronic Engineers; Distinguished Lecturer, Carnegie-Mellon University, 1981; Distinguished Lecturer, MIT, 1983; Sigma Xi, Tau Beta Pi, Eta Kappa Nu.

Founder and first President of Syntelligence, the first expert system company to address the problem of assessing large financial risks in business. Founding Director of the Schlumberger/Fairchild Laboratory for Artificial Intelligence Research, the first large AI research laboratory in a major corporation. Director of the SRI Artificial Intelligence Center, one of the oldest and largest AI laboratories in the world.

Initiator and Project Leader of PROSPECTOR, a widely-reported expert system that successfully predicted the occurrence of a deeply-buried mineral deposit. Co-developer of the A* algorithm, the first provable optimal search method developed in the field of artificial intelligence. Project Leader of SHAKEY, the first mobile robot controlled by an AI program. Co-developer of STRIPS/PLANEX, a system for learning and executing robot plans. Developer of the nearest-neighbor decision rule, a non-parametric decision procedure with provable optimal properties.

Author of several publications (see bibliography). Advisor on artificial intelligence to various governmental bodies and corporations. AAAI Executive Council (1983–1985).

Expert Systems

Co-founder and *Chief Scientist*
Teknowledge

HAYES-ROTH, Dr. Frederick

Ph.D., Mathematical Psychology; M.S., University of Michigan.

Co-founder and Chief Scientist of Teknowledge, Palo Alto, California. A principal designer of the HEARSAY-II speech understanding system and the ROSIE knowledge engineering language. Co-author of *Pattern-Directed Inference Systems* and *Building Expert Systems.*

Expert Systems, AI Research, Distributed Problem-Solving

HUDLICKA, Dr. Eva

Ph.D., Computer Science (Artificial Intelligence), University of Massachusetts, 1985; M.S., Computer Science, Ohio State University, 1979; B.S., Biochemistry, Virginia Polytechnic Institute and State University, 1977. Phi Beta Kappa.

Dr. Hudlicka is a Visiting Assistant Professor in the Computer and Information Sciences Department at the University of Massachusetts.

Designed and implemented a prototype system that uses a causal model to diagnose errors in a problem-solving system. Participated in development of a distributed problem-solving system based on extended Hearsay-II architecture.

Author and co-author (see bibliography). Member of ACM, SIGART, and AAAI.

Research interests include: developing models and languages for representing problem-solving expert systems behavior, construction and use of causal models of problem-solving systems, AI research, and distributed problem-solving.

Expert Systems, Natural Language, AI Tools

President and *Co-founder*
Inference

Co-founder
LISP Machines, Inc.

JACOBSON, Dr. Alex

Ph.D., Electrical Engineering, California Institute of Technology; M.S., Electrical Engineering, University of California, Los Angeles; B.S., Electrical Engineering, University of California, Los Angeles.

President and principal and founding member of Inference Corporation. Co-founder (with Dr. Chuck Williams) of LISP Machines, Inc. (LMI).

Prior to founding Inference, Dr. Jacobson was manager of the Liquid Crystal Display Programs in the Industrial Products Division of Hughes Aircraft, and in various capacities within Hughes for a span of 22 years. High technology management for 18 years, 13 years of which in initiating, funding, staffing, leading, and commercializing high-technology product development projects.

Dr. Jacobson is a holder or co-holder of 12 patents, and he has published 36 technical papers.

Research interests include: AI tools, expert systems, and natural language.

Expert Systems, AI Software Languages, AI Research, Natural Language

JOHNSON, W. Lewis

Ph.D., Computer Science, Yale University, 1985; M.S., Computer Science, Yale University, 1980; A.B., (Summa cum Laude) Linguistics, Princeton University, 1978.

Consultant for Courseware, IBM Federal Systems Division, Smart Systems Technology, Inc. and Computer Data Access, Inc.; Research Assistant at Yale University (1979–1980, 1982–1985); Senior Programmer at Computer Data Access (1980–1981); Teaching Assistant at Yale University (1979–1980); Programmer at Princeton University (1974–1978) and Max Planck Institut, Munich (1975). (See bibliography.)

Research interests include: program synthesis and understanding, intelligent computer-aided instruction, natural language processing, expert systems, and AI software languages.

Expert Systems, REVEAL Developer

JONES, Dr. Peter Llewelyn
B.Sc., Imperial College, 1967.

Interests: Computer-assisted planning and decision support systems (1970). Managing Director of OnLine Decision International (1973). Mr. Jone's experience in decision support system techniques, and knowledge acquisition and judgment interests in management support systems, led to the development of REVEAL in 1981 (now marketed by McDonnell Douglas Infotym Group).

Expert Systems

Founder
Applied Expert Systems, Inc.

Co-founder
The Financial Collaborative
Boston

President
J. L. Joslin Associates

JOSLIN, James L.
B.S., Harvard University.

Mr. Joslin is founder of Applied Expert Systems, Inc. (APEX), President of J. L. Joslin Associates, co-founder of The Financial Collaborative in Boston, and he is a Registered Investment Advisor and Certified Financial Planner. Previously, Mr. Joslin was Senior Vice President with investment responsibilities at Jennison Associates Capital Corp., Beacon Advisors, and Thorndike, Doran, Paine & Lewis, Inc.

Research interests include: expert systems.

Expert Systems, Tools, AI Software Languages

Senior Knowledge Engineer
Teknowledge, Inc.

JOYCE, Bob
M.S., Artificial Intelligence, Stanford University, 1983; B.S.E.E., University of British Columbia, 1976.

Senior Knowledge Engineer, Knowledge Engineering Services, Teknowledge, Inc., Palo Alto, California. Principal Implementor, M.1 v1.0, a knowledge engineering tool for the IBM PC.

Research interests include: expert systems, tools, and AI software languages. (See bibliography.)

Expert Systems, Drilling Fluids, Application of

KAHN, Dr. Gary
Ph.D., Faculty, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Recently completed work on MUD, an expert system that functions as a drilling fluids engineer. Currently working on a knowledge acquisition system called MORE. MORE elicits domain information from an expert, maps this information into a causal model, and generates corresponding diagnostic rules. (For more information on MUD and MORE, see section AI Schools, re: Carnegie-Mellon University.)

Research interests include: problem-solving, explanation, and knowledge-acquisition capabilities of expert systems.

Expert Systems

Vice President
Financial Services
Applied Expert Systems, Inc.

KARASH, Richard I.
M.S., Sloan School of Management, Massachusetts Institute of Technology, 1973; B.S., Management and Physics, Massachusetts Institute of Technology, 1969.

Mr. Karash is Vice President of Financial Services at Applied Expert Systems, Inc. (APEX); development, marketing, and operations. Previously, Vice President, Product Development at APEX, which included product management, product marketing, and new product and technology planning. Prior to joining APEX, Mr. Karash was co-founder, Senior

Vice President, and Director of Management Decision Systems, Inc., a marketing services business in testing and evaluating new consumer products (1970). As General Manager (1975–1980), established the company's software business using the EXPRESS language, supervised the company's six-fold growth, and developed international activities. Product marketing, Digital Equipment Corporation (1969–1970).

Research interests include: expert systems, and development, marketing and operations for expert systems products.

Decision-Making, Medical Applications in

Associate Chairman
Department of Medicine
Tufts University School of Medicine

KASSIRER, Dr. Jerome P.
M.D., University of Buffalo, 1957.

Professor and Associate Chairman, Department of Medicine, Tufts University School of Medicine, and Associate Physician-in-Chief, New England Medical Center.

Research interests include: clinical applications of decision analysis and descriptive analysis of physician problem-solving tactics.

Expert Systems

Executive Vice President and *General Manager*
IntelliCorp

KEHLER, Dr. Thomas P.
Ph.D., Electrical Engineering, Drexel University.

Executive Vice President and General Manager, IntelliCorp, Menlo Park, California. Before going to IntelliCorp, Dr. Kehler was Senior Member of the Artificial Intelligence Staff and Manager of the Knowledge-Based Systems Branch, Texas Instruments.

Expert Systems, AI Tools, AI Research

Senior Scientist
Artificial Intelligence Laboratory
General Research Corporation

KISELEWICH, Dr. Stephen J.
Ph.D., Engineering and Applied Science, Yale University, 1975; M.S.E., Computer, Information, and Control Engineering, University of Michigan, 1970; B.E.S., Electrical Engineering, Johns Hopkins University, 1969.

Senior Scientist, Artificial Intelligence Laboratory, General Research Corporation, Santa Barbara, California (1984). Responsible for employing knowledge engineering methods to assist experts in developing specific expert systems, as well as for investigating basic artificial intelligence research issues which have a potential impact on GRC's activities.

Recent work: assisting GRC's VAX system manager in the construction of TIMM/Tuner, an expert system for tuning VAX/VMS; studying the human ability to generalize from experiences; and examining the human ability to draw analogies between new situations and situations seen before. TIMM Product Manager, Computer Services Group (1983–1984); responsible for the start-up phase of a corporate effort to market TIMM (The Intelligent Machine Model), a domain-independent expert system applications generator. Member of the Technical Staff, Economic Resources and Planning Group/Data Processing and Software Group (1978–1983); responsible for planning and carrying out research in the field of artificial intelligence. Work included the development of methods for simulating a human being's ability to integrate information received from the environment into a perception of that environment; the construction of a computer program for detecting and correcting spelling mistakes; and the development of TIMM. (See bibliography.)

Memberships in Cognitive Science Society and AAAI.

Expert Systems, AI Tools, AI Research

KORNELL, Jim

B.S., Computer Science, University of California, Santa Barbara, 1978.

Researcher at General Research Corporation, Santa Barbara, California; knowledge acquisition automation. Previously, Mr. Kornell worked in tool development and software engineering.

Expert Systems

Manager
External Relations
Intelligent Systems Technologies Group
Digital Equipment Corporation

KRAFT, Arnold

M.B.A., Business Administration, Dartmouth College, Amos Tuck School; B.A., Business Administration, University of Massachusetts, Amherst.

Mr. Kraft is Manager of External Relations in the Intelligent Systems Technologies Group at Digital Equipment Corporation. He has been with Digital Equipment for six years, a member of the group that develops artificial intelligence-based applications for use within the corporation. Previously, Manager of Information Systems, ADT; Marketing and Research, Wang Laboratories.

Research interests include: expert systems and problem-solving.

Computer-Assisted Decision Making

KUNZ, Dr. John

Ph.D., Computer Science, Stanford University, 1984.

AI Researcher, IntelliGenetics.

Research interests include: computer-assisted decision making.

Expert Systems, Training

LEMMERMAN, Dr. John W.

Ph.D., Kent State University, 1978; M.Ed., Kent State University, 1974; B.S.E., Case Institute of Technology, 1967.

Consultant in knowledge engineering, job-task analysis, and AI tools for courseware development (analysis and design). Dr. Lemmerman was a Consultant at Verac Corporation, a Program Manager at Ford Aerospace, an Instructional Designer at Sperry Corporation, an Instructor of EET programs at Kent State University, and a Process Control Engineer at General Electric.

Research interests include: expert systems and training.

Expert Systems

Principal Scientist
Microelectronics and Computer Technology Corporation

LENAT, Dr. Douglas

Faculty, Computer Science, Stanford University.

Currently on leave as Principal Scientist at Microelectronics and Computer Technology Corporation (MCC).

Dr. Douglas has worked in AI for the past 14 years, teaching courses at CMS and Stanford in AI, LISP, problem solving, machine learning, and expert systems. His research on automated discovery and the nature of heuristics has earned IJCAI's Computers and Thought Award, and AAAI's Publisher's Prize Award. His numerous books and articles include: *Building Expert Systems*, *Knowledge-Based Systems in AI*, and a recent overview of AI in *Scientific American*.

Expert Systems, Engineering Applications in

LETSINGER, Dr. Reed

Ph.D., Philosophy, Stanford University, 1976; M.S., Computer Science, Stanford University, 1981.

AI Researcher, Hewlett-Packard.

Research interests include: engineering expert system applications.

Expert Systems, Automatic Theorem Proving

LOVELAND, Dr. Donald W.

Professor of Computer Science, Duke University.

Dr. Loveland's 20 years research in automatic theorem proving has influenced the evolution of PROLOG. He is currently building expert systems. Dr. Loveland is Editor-in-Chief for the Springer-Verlag Series in Artificial Intelligence, and is on the editorial board of *The Journal of Artificial Intelligence.*

Expert Systems

President and *CEO*
Applied Expert Systems, Inc.

Director and *CEO*
Index Systems, Inc.

LUCONI, Dr. Fred L.

Ph.D., Computer Sciences (with minor in Management), 1967; M.S., Electrical Engineering, 1965; B.S., Electrical Engineering, 1964; Massachusetts Institute of Technology.

Dr. Luconi is President and Chief Executive Officer of Applied Expert Systems, Inc. He is also Director, Executive Committee Member, and Chief Financial Officer of Index Systems, Inc. Previously, was co-founder and Vice President of Index Systems. Consultant in hardware/software selection, analysis and development of MIS and decision support systems, and strategy, organization, and management of information systems. Assistant Professor in Computer Science at Massachusetts Institute of Technology, where his research activities included modular computer systems design, large database systems design, and development of next-generation computer systems architecture. Consultant to Arthur D. Little, Raytheon, Hughes Aircraft, and others, in systems analysis, planning, and evaluation of time-shared and large-shared database computer configurations, software project management and development of automated design facilities.

Responsible for digital systems design of airborne, real-time computer hardware at Hughes Aircraft Company; conducted research and development for automated logic design and integrated circuit layout. Developed a simulation model used for inventory control and forecasting at U.S. Steel.

Research interests include: expert systems, decision support and information systems planning, evaluation, and management.

Expert Systems

Co-founder
Carnegie Group, Inc.

Associate Head and
Principal Scientist
Computer Science Department
Carnegie-Mellon University

McDERMOTT, John

Ph.D. Principal Scientist and Associate Head of the Computer Science Department at Carnegie-Mellon University.

Co-founder of Carnegie Group, Inc. Has pioneered research and development on expert systems, ranging from process diagnosis to production management. Developer of R1/XCON, an operational expert system that configures VAX and PDP/11 computer systems for Digital Equipment Corporation. (For a more complete description of R1 and other knowledge-based systems developed at Carnegie-Mellon, including XSEL, PTRANS, MUD, VT, CAT, and SPAM, see section AI Schools, re: Carnegie-Mellon University.)

Expert Systems

MICHIE, Dr. Donald

D.Sc., D.Phil., M.A., Oxford University.

Dr. Michie became interested in knowledge engineering and expert systems during WWII, while involved in the Bletchley code-breaking group at Bletchley Park. Following a post-war career in experimental genetics and immunology, he returned to machine intelligence in the early 1960's. In 1967 he was elected to a Personal Chair of Machine Intelligence at the University of Edinburgh. He is Editor-In-Chief of the Machine Intelligence series.

Dr. Michie developed Expert-Ease, the first artificial intelligence software for microcomputers.

Expert Systems, Medical Applications of

MILLER, Dr. Randolph A.

M.D., University of Pittsburgh, 1976.

Assistant Professor of Medicine, University of Pittsburgh. Associated with the INTERNIST/CADUCEUS project since 1973.

Research interests include: INTERNIST/CADUCEUS computer-assisted medical diagnosis systems.

Expert Systems, Natural Language, Voice Recognition

Consultant and *Chief Scientist*
Army Artificial Intelligence Center, the Pentagon

MILNE, Dr. Robert W.

Ph.D., University of Edinburgh, 1983; B.Sc., Electrical Engineering and Computer Science, MIT, 1978.

Army Captain Robert W. Milne is the Chief Scientist for the Department of the Army Artificial Intelligence Center, the Pentagon.

He is responsible for advising the Army Vice-Chief of Staff on Artificial Intelligence and providing technical guidance to Army AI programs. Consulting to: Army Research Office in Artificial Intelligence; Air Force Avionics Laboratory in Artificial Intelligence; Air Force Rome Air Development Center in Artificial Intelligence; Defense Advanced Research Projects Agency in the military applications of Artificial Intelligence.

Professional memberships include: Past Chairman, Artificial Intelligence Program, Air Force Institute of Technology; Past Chairman, Special Interest Group in Artificial Intelligence of the ACM, Dayton SIGART; Member of AAAI, ACL, ACM; nominated for National Treasurer, ACM SIGART.

Numerous publications (see bibliography). Forthcoming book: *Military Applications of Artificial Intelligence.*

Research Interests include: expert systems, natural language, and voice recognition.

Expert Systems, Digital Circuit Design Applications in

MITCHELL, Dr. John

Ph.D., Stanford. Faculty, Rutgers State University at New Brunswick, New Jersey, 1985.

Research interests include: machine learning, expert systems, AI approaches to digital circuit design, and self-improving programs.

Computer-Assisted Diagnostic Pediatric Cardiology Programs

MOLLER, Dr. James
M.D., Stanford University, 1959; Paul F. Dwan Professor of Pediatric Cardiology, University of Minnesota.

Research interests include: computer-assisted diagnostic pediatric cardiology programs.

Computerized Consultation Systems

MYERS, Dr. Jack D.
M.D., Stanford, 1937.

Co-developer of INTERNIST/CADUCEUS, a computerized consultation system in internal medicine.

Expert Systems

NAYLOR, Chris
Degrees in Psychology and Philosophy from the University of Keele, degree in Mathematics and Statistics from the University of London.

Member of the British Psychological Society, The Institute of Mathematics and its Applications, The Institute of Statisticians, and The British Computer Society.

Books include *Build Your Own Expert System* (Sigma Technical Press).

Expert Systems, Fuzzy Systems

NEGOITA, Dr. Virgil
Ph.D., Information Sciences, Polytechnical Institute, Bucharest, Romania.

Dr. Negoita is a Visiting Professor at Hunter College in New York City. He was head of a research laboratory at the Institute of Management and Computer Sciences for ten years at the Polytechnical Institute in Bucharest, Romania. He is an editor of *Fuzzy Sets and Systems Journal*, author of six books (see bibliography) — three of the books are in English, about Fuzzy systems and system theory application.

Research interests include: expert systems, Fuzzy systems, knowledge-based systems, and the effects of semantic systems on decision support systems.

Expert Systems, AI Research

PAN, Dr. Jeff Yung-Choa
Ph.D., University of Illinois, 1983.

Computer Scientist, AI Group of Schlumberger Palo Alto Research.

Research interests include: expert system research on domains of semiconductor fabrication and manufacturing automation, qualitative reasoning with deep-level models in engineering domains, expert system for the interpretation of parametric test data using multi-level knowledge base.

Member AAAI.

Expert Systems, Medical Applications of

PATIL, R.
Faculty, Department of Electrical Engineering and Computer Science, Purdue University.

Research interests include: modeling behavior of experts in clinical medicine, LSI circuits, design building, and knowledge-based tools for hardware design specification and analysis.

Medical Computer-Based Decision Aids

PAUKER, Dr. Stephen G.
M.D., Harvard Medical School, 1968.

Research interests include: medical decision-analysis applications and computer-based decision systems development.

Expert Systems, AI Research, Visual Recognition

PERKINS, Dr. Walton A.
Ph.D., M.A., Physics, University of California at Berkeley; B.S., Physics and Mathematics, Purdue University.

Dr. Perkins is currently the principle investigator of a 1985 Lockheed Independent Research Program on generic expert systems research. Since joining Lockheed in 1981, he initiated the development of the Lockheed Expert System (LES), and has worked to extend its capabilities and broaden its applications. His professional interests are in knowledge representation, image understanding, knowledge-based systems, automated manufacturing, and artificial intelligence in general.

Dr. Perkins worked for several years in experimental and theoretical plasma physics at the Lawrence Livermore Laboratory and generated several computer programs for determining particle trajectories in complex magnetic fields. From 1972 to 1974 he worked on scene analysis and knowledge representation (in the Hand-Eye Group) at the Stanford Artificial Intelligence Laboratory. From 1974 to 1981 he worked on image understanding at the General Motors Research Laboratory. This work involved creating computer programs for recognition and position determination of industrial parts, for general image segmentation, and for automatic visual inspection.

Dr. Perkins has published 38 articles in recognized scientific and technical journals, and a chapter of a book on plasma physics. He is a recipient of the Charles L. McCuen Award for his work on the computer vision inspection system, KEYSIGHT, and he received a patent (No. 4,399,554) for "Method and Apparatus for Inspecting Engine Valve Assemblies for Missing Keys" (1983). He is a member of the Institute of Electrical and Electronic Engineers, the Association for Computing Machinery (SIGART), and the American Association for Artificial Intelligence.

Expert Systems, AI Research

President
Jeffrey Perrone and Associates, Inc.

PERRONE, Jeffrey
M.S., Systems Design; B.A., Psychology.

Mr. Perrone is President of Jeffrey Perrone and Associates, Inc. in San Francisco, California, a management consulting firm focusing on the distribution and support for expert system development tools and applications. He is presently developing new software tools for speeding up and simplifying the development of expert systems. Before founding the company in 1979, he was employed as a management consultant at SRI International.

Research interests include: expert systms and AI research.

Expert Systems Validation Techniques, Knowledge Acquisition

Principal Engineer
Digital Equipment Corporation

POLITAKIS, Dr. Peter
Ph.D., Computer Science, Rutgers University.

Principal Engineer, Digital Equipment Corporation. Previously at MIT Lincoln Laboratory.

Research interests include: validation techniques for expert systems and knowledge acquisition.

Intelligent Decision Support Systems in Medicine

POPLE, Dr. Harry
Ph.D., Systems and Communications Sciences, Carnegie-Mellon University; MIT. Faculty, University of Pittsburgh, 1969.

Developer of CADUCEUS (originally INTERNIST), and expert system for internal medicine diagnosis.

Research interests include: expert systems, intelligent decision support systems, and applications in medicine and management.

Expert Systems, Medical Applications of

RADA, Dr. Roy
Ph.D., Computer Science, University of Illinois, 1981; M.D., Baylor College, Texas, 1977; M.S., Computer Science, University of Houston; B.A., Psychology, Yale, 1973.

Assistant Processor of Computer Science, Wayne State University, Detroit, Michigan. Editor of the newsletter of the ACM's Special Interest Group on Biomedical Computing (1983).

Research interests include: medical expert systems.

Expert Systems

RICH, Dr. Elaine
Ph.D., Computer Science, Carnegie-Mellon University, 1979.

Currently in the Human Interface Group at the Microelectronics and Computer Corporation in Austin. Prior to joining MCC, she was on the faculty in the Computer Sciences Department at the University of Texas at Austin. She is the author of a textbook on Artificial Intelligence and has presented many tutorials on AI to industrial audiences. She has also served as a consultant on several industrial expert systems projects.

Expert Systems, AI Software Languages

Senior Staff Scientist
in Expert Systems
Radian Corporation

RIESE, Charles
M.S., Physics, University of Illinois, 1968; B.S., Physics, University of Texas, 1966. Phi Beta Kappa.

Mr. Riese is Senior Staff Scientist in Expert Systems at Radian Corporation, Austin, Texas. He is a developer of RuleMaster, a software tool for building expert systems. Wrote RuleMaster, the C language rule instruction module.

Developed artificial intelligence application tools in Edinburgh, Scotland, working with Professor Donald Michie and staff.

Design and knowledge engineering of several RuleMaster system applications, one of which (EARL) diagnoses the condition of power transformers by using the concentrations of dissolved gases in the cooling oil as evidence. Design, coding, and testing of signal processing aspects of ten computer-based multichannel data acquisition and analysis systems, including sonar target detection, tracking, and display systems, a heavy equipment vibration monitoring system, meteorological monitoring

system, and air quality sampling and analysis systems. Developed mathematical models for temperature prediction for lakes used as cooling ponds, noise level contour prediction, and equilibrium distribution of chemical species.

Consultant in expert systems applications. Before joining Radian Corporation as Senior Research Scientist (1965–1966), he was Research Scientist at Tracor, Inc. (1968–1969) and Research Assistant in the Defense Research Laboratory, University of Texas (1964–1966). Author and co-author (see bibliography).

Research interests include: expert systems, AI software languages, and the application of mathematical analysis and computer programs to solve engineering and environmental problems.

Expert Systems, AI Software Languages, Workstations, AI Tools

Senior Computer Scientist
Space Telescope Science Institute

ROSENTHAL, Donald

S.M., Applied Mathematics, Harvard University, 1976; A.B. (Cum Laude), Engineering and Applied Physics, Harvard University, 1975.

Senior Computer Scientist, Operations and Data Management, Space Telescope Science Institute, Baltimore, Maryland.

Introduced knowledge-based systems and techniques into ground support systems for NASA's Hubble Space Telescope. Instructor for OPS5 programming workshop.

Research interests include: expert systems, AI software languages, workstations, and AI tools.

Intelligent Management Systems

SATHI, Mr. Arvind

B.S., Electrical Engineering, Indian Institute of Technology, India, 1977; M.B.A., Indian Institute of Management, India, 1979; M.S., Marketing and System Sciences, Carnegie-Mellon University, 1983.

Doctoral candidate at the Graduate School of Industrial Administration, Carnegie-Mellon University, working in the area of distributed project management.

Mr. Sathi is Senior Scientist at Carnegie Group, responsible for Intelligent Management Systems (IMS) applications to project and production management. Prior to joining the Carnegie Group, he was Project Leader of the CALLISTO project, an intelligent project management system developed at the Intelligent Systems Laboratory of the Robotics Institute, Carnegie-Mellon University.

Expert Systems, Tools

Director
Technical Development
Teknowledge, Inc.

SCOTT, Charles A.

M.S., Computer Science, Stanford University, 1974; B.S., Mathematics, College of William and Mary, 1973.

Director, Technical Development, Knowledge Engineering Services, Teknowledge, Inc. Software support, knowledge engineering supervision. Primary developer, Teknowledge Knowledge Engineering Methodology course. Development and maintenance of KS300 knowledge engineering tool; co-designer of S.1.

Expert Systems, Voice Recognition, AI Research, Resources

Program Manager
Information Process
Techniques Office
Defense Research Project
Agency

SEARS, Dr. Jay Allen

Ph.D., Information Systems, University of Arizona, Tucson, 1982; M.S., Finance, George Washington University, 1979; M.S., Computer Science, Naval Postgraduate School, Monterey, 1972.

Program Manager, Information Processing Techniques Office (IPTO), Defense Advanced Research Projects Agency, Arlington, Virginia (1984 to present).

Won outstanding military instructor award (1979). Computer Science instructor at U.S. Naval Academy, Annapolis, Indiana (1976–1979).

Research interests include: expert systems, voice recognition, AI research, resources, tools, and AI and database.

Expert Systems, Medical Applications of

Principal Developer
MYCIN
Stanford University

SHORTLIFFE, Dr. Edward H.

M.D., 1976; Ph.D., Medical Information Sciences, Stanford University, 1975; B.A., Mathematics, Harvard, 1970.

Associate Professor of Medicine and Computer Science, Stanford University. Principal developer of MYCIN medical expert system.

Dr. Shortliffe sits on the editorial boards of several medical computing and artificial intelligence publications. He has served on the Biomedical Library Review Committee of the National Library of Medicine and was recipient of a research career development award from that agency. He received the Grace Murray Hopper Award of the Association for Computing Machinery in 1976, and is a Henry J. Kaiser Family Foundation Faculty Scholar in General Internal Medicine. Author of over 80 articles and books in the field of medical artificial intelligence. Books include: *Computer-Based Medical Consultations: MYCIN* (Elsevier/North Holland), 1976; *Readings in Medical Artificial Intelligence: The First Decade*, with W. J. Clancey (Addison-Wesley), 1984; and *Rule-Based Expert Systems: The MYCIN Experiments of the Stanford Heuristic Programming Project*, with B. G. Buchanan (Addison-Wesley), 1984. (See bibliography.)

Research interests include: expert systems, evidential reasoning models, and representation techniques to support advanced explanation capabilities.

Exert Systems, Robotics, Natural Language, AI Software

Manager
New Technology Products
Vought Aeroproducts Division
LTV Aerospace and Defense

SKELTON, Dr. William A.

Ph.D. Computer Science Engineering, University of Texas, Austin, 1982; M.S., Computer Science, University of Texas, Austin, 1975; B.S., Chemical Engineering, University of Texas, Austin, 1948; B.A., Business Administration–management, 1962.

Dr. Skelton is Manager of New Technology Projects at Vought Aeroproducts Division, Industrial Modernization Department, at LTV Aerospace and Defense. He has been employed at LTV Aerospace for 33 years. He is presently establishing an AI program for the Vought Aeroproducts Division at LTV.

Research interests include: expert systems, robotics, natural language, AI software languages, AI workstations, voice recognition, and visual recognition.

Intelligent Computer-Aided Learning

SOLOWAY, Dr. Elliot

Ph.D., Computer Science, University of Massachusetts, 1978.

Assistant Professor in Computer Science at Yale University. Directs a research group building intelligent tutors and exploring AI approaches to software design, development and maintenance tools. In both areas, their method is a cognitive one: a cognitive model of how human experts perform a task (e.g., tutoring software design) leads to development of high-performance, computer-based systems. Dr. Soloway has published and lectured extensively on these topics. He received the distinguished teaching award while he was at the University of Massachusetts.

Expert Systems, Statistical Applications of

Founder
Green Valley Software
London

STEVENS, Dr. Anthony

Consultant. Founder of Green Valley Software (1981). Senior lecturer at the City of London Polytechnic (1971–1979).

Research interests include: statistical applications for expert systems.

Expert Systems

SWARTOUT, Dr. William R.

Ph.D., Computer Science, MIT, 1981.

Member of the Research Staff, Information Sciences Institute, University of Southern California.

Research interests include: programs that explain their own reasoning.

Expert Systems

Director
Clinical Decision Making Group
Computer Science Department
Laboratory
Massachusetts Institute of
Technology

Co-founder
Palladian Software

SZOLOVITS, Dr. Peter

Associate Professor of Computer Science and Electrical Engineering at MIT, and Director of the Clinical Decision Making Group within the MIT Laboratory for Computer Science.

Dr. Szolovits is head of the Medical Subgroup of AAAI, is editor of the book *Artificial Intelligence in Medicine*, and has written and lectured widely on computer-based decision aids. At MIT he is in charge of the Computer Science Graduate Program, and teaches a variety of artificial intelligence and programming language courses, including "Knowledge-Based Application Systems," which he has taught for the past ten years. He is also a co-founder of Palladian Software, a company producing commercial expert systems.

Research interests include: decision-making tools for clinical medicine, representation of knowledge, and improved tools for constructing knowledge-based systems.

Expert Systems

THISTED, Dr. Ronald A.

Ph.D., Stanford University, 1976; M.S., Statistics, Stanford University, 1973; B.A., Mathematics/Philosophy, Pomona College, 1972.

Associate Professor, Department of Statistics, University of Chicago.

Research interests include: expert systems. (See bibliography.)

Expert Systems, AI Research

Director
Expert Systems Laboratory
Institute of Safety and System Management
University of Southern California

TURBAN, Dr. Efraim

Ph.D., Operations Research, University of California, Berkeley, 1966.

Dr. Turban is a Professor of Systems and Science at the University of Southern California, and Director of the Expert Systems Laboratory at the Institute of Safety and System Management at the University of Southern California. He teaches courses in decision support and expert systems. Awards include a Management Science Roundtable National Award in Artificial Intelligence and Management. Author of *Decision Support and Expert Systems* (Macmillan, 1986), and other publications (see bibliography).

Research interests include: expert systems, AI research, integrating decision support and expert systems.

Expert Systems, AI Research

Principal Research Scientist
Artificial Intelligence Laboratory, MIT

WATERS, Dr. Richard

Ph.D., Computer Science (minor in Linguistics), MIT, 1978; M.S., Magna Cum Laude, Applied Mathematics (Computer Science), Brown University, 1972.

Principal Research Scientist, Artificial Intelligence Laboratory, MIT. Currently working on the Programmer's Apprentice project, developing a system to assist programmers to develop and maintain programs.

Invited lectures: SIGART/SIGPLAN Symposium on AI and Programming Languages; Bolt, Baranek & Newman; MIT; University of Maryland; Yale University; IBM Watson Research Center; Brown University; IJCAI-79; Carnegie-Mellon University; USC Information Sciences Institute; Xerox Palo Alto Research Center; Stanford University; Stanford Research Institute International; Systems Control, Inc.; Computer Corporation of America; IJCAI-81; Perkin-Elmer, Inc.; Second ACM SIGSOFT Software Engineering Symposium; General Electrical; Texas Instruments; Computer Aided Manufacturing; Computer*Thought Corporation; Softech; IBM Scientific Center Palo Alto; IBM Santa Teresa Programming Center; Daisy Systems Corporation; Air Force Studies Board of the National Academy of Sciences; ITT Advanced Technology Center.

Consulting: Brattle Research Inc., Perkin-Elmer, Inc.; Digital Equipment Corporation; Sanders Associates; Naval Electronics System Command (NAVELEX), Washington, DC.

Memberships include: ACM, SIGPLAN, IEEE, AAAI, Sigma XI Scientific Honorary Society. (See bibliography.)

Research interests include: programming languages and engineering problem solving.

Expert Systems, AI Tools, AI Software Languages

Senior Computer Scientist
California Intelligence

WEINSTOCK, Ray

B.S., Physics, 1969; M.S., Engineering, 1970; University of Washington.

Senior Computer Scientist at California Intelligence, San Francisco. Developed XSYS, a LISP-based generic expert system shell for IBM PC/XT/AT. The XSYS software incorporates advanced knowledge representation and manipulation techniques, and has been licensed by major U.S. corporations. Also engaged in knowledge engineering projects for banks in Belgium and France, and manufacturing companies in Great Britain and Spain. Consultant to the Brazilian Government.

Expert Systems, Medical Applications of

WEISS, Dr. Sholom M.

Ph.D., Computer Sciences, Rutgers University, 1974.

Associate Research Professor, Department of Computer Science, Rutgers University, and Senior Investigator, Medical Modeling and Decision-Making Group, Rutgers Research Resource on Computers in Biomedicine.

Research interests include: medical expert system applications.

Expert Systems, AI Research, AI Tools

Staff Consultant on
Electronics and Computer Science
FMC Corporation

WESCOURT, Dr. Keith

Ph.D., Cognitive Psychology, Stanford University, 1975; B.A. (Summa cum Laude), Psychology, Princeton, 1971. Phi Beta Kappa.

Dr. Wescourt is Staff Consultant in Electronics Engineering and Computer Science at FMC Corp. in Santa Clara, California. Previously, he was Senior Computer Scientist and Associate Branch Director of the Knowledge Systems Branch of Perceptronics, Inc. (1982–1984), Associate Computer Scientist in Information Systems at RAND Corporation (1979–1982), Assistant Director of Personnel and Training Research Programs in the Office of Naval Research (1978–1979), Consultant for Hewlett-Packard Laboratories (1977–1982), and Acting Assistant Professor of Psychology at the Institute for Mathematical Studies in the Social Sciences at Stanford University (1975–1979).

Research interests include: expert systems, AI research, AI tools, AI and expert systems for training and performance aiding, cognitive modeling of tactical planning and decision-making, and cognitive analysis of human-computer systems.

Memberships include: AAAI, Cognitive Science Society, American Association for the Advancement of Science, Sigma Xi, and Digital Equipment Corporation Users Society. Author and co-author of numerous publications (see bibliography).

Expert Systems

Director of Marketing
Syntelligence, Inc.

WHITE, Dennis G.

B.S., Engineering, Northwestern University, 1968; M.B.A., Washington University, 1968.

Director of Marketing, Syntelligence, Inc., Sunnyvale, California. AI experience has focused on (1) the identification and evaluation of financial expert system applications; (2) selling large-scale expert system development projects; and (3) planning and implementing expert system software product introductions to the banking and insurance industries.

Expert Systems, Natural Language, AI Tools

Co-founder and *Vice President*
Technology
Inference Corporation

Co-founder
LISP Machines, Inc.

WILLIAMS, Dr. Chuck

Ph.D., Computer Science, University of California, Irvine; M.S., Computer Science, University of California, Irvine; B.S., Computer Science, University of Southern California.

Dr. Williams is Vice President of Technology at Inference Corporation, and also a principal and founding member. He is responsible for the company's AI research and development, for new product design, and for general technology transfer to the company's commercial operations. Designed and developed Automated Reasoning Tool (ART), an AI system that provides a fundamental knowledge representation and problem-solving paradigm for use in advanced AI applications. Designed an

AI-based programming environment (ADE) for use with traditional computer languages on traditional hardware. Designed and implemented an Interlisp compatibility package for the LISP machine. Co-founded LISP Machines, Inc. (LMI) with Dr. Jacobson.

Dr. Williams served as adjunct professor of Computer Science at the University of Southern California and was research assistant for the Information Sciences Institute. While at USC/ISI, he participated in the design and development of the SAFE and HEARSAY-II systems. He has published papers on HEARSAY-II, natural language processing, and ART product manuals.

Research interests include: AI tools, expert systems, and natural languages.

Expert Systems, AI Research, AI Tools

WINSTON, Howard

Member of the professional staff in the Systems Science Department at Schlumberger-Doll Research in Ridgefield, Connecticut.

Research interests include: expert systems, AI research, and AI tools.

Expert Systems, Natural Language

Chief Scientist
Applied Expert Systems

WOODS, Dr. William A.

Ph.D., Applied Mathematics, Harvard University, 1967; M.A., Applied Mathematics, Harvard University, 1965; B.A., Mathematics and Physics, Ohio Western University, 1964.

Dr. Woods is Chief Scientist at Applied Expert Systems, Inc. He is noted for the development of the Augmented Transition Network model of grammar, and for his work in parsing and semantic interpretation of natural English questions.

Dr. Woods is Gordon McKay Professor of the Practice of Computer Science at Harvard University, where he teaches courses and supervises students in knowledge representation and language understanding. Previously an Assistant Professor at Harvard, teaching courses in Computability Theory, Information Retrieval, and Computational Linguistics; lecturer at Harvard and Massachusetts Institute of Technology.

Prior to joining Applied Expert Systems, Inc., he was a Principal Scientist at Bolt, Beranek, and Newman, Inc., where he was Manager of the Artificial Intelligence Department. Principal investigator for two projects on aspects of natural language understanding, funded by the Advanced Research Projects Agency (ARPA) and by the Office of Naval Research. Supervised a 5-year ARPA project in continuous speech understanding and a project for developing the Lunar Sciences Natural Language Information Systems (LUNAR) for the NASA Manned Spacecraft Center. Other projects include a study of reading for the National Institute of Education and a contract to investigate information system requirements for command-and-control decision making.

Dr. Woods' honors include a National Science Foundation Fellowship, a Fulbright Fellowship, Pi Mu Epsilon, and Phi Beta Kappa. Member of AAAI, ACM, the American Society for Information Science, the Association for Computational Linguistics, the National Research Council Panel on Applied Mathematics Research Alternatives for the Navy, and the National Research Council Committee on Computerized Speech Technologies.

Author of extensive papers and publications (see bibliography).

Research interests include: expert systems, natural language, natural communication between man and machine, intelligent computer systems, and understanding human intellectual processes.

Expert Systems, AI Resources, AI Tools

ZUBRICK, Steven M.

M.S., Atmospheric and Earth Sciences, Old Dominion University, Norfolk, Virginia, 1981; B.S., Physics (with Geology minor), University of Dayton, 1978.

Mr. Zubrick is a Meteorologist and Knowledge Engineer in the Expert Systems Group at Radian Corporation in Austin, Texas. Design, construction, and validation of an expert system (WILLIARD) to aid in severe thunderstorm forecasting. WILLIARD was built using RuleMaster, an expert system building tool. Mr. Zubrick has presented numerous papers on his work with expert system building to the National Weather Service Headquarters, the Environmental Research Laboratories of National Oceanic and Atmospheric Administration (NOAA), and to national scientific conferences (see bibliography).

Member of AAAI, Sigma Xi, Sigma Pi, American Meteorological Society, and American Geophysical Union.

Research interests include: expert systems, AI resources, and AI tools.

Automatic Theorem Proving, Automatic Programming

Automatic Theorem Proving, Expert Systems

ANDREWS, Dr. Peter B.

Ph.D., Mathematics, Princeton University, 1964; B.A., Mathematics, Dartmouth College, 1959.

Faculty, Departments of Computer Science and Mathematics, Carnegie-Mellon University, Pittsburgh, Pennsylvania. Interests include mathematic logic, high-order logic (type theory), and automated theorem proving. Dr. Andrews has taught in the Mathematics Department since 1963. Previously, he was a Research Mathematician at IBM (1962).

Dr. Andrews is author and co-author of numerous publications, including a book to be released in 1986, *An Introduction to Mathematical Logic and Type Theory: To Truth Through Proof* (Academic Press, 1986).

He has received eight NSF research grants. Member of Phi Beta Kappa, American Mathematical Society, Association for Symbolic Logic, Dozenal Society of America, American Association for the Advancement of Science, ACM, AAAI, and Association for Automated Reasoning.

Research interests include: development of an automated theorem-proving system for higher-order logic called TPS, and logic systems.

Automatic Programming, AI Research

Program Leader
Software Research
Schumberger-Doll
Ridgefield, Connecticut

BARSTOW, Dr. David R.

Ph.D. (with distinction), Computer Science, Stanford University, 1977; M.S., Computer Science, Stanford University, 1971; B.A., Mathematics, Carleton College, Northfield, Minnesota, 1969.

Dr. Barstow is Program Leader for Software Research at Schlumberger-Doll Research in Ridgefield, Connecticut. Member of the U.S. delegation to the first Sino-U.S. seminar on artificial intelligence at Beijing, China (June, 1984). Author of numerous publications and presentations, including two books, *Knowledge-Based Program Construction* (Elsevier-North Holland, 1979) and *Interactive Programming Environments*, edited with H. Shrobe and E. Sandewall (McGraw-Hill, 1984). (See bibliography.)

Dr. Barstow was a faculty member of the Department of Computer Science at Yale University (1977–1980).

Research interests include: AI research and automatic programming.

Automating the Design and Analyzation of Algorithms

KANT, Dr. Elaine

Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University.

Research includes: The Designer Project; project goals are to implement an AI program that designs a variety of algorithms and programs from specifications of the inputs and outputs. (For a more complete description of The Designer Project, see section on AI Schools, re: Carnegie-Mellon.)

Research interests include: understanding and automating the design and analyzation of algorithms, program synthesis and optimization, expert systems, computer-aided instruction systems, and programming environments.

Automatic Programming, Formal Models of Language

MOLL, Dr. Robert N.
Ph.D., Associate Professor, Computer and Information Science Department, University of Massachusetts at Amherst.

Research interests include: automatic programming, formal models of language, and theory of computation.

Automatic Theory Formation, Learning Systems

SRINIVASAN, Dr. Chitoor V.
D. Eng. Sc., Columbia. Faculty, Rutgers State University at New Brunswick, New Jersey.

Research interests include: automatic theory formation and learning systems.

Automatic Programming

TONG, Dr. Chris
Ph.D., Stanford. Faculty, Rutgers State University at New Brunswick, New Jersey 1985.

Research interests include: expert system models of the design process and machine learning.

Knowledge Representation

Knowledge Representation, Expert Systems, Decision Support Systems

ACOCK, Dr. Malcolm

Ph.D., Philosophy, University of British Columbia, 1977; M.A., Philosophy of Science, Indiana University, 1968; B.A., Philosophy, Leicester University, England, 1966.

Dr. Acock is a Research Scientist at Carnegie Group responsible for managing the FMS Scheduler/Controller Production Management System project. Prior to joining Carnegie Group, Dr. Acock was Professor of Philosophy, specializing in the theory of knowledge, philosophy of science and logic, at the University of Alabama in Birmingham.

Knowledge Representation

AMAREL, Dr. Saul

D.Eng. Sci., Columbia. Faculty, Rutgers State University at New Brunswick, New Jersey, 1985.

Research interests include: knowledge representation and modeling in problem solving.

Knowledge Representation

BERLINER, Dr. Hans

Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Research interests include: knowledge representation, theory of searching, problem solving using learned chunks, learning, and parallel chess move problem solving.

Knowledge Engineering

Vice President
Engineering Development
Teknowledge

BROWN, Dennis P.

Mr. Brown is Vice President, Engineering Development at Teknowledge, Palo Alto, California. He is a former Associate Chairman of the Computer Science Department at Stanford University. Member of the editorial board of the Teknowledge Series in Knowledge Engineering.

Knowledge Representation

BUNEMAN, Dr. Peter

Ph.D., Warwick. Associate Professor of Computer and Information Science, Pennsylvania University.

Research interests include: intelligent database systems, high-level languages, mathematical theories of problem solving and learning, and design and analysis of algorithms.

Knowledge Representation

Vice President
World Trade
Carnegie Group, Inc.

CHAMBERS, Michael G.
Vice President of World Trade at Carnegie Group, Inc. Seventeen years of international experience. Mr. Chambers previously directed the London-based operations of the Diebold Group, an international information technology company. He also acted as Executive Vice President of the MAK Holding Company and MWS Consultant, Inc., with offices and projects in over 40 countries on four continents. Mr. Chambers completed graduate work in Computer Science at the University of Houston.

Knowledge Representation, Computer-Based Medical Therapy Planning

FAGAN, Dr. Lawrence M.
Ph.D., Department of Computer Science and Department of Medicine; M.D., University of Miami; B.S., Computer Science, Psychology, Decision-Making, MIT. Faculty, Senior Research Scientist Associate, Department of Medicine.

Research interests include: computer-based therapy and knowledge representation.

Knowledge Representation

Director
Knowledge Systems R&D
IntelliCorp

FIKES, Dr. Richard
Ph.D., Carnegie-Mellon University.

Director of Knowledge Systems Research and Development at IntelliCorp. Dr. Fikes is one of the principal architects of IntelliCorp's KEE (Knowledge Engineering Environment) system.

Research interests include: knowledge representation, automatic planning, constraint satisfaction, and automatic deduction.

Knowledge Representation, Medical Systems in

GARFINKEL, Dr. David
Ph.D., Harvard. Professor of Computer and Information Science, University of Pennsylvania.

Research interests include: AI techniques in medicine, biomedical computing, simulation of metabolic processes, and computer-aided instruction.

Knowledge Representation, Expert Systems, Decision Support Systems

Director of Marketing
Carnegie Group, Inc.

GEER, Jack H.
Mr. Geer is Director of Marketing at Carnegie Group, Inc. (Pittsburgh, Pennsylvania). Over 19 years of experience in marketing and product planning and development. Mr. Geer recently served as North American sales manager for the Knowledge Engineering Division of McDonnell Douglas Information Systems Group, where his efforts led to the successful introduction of REVEAL, the first AI product suitable for financial applications on a distributed basis. Previous positions have included Vice President/Group Systems Manager, Bank of American Corporation; Marketing Manager for Volkswagon RBM; and Marketing Manager for Exxon/Vydec Systems.

Knowledge Engineering

HEWITT, Dr. Carl

Ph.D., MIT. Assistant Professor, Department of Computer Science, MIT.

Research interests include: knowledge engineering and semantics of computation.

Knowledge Engineering Tools

HORNIG, Dr. David

Ph.D., Computer Science, Carnegie-Mellon University, 1984; B.A., Applied Mathematics, Harvard University, 1976.

Dr. Hornig is Research Scientist at Carnegie Group in the area of knowledge engineering tools. Prior to joining Carnegie Group, he was a member of the Speech Understanding Project at Carnegie-Mellon University. His doctoral research involved application languages and distributed processing.

Knowledge Engineering

Chief Scientist
Carnegie Group, Inc.

KIM, Dr. Jin

Ph.D., 1985; M.S., 1980; B.S., 1978; Electrical Engineering, Carnegie-Mellon University. Recipient of the Xerox PARC Fellowship.

Dr. Kim is Chief Scientist at Carnegie Group, responsible for projects in the area of engineering design. He also holds the position of Visiting Assistant Professor in the Electrical and Computer Engineering (ECE) Department at Carnegie-Mellon University. Prior to joining Carnegie Group, Dr. Kim was responsible for the development of TALKIB, a knowledge-based system for designing layouts for integrated circuit chips. He was also involved in the CMU-DA project, a system for automating the process of designing computers.

Knowledge Representation, Theories of Intelligence

MINSKY, Dr. Marvin

Ph.D., Mathematics, Princeton University; B.A., Mathematics, Harvard University. Faculty, Artificial Intelligence Laboratory, MIT.

Dr. Minsky's Music Cognition Group investigates the cognitive foundations of musical behavior, to extract and represent expert knowledge about music by building computational models of the cognitive processes involved in composing, performing, and listening, and to investigate problem solving, reasoning, and knowledge representation.

Knowledge Representation

CEO,
Vice President of Finance
Carnegie Group, Inc.

Director
Pittsburgh High Technology Council

NICHOLSON, Richard

M.B.A., Rutgers School of Business.

Vice President of Finance and Administration, and Chief Financial Officer of Carnegie Group, Inc. Mr. Nicholson joined Carnegie Group after 20 years with Coopers and Lybrand, the international accounting firm, where he was partner in charge of emerging business and high technology services for the Pittsburgh office. He is also treasurer and a director of the Pittsburgh High Technology Council.

Knowledge Representation

Principal Reserch Scientist
Artificial Intelligence
Laboratory
MIT

RICH, Dr. Charles

Ph.D., AI, MIT, 1980; M.S., Electrical Engineering and Computer Science, MIT, 1975; B.S., Electrical Engineering, University of Toronto, 1973.

Principal Research Scientist, Artificial Intelligence Laboratory, MIT.

Invited lectures include: Digital Signal Processing Group; IBM T.J. Watson Research Center; Schlumberger-Doll Research Center; USC, Information Sciences Institute; UC Irvine; Computer Corporation of America; Stanford University; Xerox Palo Also Research Center Stanford Research Institute International; Systems Control, Inc.; Fairchild Instrument Company; Carnegie-Mellon University; University of Pennsylvania; Bolt, Beranek & Newman; MIT; and University of Toronto. Consulting on AI, expert systems and software engineering to: Computer Corporation of America, Cambridge, Massachusetts; Crowntek Investments, Inc., Toronto, Canada; GET Laboratories, Waltham, Massachusetts; Hazelcom, Inc., Toronto, Canada; Kestrel, Inc., Palo Alto, California; MITRE Corporation, Bedford, Massachusetts; Sanders Associates, Nashua, New Hampshire; Sperry Corporation, Waltham, Massachusetts; Westinghouse Electric Company, Hunt Valley, Maryland; RCA Government Systems Division, Cherry Hill, New Jersey; United Technologies Research Center, East Hartford, Connecticut.

Professional memberships include: ACM, IEEE, AAAI, CSCSI. (See bibliography.)

Research interests include: knowledge representation, reasoning, learning, automatic programming, expert systems, computer-aided design, high-level languages, software tools, and program verification.

Programming Languages and Software

Clark, Dr. K. L.
Clarke, Dr. Lori A.
Ellison, Dr. Robert
Forgy, Dr. Charles
Green, Dr. Cordell
Hass, Dr. Joel
Kedzierski, Dr. Beverly
Kornfeld, William A.
Kunze, Franz
Meehan, Dr. James
Miller, Dr. David
Modelski, Mitch
Morgan, Dr. Howard
Novak, Dr. Gordon
Sheil, Dr. Beau
Shrobe, Dr. Howard
Warren, M.D., Dr. David

Non-Deterministic Programming Notations, First Order Logic in

CLARK, Dr. K. L.

Ph.D., Computer Science, London University; B.A., Logic and Philosophy of Science, Cambridge; B.A., Mathematics, Durham University. Senior Lecturer in Computer Science, Imperial College, London.

Research interests include: applicative and non-deterministic programming notations, particularly first order logic; the decomposition of algorithms into an applicative program and execution strategy; the formal transformation and derivation of programs and predicate logic as a database description and query language.

AI Software Languages, Software Validation and Development

CLARKE, Dr. Lori A.

Ph.D. Associate Professor, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: AI software languages, programming languages, software validation, software development environments, and programming methodology.

Program Design and Programming Environments

ELLISON, Dr. Robert

Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Research interests include: program design and program environments; Gandalf project, an integrated system to support program development that includes a text editor, an incremental compiler and loader, and a structure for managing the project and maintaining system consistency among several programmers.

Rule-Based Programming Languages for Parallel Implementations

FORGY, Dr. Charles

Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Research interests include: rule-based programming languages (production systems), development of the OPS family of languages and in the construction of the interpreters for them, efficient uses of OPS languages in AI environments, parallel implementation of production systems, and special hardware utility.

AI Software Languages, Knowledge-Based Software Tools

Director and *Chief Scientist*
Kestrel Institute

GREEN, Dr. Cordell

Ph.D., Electrical Engineering, Stanford University, 1969; M.S., Electrical Engineering, Stanford University, 1965; B.A., Electrical Engineering, Rice University, 1963.

Dr. Green is Director and Chief Scientist of Kestrel Institute. Prior to forming Kestrel Institute, he was Chief Scientist and Program Manager of Computer Science at Systems Control, Inc. (SCI). He was responsible for coordinating computer science research projects at SCI and was the Principal Investigator for research in program synthesis. During 1976–1978, Dr. Green consulted for SCI in artificial intelligence, signal understanding systems, and connected speech recognition.

Dr. Green is a member of the editorial board of the *Journal of Automated Reasoning*. From 1977 through 1980, he was on the editorial board of *Cognitive Science*. During 1972–1979, he was the artificial intelligence editor for the *Journal of Association for Computing Machinery*. During 1971–1976, he served on the steering committee of the ARPA Speech Understanding Research Project. He is currently a Consulting Professor of Computer Science at Stanford University. From 1971 to 1978, he was Assistant Professor of Computer Science at Stanford University. During 1970–1971, he worked for the ARPA Information Processing Techniques Office as Research and Development Program Manager for artificial intelligence. From 1966 to 1969, he served as Research Mathematician in the Artificial Intelligence Group at Stanford Research Institute.

Dr. Green is a member of the Air Force Studies Board. He has consulted for Xerox Corporation, Stanford Research Institute, Electromechanical Laboratory (Japan), Philips Electrologica (The Netherlands), University of Edinburgh, Air Force Studies Board, Research Triangle Institute, and other organizations. (See bibliography.)

Research interests include: knowledge-based programming (automatic acquisition and synthesis of programs), problem solving, knowledge engineering, theory formation, and natural language understanding systems.

AI Software Languages, AI Tools, Expert Systems

Marketing Director
Franz, Inc.

HASS, Dr. Joel

Ph.D., Mathematics, University of California, Berkeley, 1981; B.A., Columbia University, 1976.

Dr. Hass is the Marketing Director of Franz, Inc., Alameda, California, developers of Franz LISP and Common LISP. He is co-author of Optisolve Mathematical Equations Package.

Dr. Hass was a Postdoctoral Fellow at Hebrew University of Jersalem (1981–1982), and Assistant Professor at the University of Michigan (1982–1984). He is a member of the Mathematical Sciences Research Institute at Berkeley, and he is a National Science Fellow (1984–1986).

Research interests include: AI software languages, AI tools, and expert systems.

Programming Languages and Software

Leader and
Chief Scientist
Software Project Management System
Carnegie Group

KEDZIERSKI, Dr. Beverly

Ph.D., Computer Science, USL and Stanford University, 1983; M.S., Computer Science, University of Southwestern Louisiana, 1980; B.A., Mathematics and Computer Science, Augustana College, Illinois, 1975.

Dr. Kedzierski is Chief Scientist at Carnegie Group in the area of project management and is leader of Carnegie Group's Software Project Management System project. Prior to joining Carnegie Group, Dr. Kedzierski was

computer scientist and corporate officer of the Kestrel Institute, an artificial intelligence company based in Palo Alto, California. She served as principal investigator and leader of the Project Management Assistant project.

Programming Languages and Software

Co-founder
Quintus Computer Systems

KORNFELD, William A.
Ph.D. in Computer Science from MIT.

Conducted research over several years at MIT in logic programming and related areas. Expert in PROLOG and LISP. Dr. Kornfeld left MIT in 1984 to co-found Quintus Computer Systems. Dr. Kornfeld has taught both PROLOG and LISP, and has lectured widely in the areas of artificial intelligence and logic programming.

AI Software Languages (Algorithms)

President
Franz, Inc.

KUNZE, Franz
M.A., Mathematics, University of California, Berkeley, 1979; A.B., Mathematics, University of California, Berkeley, 1976.

President of Franz, Inc., developers of Franz LISP and Common LISP. Development of programs for solving non-linear systems of ordinary differential equations using MACSYMA. (See bibliography.)

AI Software Languages, Natural Language, AI Research

Director of Research
Cognitive Systems, Inc.

MEEHAN, Dr. James
Ph.D., Computer Science, Yale University, 1976; M.Phil., Computer Science, Yale University, 1974; M.S., Computer Science, Yale University, 1972; B.S. (Cum Laude), Mathematics and Music Theory, Yale University, 1971.

Dr. Meehan is Director of Research at Cognitive Systems, Inc. in New Haven, Connecticut. He was Senior Research Scientist at the company from 1982–1984; Assistant Professor (1976–1982); and Associate Professor (1982–1984) at the University of California, Irvine; Visiting Assistant Professor, Computer Science Department, Yale University. Software Consultant for LISP and APL.

Author of 15 books, reference manuals, and papers on natural-language processing, AI, LISP programming, and computer music (see bibliography). Reviewer for 12 journals as well as conferences, foundations, and publishers. Member of ACM and the Society for Music Theory.

Research interests include: AI software languages, natural language, AI research, expert systems, and AI tools.

Programming Languages

MILLER, Dr. David
Ph.D., Carnegie-Mellon University.

Assistant Professor of Computer and Information Science, University of Pennsylvania. Semantics of programming languages; mechanical theorem proving.

Programming Languages and Software

President
Mitchell Associates

MODELSKI, Mitch
President of Mitchell Associates, distributor of LISP/PROLOG implementation for Prime Computer Systems.

Research interests include: AI software languages.

Programming Languages, Intelligent Databases

MORGAN, Dr. Howard

Ph.D., Cornell. Professor of Computer and Science, and Professor of Decision Sciences, University of Pennsylvania.

Research interests include: intelligent database systems and programming languages.

Programming Languages, Software

Director
Artificial Intelligence
Laboratory
University of Austin, Texas

NOVAK, Dr. Gordon

Ph.D., University of Texas, 1976.

Associate Professor of Computer Sciences and Director of the Artificial Intelligence Laboratory at the University of Texas at Austin. Dr. Novak has spent one year with the AI Center at SRI International and two years with the Heuristics Programming Project at Stanford. He has ten years of experience in systems programming and programming management in industry. He has taught courses in LISP at Stanford and the University of Texas, and has also taught courses in AI and Expert Systems. He is author of the ISAAC program, for solving physics problems stated in English, and the GLISP programming system.

AI Software Languages, AI Workstations, AI Tools

Manager
Product Development
Artificial Intelligence Systems
Xerox Corporation

SHEIL, Dr. Beau

Ph.D., Computer Science, Harvard University, 1976; B.A., Psychology, University of Sydney.

Manager, Product Development, Artificial Intelligence Systems, Xerox Corporation, Stanford, California since 1983. Previously, Dr. Sheil researched programming systems and the psychology of programming in the Intelligent Systems Laboratory at Xerox's Palo Alto Research Center (PARC); a developer of the Xerox 100 series of Artificial Intelligence workstations or LISP machines at PARC.

Research interests include: AI software languages, AI workstations, and AI tools. (See bibliography.)

Programming Languages and Software

Technical Director
Symbolics, Inc.

SHROBE, Dr. Howard

Ph.D. in Computer Science in 1978 from the MIT Artificial Intelligence Laboratory.

Dr. Shrobe is currently a part-time lecturer and research scientist at MIT and a technical director at Symbolics, Inc. in Cambridge, Massachusetts. Dr. Shrobe is an experienced user of the Symbolics 3600 LISP Machine programming environment.

Research interests include: design of AI-oriented hardware and the use of AI techniques in computer-aided design.

Programming Languages and Software, Natural Language

Founder and
Chief Technical Officer
Quintus Computer Systems

WARREN, Dr. David M.D.

Ph.D. in Artificial Intelligence from Edinburgh University.

Author of the world's first PROLOG compiler, which forms part of the DEC-10 PROLOG system. His other areas of research, conducted at Edinburgh University and SRI International, include natural language access to databases and computer architectures for PROLOG. He is the founder and Chief Technical Officer of Quintus Computer Systems, Palo Alto, California. Dr. Warren has given numerous lectures and tutorials on PROLOG in the United States, Japan, and Europe.

Learning, Knowledge Acquisition

Learning

CARR III, Dr. John W.
Ph.D., MIT. Professor of Computer and Information Science, University of Pennsylvania.

Research interests include: learning, problem solving, and applications of microprocessors.

Learning

GRAY, Dr. Harry J.
Ph.D., Pennsylvania. Professor of Computer and Information Science, and Professor of Electrical Engineering and Science, University of Pennsylvania.

Research interests include: learning theories, neural models, logic design of integrated circuits, computer architecture, and computer hardware design.

Learning

JOHNSON, Dr. Paul E.
Ph.D., Johns Hopkins University, 1964.

Professor of Management Sciences and Psychology, and Faculty of Center for Research in Human Learning, University of Minnesota.

Research interests include: complex decision environment methodology, expert problem solving in management, medicine, engineering, and law.

Learning

LANGLEY, Dr. Pat
Ph.D., Psychology, Carnegie-Mellon University, 1979.

Associate Professor in the Department of Information and Computer Science at the University of California, Irving.

Dr. Langley has published widely in the area of learning, and he is Executive Editor of the new journal *Machine Learning*.

Before coming to UCI, Dr. Langley was a Research Scientist at Carnegie-Mellon University's Robotics Institute. He has taught courses in artificial intelligence, and graduate seminars on machine learning.

Computer-Assisted Learning, Programming Language Modeling

Chairman
Computer-Assisted Learning Research Group
Institute of Educational Technology
Open University, United Kingdom

Chairman
AISB

O'SHEA, T.
Lecturer, Institute of Educational Technology, Open University. Also Chairman of the University's Computer-Assisted Learning Research Group. He has also been involved in AI education application research at the University of Edinburgh, University of Texas, and Leeds University.

Dr. O'Shea is Chairman of AISB, and a former editor of the AISB Quarterly.

Research interests include: user models of programming languages, computational models of mathematical competence, and evaluation methods in computer-assisted learning.

Learning

SUSSMAN, G.
Faculty, Department of Electrical Engineering and Computer Science, Purdue University.

Research interests include: learning, problem solving, programming, and computational performance models for intelligent behavior.

Computer Applications in Medical Education

Assistant Director
American Board of Internal Medicine
Philadelphia

SWANSON, David B.
Ph.D., Educational Psychology, University of Minnesota, 1978.

Assistant Director, American Board of Internal Medicine, Philadelphia.

Research interests include: computer applications in medical education, clinical decision-making, and measurement of clinical efficiency.

Learning

Director
Artificial Intelligence Laboratory
Massachusetts Institute of Technology

WINSTON, Dr. Patrick H
Ph.D. Faculty, Director of the Artificial Intelligence Laboratory, Massachusetts Institute of Technology.

Dr. Winson's theory of reasoning by analogy consists of: an English-understanding module that converts prepared text into relations in a semantic network; a cause-dominated matcher that finds the best possible correspondence according to the causal framework determined by the situations themselves; an analogizing module that reaches conclusions about a given situation by using a remembered precedent; and a rule builder that constructs if-then rules.

Dr. Winston extended the theory to the problem of learning what things look like from functional definitions, prior knowledge, and particular examples.

Books published include: *Artificial Intelligence*, second edition (Addison-Wesley); *LISP*, second edition, with Berthold K. P. Horn (Addison-Wesley); *The AI Business: The Commercial Uses of Artificial Intelligence*, with Karen A. Prendergast (MIT Press).

Intelligent CAI

WOOLF, Beverly
AI Researcher, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: intelligent computer-assisted instruction.

Dynamic Modeling Language Parser, Distributed Systems

YANGHONG, Wang
AI Researcher, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: dynamic modeling language parser, and distributed system with dynamic structure (written by DYMOL) simulator on VAX.

Educational Computing Applications

YAZDANI, Masoud
B.Sc., Essex University, 1978. Lecturer in the Computer Science Department, Exeter University, 1981.

Research interests include: educational applications.

Natural Language

Natural Language

ASHOK, Mahalakshmi

M.S., Operations Research and Statistics, Rensselaer Polytechnic Institute, Troy, New York, 1979–1981.

Mr. Ashok is a Research Scientist at Cognitive Systems Inc. in New Haven, Connecticut. Previously, he was a computer programmer at Yale University (1982–1983). He worked on the generation of natural language from a MOP representation at Yale, and he developed rules to parse natural language into a rational representation. Designed and developed the integrated Pattern-Matching Parser for Easytalk at Cognitive Systems.

Research interests include: natural language.

Natural Language, AI Research, ICAI

Project Manager
Bolt, Beranek, and Newman

BATES, Dr. Madeleine

Ph.D., Applied Mathematics, Harvard University, 1975; M.A., Applied Mathematics, Harvard University, 1969; B.S., Mathematics, Carnegie-Mellon University, 1968.

Dr. Bates is Senior Scientist at BBN Laboratories, Cambridge, Massachusetts (1980–1985). She was a scientist at Bolt, Beranek, and Newman, Incorporated (1971–1980); Assistant Professor of Mathematics, Boston University (1975–1978); Research Assistant at Harvard University (1974–1975); Teaching Fellow at Harvard University (1971–1972); and technical writer, Datanamics, Inc. (1970–1971).

Dr. Bates has had more than a decade of research experience in many aspects of artificial intelligence and computational linguistics. Member and leader of various research groups. Developed systems in such diverse areas as speech understanding, text generation, computer-assisted instruction, interfaces to databases, and human factors. Currently Project Manager of a ten-person team developing an artificial intelligence software product, the RUS system, a transportable natural language front end for database query, including system design, implementation group management, and coordination.

Design and implementation of the syntactic component of an automatic speech understanding system at Bolt, Beranek, and Newman, Inc. (sole responsibility for, 1971–1975). Member of a group developing an interactive help system for users of a message system on the ARPANET and a group assessing the potential utility of artificial intelligence techniques for the problem of naval situational assessment. Produced a natural language front-end for an instructional system to teach causal knowledge; designed

and implemented a human factors test and evaluation facility for the Social Security Administration; co-directed a three-year project funded by the Office of Special Education to develop a computer-assisted instruction system using artificial intelligence techniques; developed lexical and semantic acquisition procedures for nonexperts to use in building knowledge bases for the RUS system; principal investigator of a project for the National Library of Medicine concerned with knowledge base display and access; consultant.

Professional activities include: President, Association for Computational Linguistics (1985); Book Review Editor, *American Journal of Computational Linguistics*; Associate Editor, *AI Magazine*; member of American Association for Artificial Intelligence, Cognitive Science Society, Association for Computing Machinery, Association for Computational Linguistics, and American Association for the Advancement of Science; Program Committee Chairperson, Annual Meeting of the Association for Computational Linguistics (1982); Advisory Board Member, Late Entry Accelerated Program (NSF-sponsored), Boston University School of Engineering (1981–1982); invited participant in the Applied Computation Linguistics in Perspective Workshop, sponsored by the Naval Research Laboratory and the National Science Foundation, Stanford University (1981); Johns Hopkins University First National Search Merit Award (1981); testified at Joint Hearings before the Subcommittee on Science, Research, and Technology, and the Subcommittee on Select Education, House of Representatives (1980).

Research interests include: natural language, AI research, and intelligent computer-assisted instruction (ICAI).

Learning, Natural Language Syntax Acquisition in

BERWICK, Dr. Robert C.

Ph.D. Faculty, Artificial Intelligence Laboratory, MIT.

Preliminary work in progress concerns linking the word-learning program to the existing syntax-learning program.

New representational formats for grammars were investigated so that previously difficult constructions using conjunctions like "and" can be easily handled. This analysis does not use conventional syntactic trees, but relies on set representations. This new representation may solve many computationally difficult problems in the syntactic analysis of natural language.

Research interests include programs that can acquire the meanings of new words as a network of causal relationships in small database story plots.

Books published include: *The Grammatical Basis of Linguistic Performance*, with Amy Weinberg (MIT Press).

Robust Natural Language Interface, Knowledge Representation

CARBONELL, Dr. Jamie

Co-founder
Carnegie Group, Inc.

Director
Natural Language
Processing Project
Carnegie-Mellon University

Ph.D. Associate Professor of Computer Science and Director of the Natural Language Processing Project at Carnegie-Mellon University.

Co-founder of Carnegie Group. Dr. Carbonell was Project Leader for XCALIBUR, a robust natural language interface to expert systems and databases, and SMOKEY, a real-time sensor-based fire diagnosis system.

Books include: *Subjective Understanding: Computer Models of Belief Systems*; multi-volume series entitled, *Machine Learning*.

Chairman of SIGART (the Special Interest Group in Artificial Intelligence of the ACM).

Research interests include: analogical reasoning, natural language processing, machine learning, planning in adversary situations, knowledge representation, expert systems, AI research, and AI tools.

Natural Language, AI Research, Expert Systems, AI Software

Director of Marketing
Cognitive Systems, Inc.

DRINAN, Ann L.
M.A., International Relations, Yale University, 1976; B.A. (Cum Laude), University of Wisconsin, 1972.

Director of Marketing at Cognitive Systems, Inc. in New Haven, Connecticut. Previously Director of Publications and Publicity at the Yale University AI Laboratory (1977–1980). Editor, *Proceedings of the International Joint Conference on AI* at Vancouver, B.C. (1980–1981); Editor, numerous AI books and dissertation (see bibliography).

Research interests include: natural language, AI research, expert systems, and AI software languages.

Natural Language Processing, Computer Vision

FININ, Dr. Timothy
Ph.D., Illinois. Assistant Professor of Computer and Information Science, University of Pennsylvania.

Research interests include: natural language processing, computer vision, and software engineering.

Natural Language, AI Research, Expert Systems

Founder and *President*
Cognitive Systems, Inc.

Chairman
Computer Science Department
Yale University

FOX, Dr. David
Ph.D., Mathematics, New York University, 1961.

Dr. Fox is President and Founder of Cognitive Systems, Inc. in New Haven, Connecticut, and Chairman of the Computer Science Department at Yale University. Dr. Fox previously was President of Container Transport International (CIT), a lessor of marine cargo containers; and was previously a Director and Executive Vice President of Gelca Corporation, CIT's parent company.

Dr. Fox has been active in the computer field since the mid-1950's. He founded Fox Computer Services, a consulting firm, after he received his doctorate in 1961. Designed a computer system for tracking, controlling, and forecasting the international movement of containers for CTI (1970) and became President of the company in 1971. During his 11-year tenure in office, his accomplishments include the increase in company revenue from $17 million to more than $182 million, the pioneering use of operating leases, the opening of Russia to container leasing in 1972, and the agreement to establish the first marine container factory in the People's Republic of China in 1979.

Research interests include: computer modeling and simulation, natural language, AI research, and expert systems. Numerous publications (see bibliography).

Natural Language, Expert Systems, AI Research

Vice President of Technology
Cognitive Systems, Inc.

GERSHMAN, Dr. Anatole
Ph.D., Computer Science, Yale University, 1979; M.S., Mathematics, Moscow State Pedagogical Institute, 1971.

Dr. Gershman is Vice President of Technology at Cognitive Systems, Inc. He was previously at Schlumberger-Doll Research Center as researcher and developer in applications of AI techniques to geology and signal processing (1980–1982), and at Bell Laboratories as a technical researcher in

natural language processing and man-machine interfaces. Research Assistant, Yale University AI Project (1975–1979); Technical Staff, International Communication Sciences (1973–1975); Research Assistant, AI Project, University of California, Los Angeles, School of Engineering (1973–1975).

Research interests include: natural language, expert systems, and AI research. (For publications, see bibliography.)

Natural Language, Knowledge Acquisition via

GOMEZ, Dr. Fernando

Ph.D., Computer Science, 1981; M.A., Romance Linguistics, Ohio State University, 1974; Licenciature, Phil., University of Valencia, Spain, 1972.

Assistant Professor of Computer Science, University of Central Florida.

Research interests include: natural language knowledge acquisition.

Natural Language, Robotics

HAAS, Norman

M.S., Computer Science, Stanford University, 1978; B.S., Physics, State University of New York, Stony Brook, 1970.

Mr. Haas is Senior Computer Scientist at Symantec. Previously, he was a member of the robotics group at the Stanford Artificial Intelligence Laboratory, before joining a natural language research program at Stanford Research Institute (SRI).

Contributing author, *Machine Learning, An Artificial Intelligence Approach* (Tioga, 1983).

Research interests include: natural language and robotics.

Natural Language, AI Software Languages, AI Research

President and *Director*
Artificial Intelligence Corporation

HARRIS, Dr. Larry R.

Ph.D., Computer Science, Cornell University, 1972.

President and Director, Artificial Intelligence Corporation (AIC). INTELLECT is the culmination of Dr. Harris's professional career as a research computer scientist. Dr. Harris's early studies involved a unique natural language parsing technique that has become the foundation of INTELLECT. INTELLECT is currently in use at 300 organizations worldwide. During his tenure as Professor of Computer Science at Dartmouth College in 1975, Dr. Harris founded AIC to develop a commercially-marketable product based on his research.

As the original author of INTELLECT, Dr. Harris's early contributions to AIC were primarily in a technical capacity. Over the years, as the corporation and product evolved, he has taken on higher-level responsibilities by addressing the financial and marketing issues involved in bringing INTELLECT to the marketplace.

Dr. Harris has acted as a consultant for a number of companies, including IBM. He was a visiting professor at MIT. He has been invited to lecture on artificial intelligence and natural language technology throughout North America, Europe, Japan, Australia, Brazil, and the Soviet Union.

Natural Language Processing

HAYES, Dr. Philip

Docteur es Sciences (Ph.D.), Computer Science, Ecole Polytechnique Federale de Lausanne, Switzerland, 1977; M.A., Artificial Intelligence, University of Edinburgh, Scotland, 1973; DIC, Computer Science, Imperial College, London, 1971; B.A., Mathematics, University College, Oxford, England, 1970. Faculty, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Dr. Hayes is Chief Scientist at Carnegie Group, responsible for developing natural language interpreters. Prior to joining Carnegie Group, he was Assistant Professor of Computer Science and Research Computer Scientist at Carnegie-Mellon University.

Research interests include: robust natural language processing, flexible construction-specific parsing; error recovery and negotiation; conversational modeling; COUSIN, a COoperative USer INterface, explanation and help facilities; and higher-level commands, continuity mechanisms, graphically-oriented form specification.

Natural Language, Knowledge Representation

Founder and *President*
Symantec, Inc.

HENDRIX, Dr. Gary G.

Ph.D., University of Texas, Austin, 1975; M.S., University of Texas, Austin, 1970; B.A., University of Texas, Austin, 1970.

Dr. Hendrix is President and founder of Symantec, Inc. Previously, he was Director of the Natural Language Research Program at SRI International and Manager of Natural Language Research Development at Machine Intelligence. Contributing author, *Machine Learning, An Artificial Intelligence Approach* (Tioga, 1983).

Research interests include: natural language and natural language semantics, parsing systems, pragmatic and linguistically motivated grammars, knowledge representation structures (particularly semantic networks), computational systems for knowledge acquisition and question answering, and knowledge representation.

Natural Language, Cognitive Science

HIRST, Dr. Graeme

Ph.D., Computer Science, Brown University, 1984; M.S., Engineering Physics, Australian National University, 1980; B.A. and B.S., Information Science and Mathematics, Monash University, Australia, 1973.

Dr. Hirst is Assistant Professor of Computer Science at the University of Toronto, Canada. Editor of *Canadian Artificial Intelligence*, a magazine, and Book Review Editor, *Computational Linguistics* (1984–1985). Author of two books, an award-winning paper, and other publications (see bibliography).

Research interests include: natural language understanding, cognitive science, and cognitive modeling.

Natural Language, Expert Systems, AI Software Languages

JOHNSON, Peter N.

M.S., Computer Science, Yale University, 1982; B.S., Computer Science, University of Illinois, 1979.

Mr. Johnson is a Research Scientist at Cognitive Systems. Currently, he is designing an expert business advisory system with a natural language front-end. Researcher in natural language with Roger Schank at Yale

University (1979–1982) before working at Dr. Schank's companies (Cognitive Systems and Intelligent Business Systems); Director of Artificial Intelligence at Intelligent Business Systems; Chief Designer of the Easytalk System, a natural language query system for accounting databases (a product sold by Intelligent Business Systems); Consultant, International Business Machines Corp. (IBM) (1977); Junior Scientist, IBM (1978); Consultant, Real World Software, Inc. (1979).

Research interests include: knowledge representation, expert memory modeling, natural language, AI software languages, and AI tools.

Natural Language

Chairman
Computer and Information Science Department
University of Pennsylvania

JOSHI, Dr. Aravind K.

Ph.D., Pennsylvania. Professor of Computer and Information Science, and Chairman of the Computer and Information Science Department, School of Engineering and Applied Science, University of Pennsylvania.

Natural language processing, natural language design, integrated systems for language and vision, and mathematical linguistics.

Research interests include: natural language parsing, semantic interpretation, discourse structure and processing, natural language generation, theory of computing in relation to natural language, natural language interfaces for expert systems and knowledge bases.

Program Chairman, IJCAI-85.

Natural Language, Knowledge Engineering, Expert Systems

KULICH, Dr. Karen

Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University.

Research interests include: natural language and expert systems; identification of regularities that exist across domains, so that those regularities can be made into more general computational procedures that embody theories of discourse processing. A knowledge-engineering approach to natural language processing applied to expert systems.

Natural Language

LEBOWITZ, Dr. Michael

Ph.D., Yale, 1980; S.B., MIT, 1975. Assistant Professor in the Department of Computer Science, Columbia University.

Professor Lebowitz has a wide range of teaching and research experience in Artificial Intelligence. In the past five years, he has taught introductory Artificial Intelligence to both undergraduate and graduate students, as well as courses in natural language processing and cognitive science. He was named Henry M. Singer Assistant Professor for 1984–1985 for his commitment to quality education. He has been involved in teaching AI short courses for AT&T Bell Laboratories and Atari Research Laboratory.

Professor Lebowitz's research interests lie primarily in the areas of natural language processing, machine learning and cognitive modeling, in which he has published extensively. He has served as a technical consultant for a New York law firm, numerous major publishers, and a media foundation.

Natural Language, Machine Translation

LYTINEN, Dr. Steven L.

Ph.D., Computer Science, Yale University, 1984; M.S., Computer science, 1981; B.S., Electrical Engineering/Mathematical Science, 1979.

Dr. Lytinen is a Senior Research Scientist at Cognitive Systems, Inc. in New Haven, Connecticut, where he specializes in natural-language understanding and knowledge representation. Research Assistant at Yale University in the Department of Computer Science, primary research: machine translation and natural language understanding (1980–1984); Teaching Assistant, Computer Science Department, Yale University (1980–1981); Computer Programmer, Anderson-Clayton Company (1979); Programmer and Research Assistant at Argonne National Laboratory (1978); and Research Assistant at Rice University in the Department of Electrical Engineering (1978). (See bibliography.)

Research interests include: natural language and machine translation.

Natural Language Processing, AI Programming Environments

MacDONALD, Dr. David A.

Ph.D. Assistant Professor, Computer and Information Science Department, University of Massachusetts at Amherst.

Research interests include: natural language processing and AI processing.

Natural Language, Expert Systems, Knowledge Representation

MAZLACK, Dr. Lawrence J.

D.Sc., Computer Science, Washington University, St. Louis, 1973; M.Sc., Computer Science, Washington University, St. Louis, 1972; M.Sc., Electrical Engineering, 1966; B.S.E.E., Electrical Engineering, Marquette University.

Director, graduate program. Consultant, natural language interfaces and expert systems.

Research interests include: natural language, expert systems, fuzzy systems, and knowledge representation and conceptualization.

Natural Language, Expert Systems, AI Research

Director
Business Development
Cognitive Systems, Inc.

NELSON, Ruth A.

M.Mgt. (highest honors), Management, Simmons College, 1983; A.B.D., Master of Arts and Master of Philosophy in American Studies, 1972, 1975; B.A. (Summa cum Laude), English Literature, Brown University, 1968.

Director of Business Development at Cognitive Systems, Inc. in New Haven, Connecticut. Management of sales of artificial intelligence software for financial services and investment industry (1983–1985). Business Analyst, Wang Laboratories (1983). Developed and implemented a modeling system for processing and reporting booking data for market analysis and forecasting. Marketing Consultant, Digital Equipment Corporation, Corporate Research and Architecture. Team leader for research on advanced equipment design project, new products recommendations. Director of Marketing, Cognitive Systems, Inc. (1982); Script Consultant, Media Design Studio (1980–1981); Public Relations Coordinator, Media Design Studio (1977); Film Designer, Media Design Studio (1976); Instructor, American Studies Program and American Film History, Yale University (1972–1973); Discussion leader, American Literature and American Art History, Yale University (1972–1980). Publications (see bibliography).

Research interests include: natural language, expert systems, and AI research.

Natural Language, Knowledge Acquisition, Robotics

PEREIRA, Dr. Ferando C. N.

Ph.D., Artificial Intelligence, University of Edinburgh, 1982; M.Sc., Mathematics, University of Lisbon, 1975.

Senior Computer Scientist at the Artificial Intelligence Center of SRI International. A Principal Researcher at the Center for the Study of Language and Information, Stanford University, researching robot knowledge and action. Also worked and published in logic programming, PROLOG implementation and computer-aided design.

Research interests include: natural-language knowledge acquisition.

Natural Language Parsing and Generation, Expert Systems

PUSTEJOVSKY, James

AI Researcher, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: natural language parsing and generation, and natural language interfaces for expert systems.

Natural Language, Parallel Computation, AI Research

SABOT, Gary

M.S., Computer Science, Harvard University, 1985

A developer of the TMC Indexer, which produces an index from unformatted natural language text. Wrote intelligent stock market analysis program (the TTMII Stock Market Analysis System) for Sabtek Corporation.

Research interests include: natural language, parallel computation, and AI research.

Natural Language, AI Research, Expert Systems

Founder, Chairman
and *President*
Cognitive Systems

Chairman
Computer Science Dept.
Yale University

Director
Artificial Intelligence Dept.
Yale University

Founder
Cognitive Science Journal

SCHANK, Dr. Robert C.

Ph.D., Linguistics, University of Texas, Austin, 1969; M.A., Linguistics, University of Texas, Austin, 1967; B.S., Mathematics, Carnegie-Mellon University, 1966; M.A. (honorary), Yale University, 1976.

Dr. Schank is Chairman of the board of Cognitive Systems, Inc., as well as Chairman of the Board at Yale University Computer Science Department. Professor of Computer Science and Psychology, Yale University (1976–1985). Previously, President of Cognitive Systems, Inc. (1979–1983); Associate Professor of Computer Science and Psychology, Yale University (1974–1976); Research Fellow, Institute for Semantics and Cognition, Castagnola, Switzerland; Assistant Professor of Linguistics and Computer Science, Stanford University (1969–1974); Research Associate, Computer Science Department, Stanford University (1968–1969); Engineer/Scientist, Semiotics Group, Tracor (1966–1968).

Dr. Schanks professional activities include membership on the editorial boards of *Cognitive Science*, *Information Systems*, *Pragmatics*, *Discourse Processing*, *The Brain and Behavioral Science*, and *Experimental Psychology, Human Learning and Memory*. He is on the governing board of the Cognitive Science Society. He is the author of numerous books and papers (see bibliography).

Research interests include: natural language, AI research, and expert systems.

Natural Language Computations, Fuzzy Sets, Risk Analysis

SCHMUCKER, Dr. Kurt J.

Ph.D., Computer Science, George Washington University (in completion); M.S., Michigan State University and Johns Hopkins University; B.S., Michigan State University.

Computer Research Scientist with the United States Department of Defense, Washington, DC. Author of the book, *Fuzzy Sets, Natural Language Computations, and Risk Analysis* (Computer Science Press).

Research interests include: computer graphics, computational linguistics, computer security, and technology forecasting.

Natural Language, Expert Systems, AI Research, AI Tools

Vice President
Software Development
Cognitive Systems, Inc.

SHWARTZ, Dr. Steven P.

Ph.D., Cognitive Psychology, Johns Hopkins University, 1979; M.A., Cognitive Psychology, Johns Hopkins University; B.A., Psychology, New College, Sarasota, Florida, 1974.

Dr. Schwartz is Vice President, Software Development at Cognitive Systems, Inc. Postdoctoral Research Associate in Artificial Intelligence at Yale University (1979–1981); Psychology Instructor at Johns Hopkins University and Towson State University (1978); Statistics Instructor, Towson State University (1977); APL Programming Instructor, Johns Hopkins University (1976); Computer Programmer, Office Computer Corporation (1974–1975); Research Assistant at New College (1972–1974).

Dr. Schwartz received a National Institute of Mental Health Graduate Fellowship and a National Science Foundation Graduate Fellowship at Johns Hopkins University, as well as an Alfred P. Sloan Postdoctoral Fellowship at Yale University. He has written numerous papers on cognitive science, visual imagery, and other topics in AI (see bibliography).

Research interests include: natural language, expert systems, AI research, AI tools, and AI resources.

Natural Language, AI Research, Knowledge Representation

SIDNER, Dr. Candace L.

Ph.D., Computer Science, Massachusetts Institute of Technology, 1979; M.S., Computer Science, University of Pittsburgh, 1975; B.A. (Cum Laude), Mathematics, 1971.

Dr. Sidner is Senior Scientist in the Artificial Intelligence Department of Bolt, Beranek, and Newman, Inc. (BBN Laboratories) (1979–1983). Previously, a Research Scientist in the Artificial Intelligence Center at SRI International (1978) and a Research Assistant in the Artificial Intelligence Laboratory at Massachusetts Institute of Technology (1974–1979).

Principal Investigator at BBN Laboratories of the ARPA Knowledge Representation for Natural Language Understanding Project. Implemented the prototype system developed for this project, primarily in work on anaphora interpretation. Implementation of semantic and discourse components, concentrating on natural language, at MIT. Headed MIT AI Laboratory's Natural Language Seminars for one year. Joined SRI International to implement rules for pronoun interpretation in the Task Dialogue Understanding Project.

Extensive publications (see bibliography) and presentations. Member of AAAI, Association for Computational Linguists, ACM, Women in Science and Engineering, and Alpha Lambda Delta.

Research interests include: natural language, AI research, knowledge representation, planning for natural language, knowledge representation for planning and discourse, and models of discourse which coordinate understanding of reference, anaphora, and speaker's meaning.

Natural Language, Expert Systems, AI Research

SPRINGER, Stephen R.

B.A. (Magna cum Laude), Computer Science, Brown University, 1983. Phi Beta Kappa, 1982.

Mr. Springer is a Research Scientist at Cognitive Systems in New Haven, Connecticut, where he is designing and implementing Easytalk I, a business accounting system with an expert natural language front-end.

Research interests include: all aspects of computer-aided instruction and psycholinguistic research, natural language, expert systems, and AI research.

Natural Language Processing

Director
Symbolic Processing Research Group
Texas Instruments

TENNANT, Dr. Harry

Ph.D., M.S., Informational Engineering and Computer Science, University of Illinois.

Director, Symbolic Processing Research Group, Texas Instruments. Researching natural language interfaces, developed the concept of menu-based natural language understanding systems.

Recently selected one of 100 Outstanding Scientists Under Age 40, by Science Digest Magazine.

Author of *Natural Language Processing: An Introduction to an Emerging Technology.*

Natural Language, Voice Recognition, Expert Systems

TOMITA, Dr. Masaru

Ph.D., Computer Science, Carnegie-Mellon University, 1985; M.S. Computer Science, Carnegie-Mellon University, 1983; B.S., Mathematics, Keio University, Tokyo, Japan, 1981.

Dr. Tomita is a consultant for Carnegie Group, Inc. on Japanese user interface, as well as a consultant for Sumitomo Electric Company in Osaka, Japan, regarding its knowledge-based system developing tool. Previously, Dr. Tomita worked on the English-Japanese Machine Translation Project at Kyoto University in Kyoto, Japan (1984).

Dr. Tomita has published numerous papers, primarily on natural language and machine translation (see bibliography).

Research interests include: natural language, voice recognition, and expert systems.

Natural Language

VAN LEHN, Dr. Kurt

Ph.D., Computer Science, MIT, 1983.

Research Associate at the Xerox Palo Alto Research Center in a laboratory that applies AI to problems in training, user interfaces, natural language, and other fields. Dr. Van Lehn has lectured widely on education applications of AI, as an invited speaker at various universities and conferences. Previously, he was involved in building the BUGGY and DEBUGGY systems, and testing them on several thousand students around the world.

Natural Language, Information Science, AI Research

District Manager
Artificial Intelligence
and Information
Science Research
Bell Communications Research

WALKER, Dr. Donald E.

Ph.D., Psychology, University of Chicago, 1955.

Dr. Walker is District Manager of Artificial Intelligence and Information Science Research at Bell Communications Research in Morristown, New Jersey. Previously at SRI International, where he was a Program Manager (1983–1984) and Senior Research Linguist (1971–1983), and MITRE Corporation, where he was head of Language and Text Processing. Research Psychologist, Veterans Administration Hospital (1957–1961) and Assistant Professor of Psychology at Rice University (1953–1961). Yale University Social Science Research Council Fellow in Linguistics.

Dr. Walker is on ten editorial boards, including those of *American Journal of Computational Linguistics* (as Managing Editor), *Annual Review of Information Science and Technology*, *Artificial Intelligence, An International Journal*, *Linguistica Computazionale*, *Computers and the Humanities*, *Data and Knowledge Engineering*, *Encyclopedia of Artificial Intelligence*, *International Forum on Information and Documentation*, *Linguistic Calculation*, *Sprache und Datenverarbeitung*, and *Studies in Natural Language Processing*. Author of more than 50 publications on AI, linguistics, psychology, and anthropology topics.

Research interests include: natural language, Information Science, AI research, expert systems, AI resources, AI workstations, AI tools, voice recognition, and computational linguistics.

Natural Language, Visual Recognition, Expert Systems, Robotics

WALTZ, Dr. David L.

Ph.D., Electrical Engineering and Artificial Intelligence, 1972; S.M., E.E., Electrical Engineering, Massachusetts Institute of Technology; S.B., Electrical Engineering, Massachusetts Institute of Technology, 1965.

Senior Scientist, Thinking Machines Corporation, Cambridge, Massachusetts. Professor of Computer Science, Brandeis University (1984–1985). Professor of Electrical Engineering and Research Professor at the Coordinated Science Laboratory (1982–1984), and Associate Professor at University of Illinois, Urbana (1973–1982). AI Laboratory Researcher (1967–1973) and Electrical Engineering Teaching Assistant at Massachusetts Institute of Technology (1966–1967).

Consultant for Bolt, Beranek, and Newman, Inc., Machine Intelligence Corporation, Symantec, Hughes Aircraft Company, Comtex Scientific Corporation, the National Science Foundation, and others.

Dr. Waltz is a Member Editor for *AI Communications of the ACM*, Association for Computing Machinery (ACM). he has held offices for ACM-SIGART (Special Interest Group on Artificial Intelligence). He is a member of the Association for Computational Linguistics (ACL) and Cognitive Science Society. He is a Journal Editor of *Cognitive Science*, and was on the editorial board of *Cognitive Science* from 1981 to 1984. He is an Executive Committee Member of the International Joint Conferences on Artificial Intelligence (IJCAI), and a member of the Harvard University Press Cognitive Science Editorial Board (1980–1985), and serves on the MIT Press/Bradford Books Editorial Advisory Board for series on Computational Models of Cognition and Perception (1983–1985). He was a Computer Science Advisory Committee Member (1982–1984) for National Science Foundation (NSF), and served as an Experimental Research Program Site Visitor (1981–1985).

Dr. Waltz is a distinguished lecturer; whose recent presentations have been at Harvard University; Carnegie-Mellon University; Stanford University; Yale University; and other universities, as well as the Naval Research Laboratory; National Security Agency; IBM Watson Research Laboratories; Cognitive Science Society Conference; Hughes Aircraft; Bell Laboratories; Digital Equipment Corporation; Bolt, Beranek, and Newman, Inc.; and other organizations and corporations.

Dr. Waltz's current contracts and grants include "Understanding and Representing Natural Language Meaning" (Office of Naval Research), "An Expert Distributed Robotics System with Comprehension and Learning Abilities in the Aircraft Flight Domain" (Air Force Office of Scientific Research), "Understanding Natural Language Scene and Event Descriptions: Cognitive Universals and Computer Programs Based on Combined AI and Linguistics Methodologies" (NSF), "Equipment for AI Research" (NSF), and a DoD Instrumentation Grant.

Dr. Waltz has published extensively (see bibliography).

Research interests include: natural language processing; robotics systems integrating language, perception, and learning; cognitive and linguistic universals; causal/physical reasoning for expert systems; parallel computation models based on constraint propagation and activation/inhibition networks; and story and metaphors comprehension.

Natural Language Processing, Speech Recognition

WEBBER, Dr. Bonnie Lynn

Ph.D., Harvard. Associate Professor of Computer and Information Science, University of Pennsylvania.

Research interests include: natural language processing and speech recognition.

Natural Language Processing, AI Software Languages

WINOGRAD, Dr. Terry

Ph.D., Applied Mathematics, Massachusetts Institute of Technology, 1970; M.A., Linguistics, 1967; B.A., Mathematics, Colorado College, 1965.

Scholarships and Fellowships include: Danforth Fellowship (1967–1970), Honorary National Science Foundation Fellowship (1966), Honorary Woodrow Wilson Fellowship (1966), Fulbright Fellowship (1966–1967), and Boettcher Scholarship (1962–1966).

Consulting: 1983–present, Action Technologies, Inc., San Francisco; 1972–present, Xerox Palo Alto Research Center; 1981–1983 Hermenet, Inc., San Francisco; November 1982, Special Consultant to the President, Fuji Xerox, Japan; August–November 1981, Special Consultant to the French Government on establishment of a center for the development of human resources through computers.

Awards include Mellon Junior Faculty Fellowship (1977) and Dean's Award for excellence in teaching, Stanford (1977). Research grants: 1965–1985–present from System Development Foundation, National Science Foundation, Sloan Foundation, Xerox, and ARPA.

University Committees: 1981–1983, Academic Council Committee on Information Technology; and 1979–1983, Academic Council Committee on Information Technology. Journal editorial board memberships include: 1985–present, *Cybernetics*; 1983–present, *Fifth Generation Computing*; 1978–present, *The Behavioral and Brain Sciences* (Commentator); 1978–present, *Discourse Processes*; 1977–1980, *Cognitive Science*; 1974–1977, *American Journal of Computational Linguistics*; 1973–present, *Artificial Intelligence*.

Government panels: 1974–present, proposal reviewer for National Science Foundation; 1983, Advisor to State of California panel on general education in community colleges; 1975–1977, National Science Foundation Computer Science and Engineering Study; 1975, National Institute of Education Study on Artificial Intelligence.

Outside boards include: 1984–present, National Board, Computer Professionals for Social Responsibility; 1983–present, National Executive Committee, Computer Professionals for Social Responsibility; 1980–present, Boar Member, Live Oak Institute (Berkeley), President, 1984–present; 1979–1982, Advisory Board, Cognitive Science Program, University of California, San Diego; 1979–1981, National Board, Association for Artificial Intelligence.

Memberships: Association for Computational Linguistics, Linguistic Society of America, American Association for Artificial Intelligence, Union of Concerned Scientists, Computer Professionals for Social Responsibility, and Association for Computing Machinery.

Natural Language

Vice President
Marketing
Cognitive Systems, Inc.

WIRT, Kenneth R.

Ph.D. program, Mass Communication Research, University of Michigan; M.B.A., Marketing and General Management, Stanford Graduate School of Business; B.A., Psychology of Kinetic Media, University of Michigan, 1973.

Mr. Wirt is Vice President of Marketing at Cognitive Systems, Inc. in New Haven, Connecticut. Sales, marketing, and strategic planning for artificial intelligence-based natural-language software products. Previously, vice president of computer marketing at Atari, Inc. (1981–1983); associate director of research, Public Broadcasting Service (1977–1980); business manager, Renan Productions (1975–1977); chief research associate, Research and Programming Services; research assistant, Institute for Social Research (1973–1975).

Award-winning film; publications, with N. Katzman (see bibliography).

Research interests include: natural language.

Natural Language, Advisory Systems, Expert Systems, AI Tools

Director
Knowledge Engineering and
Parser Development
Cognitive Systems, Inc.

WOLFE, Thomas C.

B.S., Applied Mathematics, Brown University, 1980.

Mr. Wolfe is a Senior Research Scientist at Cognitive Systems, Inc. in New Haven, Connecticut. He is Director of Knowledge Engineering and Parser Development for several natural language and expert systems, including Explorer, Broker, ENI, and Le Courtier (1981–1985). Previously a programmer at the Yale University AI Laboratory, where he developed a story-understanding system named BORIS (1980–1981). Teacher's Assistant, Artificial Intelligence, Brown University (1979); Staff Member, Argonne National Laboratory (1979); programmer, University of Chicago (1977–1978); programmer, University of Chicago (1975). (See bibliography.)

Research interests include: natural language, advisory systems, expert systems, and AI tools.

Natural Language, Expert Systems, Visual Recognition

WYCKOFF, Richard O.

B.A., Cognitive Science, AI, University of Rochester, 1979–1984.

Mr. Wyckoff is a Research Scientist at Cognitive Systems, Inc. in New Haven, Connecticut.

Research interests include: AI software development, natural language, expert systems, and visual recognition.

Natural Language

YOUNG, Dr. Sheryl

Ph.D., Cognitive Psychology, University of Colorado, 1984; M.A., Wayne State University, 1980; B.A., University of Michigan, 1978.

Dr. Young is a Senior Scientist at Carnegie Group, responsible for natural language application development. Prior to joining Carnegie Group, she worked on optimizing human text comprehension by manipulating computer displays of text for the Navy (ONR). These efforts formed the basis of new educational and naval grants to the Institute of Cognitive Science in Boulder, Colorado. Dr. Young's dissertation introduced a new theory for processing and storing memory of textual material. The theory was computer simulated and provided an accurate predictor of human memory for texts.

Voice Recognition

Voice Recognition, AI Research, Expert Systems

Director
Research and Development
Interstate Voice Products

AHMED, Dr. Wissam W.

Ph.D., Speech Science and Technologies, University of Southern California, 1984; M.S., Computer Science, Pennsylvania State University, 1974; M.S., Electrical Engineering, University of Baghdad, 1971.

Dr. Ahmed is a Senior Scientist and the Director of Research and Development at Interstate Voice Products. He was Director of Software Development at Pioneer Technologies and Sciences Corporation (1983–1984), senior member of the technical staff at Mattel Electronics (1982–1983), and Research Scientist and Computer Manager at Speech Communication Research Laboratory — working in computer speech recognition, analysis, and synthesis (1979–1982).

He is a lecturer in the Speech Science and Technology Department at the University of Southern California and a lecturer in the Math and Computer Science Department at California State University, Long Beach, where he teaches a master's course in advanced compiler design. He has taught courses in programming concepts, programming languages, data structure, compiler design, and artificial intelligence in the Computer Science Department at California State University, Dominguez Hills (1982–1984), and taught a graduate course on interactive laboratory systems for signal, speech analysis and synthesis at the University of Southern California (1981). In addition, he has been a consultant for Computalker, Inc. (1982), and Ear Research Institute (1980), and has published several papers (see bibliography).

Dr. Ahmed is a member of IEEE, Association of Computer Machinery, American Association for Artificial Intelligence, Sigma Xi (Scientific Research Society of North America), and the honor societies Phi Kappa Phi and Upsilon Pi Epsilon.

Research interests include: voice recognition, AI research, expert systems, AI software languages, natural languages, pattern recognition, speech base system, software development and system analysis, and digital speech processing.

Speech Recognition, Natural Language, Custom Integrated Circuits

ALLEN, J.

Faculty member, Department of Electrical Engineering and Computer Science, Purdue University.

Research interests include: speech recognition, understanding, and generation; natural language processing; computer design for speech recognition and natural language processing; computer architecture; and design of custom integrated circuits, including computer-aided design tools.

Speech Recognition, VLSI

BISIANI, Dr. Roberto

Ph.D. Faculty, Departments of Computer Science and Robotics, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Research interests include: distributed speech recognition, AI search/VLSI, in-system testing of VLSI chips, and a software generator of search chips for custom speech recognition tasks.

Voice Recognition, Natural Language, Expert Systems

GOODMAN, Dr. R. Gary

Ph.D., Computer Science, Stanford University, 1976; M.S., Computer Science, Stanford University, 1967; M.S., Electrical Engineering, Oklahoma State University, 1965; B.S., Electrical Engineering, Oklahoma State University, 1963.

Dr. Goodman is Director of Research and Development at Scott Instruments Corporation. Previously, Senior Systems Analyst in Research and Development at Scott Instruments (1979–1982); Research Associate and Lecturer, Computer Science Department, Carnegie-Mellon University (1974–1979); Assistant Professor, Computer Science Department, University of Nebraska (1972–1974); Research and Teaching Assistant, Computer Science Department, Stanford University (1966–1972); CAI System Document Coordinator and Programmer, Advanced Systems Development Laboratory, IBM (1965–1966); Scientific Programmer, Mathematical and Computational Services Group, Texas Instruments (1964–1965).

Dr. Goodman has published numerous papers, presentations, and publications (see bibliography).

Research interests include: voice recognition, natural language, and expert systems.

Voice Recognition, Expert Systems, AI Research

Founder and *President*
Kurzweil Applied Intelligence, Inc.

KURZWEIL, Dr. Raymond

Ph.D. (honorary), Hofstra University (1982); admitted to Computer Industry Hall of Fame (1982); selected "Outstanding Young Computer Scientist of 1978" by the Association for Computing Machinery (ACM); received entrepreneurship award from Massachusetts Institute of Technology, Sloan School of Management (1968); received awards from President Reagan (1982) and Massachusetts Governor Dukakis (1977); delivered keynote address at an annual Institute of Electrical and Electronic Engineers (IEEE) Conference (1984).

Dr. Kurzweil is President and founder of Kurzweil Applied Intelligence, Inc. He is developing a voice-activated typewriter and other products incorporating AI and speech recognition technology. Also founded Kurzweil Music Systems, Inc. in 1982. Developed computer music keyboard (the Kurzweil 250) capable of accurately reproducing the sounds of the grand piano and other orchestral instruments. Founded Kurzweil Computer Products, Inc. in 1974. Developed omni-font optical character recognition (OCR) technology in 1976. The Kurzweil Reading Machine (KRM) and Kurzweil Data Entry Machine (KDEM) are omni-font OCR products. Developed unlimited vocabulary speech generation system in 1976.

At age 18, sold software package to major New York publisher. At age 16, in 1964, won seven national awards for a pioneering Artificial Intelligence project, including first prize in the International Science Fair in Electronics and Communications. At age 12, developed software package distributed by IBM.

Research interests include: voice recognition, expert systems, and AI research.

Voice Recognition, Natural Language, AI Research

Founder and *President*
Speech Systems, Inc.

MEISEL, Dr. William Stuart

Ph.D., Electrical Engineering, University of Southern California, 1967; M.S., Electrical Engineering, University of Southern California; B.S., Engineering, Caltech, 1964.

Dr. Meisel is President of Speech Systems Incorporated (SSI), Tarzana, California. SSI is developing a large-vocabulary, continuous speech recognition system which will transcribe dictation in an office environment. Dr. Meisel began his career as a professor at the University of Southern California in the Electrical Engineering Department, teaching courses on pattern recognition and its applications, artificial intelligence, and computer design. Scientist at TSC, Inc. for 11 years, applying pattern recognition technology to radar, sonar, speech, transportation, and air pollution applications. Founded SSI in 1981 to develop talkwriter using Empirical Artificial Intelligence (EAI), which combines statistical pattern recognition techniques and automated incorporation of expert opinion.

Dr. Meisel wrote one of the first textbooks in computer pattern recognition and he has published over 50 papers (see bibliography).

Speech Recognition, VLSI, Expert Systems, Machine Learning

MOSTOW, Dr. Jack

Ph.D., Computer Sciences, Carnegie-Mellon University. Assistant Professor of Computer Science, Rutgers University.

Co-developer of HEARSAY-II, speech recognition program. Guest Editor of the IEEE Transactions on Software Engineering.

Research interests include: machine learning, VLSI design, and expert systems.

Speech Recognition, Speech Synthesis

RUDNICKY, Dr. Alexander

Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University.

Major issues of interest: development of robust phonetic transcription, understanding techniques for modeling time-varying phenomena in speech, and signal transformation techniques; design of a lexicon that allows for phonetic transcription, prosodic structure, *a priori* probabilities, and task-specific constraints; and development of candidate-set techniques analyzing set structure and guided reanalysis of the signal.

Research interests include: speech recognition and design of systems capable of understanding very large vocabularies (50,000 words and larger).

Speech Recognition

SIEGAL, Dr. Leah Jamieson

Ph.D., 1976; M.S.E., 1974; M.A., 1974; Princeton University.

Associate Professor, School of Electrical Engineering, Purdue University (1976).

Research interests include: speech recognition, pattern recognition, and computer algorithms and languages.

Speech Processing, Speech Recognition, Acoustic Characterization

ZUE, V.

Faculty, Department of Electrical Engineering and Computer Science, Purdue University.

Research interests include: speech processing, speech recognition, speech analysis, speech synthesis, speech communication (including acoustic characterization of continuous speech), speech training aids for the deaf, and lexical access.

Robotics, Machine Learning

Robotics, Load Characteristics Identification in

AN, Chae Hun
Research Staff, Artificial Intelligence Laboratory, MIT.

Research interests include: using system-identification techniques to derive load mass, center of gravity, and moments of inertia.

Robotics, Sensing Approaches to Distributed Planning for

ARIB, Dr. Michael A.
Ph.D. Professor, Computer and Information Science Department, University of Massachusetts at Amherst.

Research interests include: network simulation and neural modeling of mechanisms of visuomotor coordination, and dynamic sensing approach to distributed planning and control for robots.

Robotics, Load Characteristic Studies in

ATKESON, Christopher G.
Research Staff, Artificial Intelligence Laboratory, MIT.

Research interests include: load characteristic identification using Newton-Euler equations to relate force readings to velocities and accelerations derived from joint angle readings.

Machine Learning, Parallel Architectures, Neural Modeling

BARTO, Dr. Andrew G.
Ph.D. Associate Professor, Computer and Information Science Department, University of Massachusetts at Amherst.

Research interests include: machine learning, adaptive problem solving, neural basis of learning and memory, neural modeling, and architecture for parallel distributed processing.

Robotics, Visual Recognition

Senior Research Scientist
Artificial Intelligence
Laboratory, MIT

Founding Editor
The International Journal
of Robotics Research

BRADY, Dr. J. Michael

Ph.D., Mathematics, Australian National University, Canberra, 1970; M.A., Mathematics, Manchester, England, 1967; B.A., Mathematics, Manchester, England, 1966.

Dr. Brady is Senior Research Scientist in the Artificial Intelligence Laboratory at Massachusetts Institute of Technology.

Before joining Massachusetts Institute of Technology in 1980, Dr. Brady taught Computer Science at Essex University, England. Author and editor of several books, including *Robot Motion* (MIT Press, 1982), *Computer Vision* (North Holland, 1982), *Computational Models of Discourse* (MIT Press, 1983), and *The Theory of Computer Science: A Programming Approach* (Chapman and Hall, 1977). Founding Editor (with Richard Paul) of *The International Journal of Robotics Research*. Edited collections in print include *The First International Symposium of Robotics Research* (with Richard Paul), and *Artificial Intelligence and Robotics* (with L. Gerhardt).

He has served on the National Research Council for the Army and is on the editorial board of *Artificial Intelligence*. He is series editor (with Patrick H. Winston) of the MIT Press series on Artificial Intelligence. Dr. Brady has written over 50 research papers, mostly in vision and robotics. (See bibliography.)

Research interests include: robotics, visual recognition, and image understanding.

Robotics, Vision, LISP Compilers and Language Systems

BROOKS, Dr. Rodney

Ph.D., Stanford University, 1981. Assistant Professor of Computer Science, Department of Computer Science, Stanford University.

Research interests include: mobile robots and manipulators, vision systems, spatial reasoning, and LISP compilers and languages.

Robotics, Theory and Practce of

DEKEN, Dr. Joseph

Ph.D., Mathematical Statistics, Stanford University. Associate Professor, Computer Sciences Department, University of Texas at Austin.

Dr. Deken received the 1983 Teaching Innovation Award from the University of Texas College of Business. He has written several books, including: *The Electronic Cottage*, and *Silico Sapiens: The Theory and Practice of Robotics*. (See bibliography.)

Machine Learning, Inference Formalization

DIETTERICH, Thomas G.

Ph.D. (in progress), Computer Science, Stanford University; M.S., University of Illinois, 1979; B.A., Oberlin College, 1977.

Author of a number of papers on machine learning, contributed to *Machine Learning, An Artificial Intelligence Approach* (Tioga, 1983) and *Handbook of Artificial Intelligence* (Kaufmann, 1982).

Research interests include: machine learning, inference formalization, and AI research.

Nonlinear Adaptive Control of Robots

DJAFERIS, R.
AI Researcher, Department of Electrical and Computer Engineering, University of Massachusetts at Amherst.

Research interests include: nonlinear adaptive control of robots — applications of modern control methodologies, including adaptive techniques, to the control of the nonlinear dynamics associated with robotic manipulators.

Robotics, Motion Planning and Collision Avoidance

DONALD, Bruce R.
Research Staff, Artificial Intelligence Laboratory, MIT.

Research interests include: development and testing algorithms for planning collision-free motions of complex polyhedral objects among obstacles for robots with six degrees of motion freedom; three rotational degrees of freedom of a moving object, as well as the three translational degrees of freedom.

Robotics, Automatic Compliant Motion Planning

ERDMANN, Michael
Research Staff, Artificial Intelligence Laboratory, MIT.

Research interests include: development of a method for automatically planning compliant motions for robots to perform mechanical assembly.

Robotics, Large-Array Tactile Sensors for Fingers in

GARABIETA, Ignacio H.
Research Staff, Artificial Intelligence Laboratory, MIT.

Research interests include: design of large-array tactile sensors based on capacitance sensors to see thermal conductivity differences to distinguish materials.

Robotics, Visual Recognition

President and *CEO*
Object Recognition Systems, Inc.

Chairman
Robotic Industries Association
Vision Group

GUSTAFSSON, Y. Len Gstafsson
M.B.A., Fairleigh Dickinson University, 1976; B.S., Engineering, Stockholm Technical Institute, 1960.

President and CEO, Object Recognition Systems, Inc. since 1983. Previously, Mr. Gustafsson served as General Manager, Industrial Robots Division of ASEA, Inc. (1981–1983). Trade Commissioner of the Swedish Trade Office in Southfield, Michigan (1978–1981), and Manager of Business Development at Sandvik, Inc. (1970–1978).

Mr. Gustafsson is Chairman of the Robotic Industries Association (RIA) Vision Group.

Robotics

HOLLERBACK, Dr. John
Ph.D. Faculty, Artificial Intelligence Laboratory, MIT.

Research interests include: development of efficient algorithms for kinematics, dynamics, and trajectory planning in robotics; minimal time-path applications from time-scaling formulations of manipulator dynamics; configurations for seven degrees-of-freedom rotary manipulators; control algorithm for redundant arms that resolves the redundancy by minimizing the torque loading at the weaker joints; using generalized inverses for accelerations, rather than the common formulation of generalized inverses for velocities, substituting these accelerations into inverse dynamics.

Research and interests also include: identification of new load characteristics using Newton-Euler equations for relating force readings to velocities and accelerations derived from joint angle readings; co-design and construction of a multiprocessor system based on the Motorola 68000 and the multibus, where each finger and its eight tendons are controlled by one microprocessor; co-design of large-array tactile sensors based on capacitance sensors, defined by conductive strips screened onto thin rubber sheets, and a special electronic circuit detecting capacitance change due to decreased distance between conductive strips from pressure deformation.

Robotics, Compliant Motion Capabilities

JONES, Joseph L.
Research Staff, Artificial Intelligence Laboratory, MIT.

Research interests include: implementation of compliant motion capabilities for commercial manipulators, which allows planned compliant motions to be tested, aimed at automatic synthesis of robot programs from high-level task specification.

Robotics, 3-D Robot Vision, Image Understanding

KANADE, Dr. Takeo
Ph.D. Faculty, Departments of Computer Science and Robotics, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Research interests include: computer vision and robot manipulation; image understanding systems, shape understanding, incremental 3-D mosaic, vision algorithms on WARP (systolic array machine); 3-D robot vision, 3-D sensors and range-data analysis; navigational vision; CMU direct-drive arm project, geometric model-based robot programming with simulation, microcomputer-based architectures for joint motor control and sensing, advanced control schemes for taking advantage of low-friction, high-speed direct-drive arm motion.

Robotics

KOIVO, Dr. Antti
Ph.D., Cornell University, 1963; Dipl. Eng., Finland Institute of Technology, 1956. Professor, School of Electrical Engineering, Purdue University, 1965.

Research interests include: robotics, microprocessor control systems, and identification, estimation and control of biomedical systems.

Autonomous Vehicles, Computer Vision, Processing Dynamic Images

LAWTON, Daryl T.
AI Researcher, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: computer vision, processing dynamic image sequences, highly parallel architectures for artificial intelligence, autonomous vehicles, and sensory motor learning systems.

Robotics

LOZANO-PEREZ, Dr. Thomas

Ph.D. Faculty, Artificial Intelligence Laboratory, MIT.

Research interests include: development of algorithms for space planning in robotics, motion planning and collision avoidance for robots with six degrees of motion freedom, automatic planning compliant motions for robots to perform mechanical assembly, automatic synthesis of robot programs from high-level task specifications, and object recognition.

Robotics, Multiple-Processor Applications

LUH, Dr. Johnson Y-S

Ph.D., University of Minnesota, 1963; M.S., Harvard University, 1950; B.S., Universitato Utopia, China, 1974. Professor, School of Electrical Engineering, Purdue University, 1965.

Research interests include: robot systems, applications of multiple-microprocessors, and decision theory.

Robotics, Visual Recognition, AI Software Languages

Vice President
Marketing
Intelledex, Inc.

MAHONEY, William A.

B.S., Civil Engineering, University of Illinois.

Vice President, Marketing, Intelledex, Inc., Corvallis, Oregon. Marketing and strategic planning of artificial intelligence products and services.

Previously Sales and Marketing Manager at Hitachi America Ltd. (1971–1984) and Senior Sales Engineer at Westinghouse Electric Company (1967–1971).

Research interests include: robotics, visual recognition, and visual recognition systems combined with robotics as vision-guided robots or stand-alone robot or vision systems.

Robotics

MASON, Dr. Matt

Ph.D. Faculty, Departments of Computer Science and Robotics, Carnegie-Mellon University.

Research interests include: providing the robot with new manipulation primitives; developing automatic robot programming languages; manipulation theory investigating methods for picking up uncertainly-positioned objects without vision or other sensory feedback, related to the study of kinematic constraints during manipulation for force-control compliant motion.

Machine Learning, Expert Systems, Inductive Inference

Director
Artificial Intelligence
Laboratory
University of Illinois

MICHALSKI, Dr. Ryszard S.

Ph.D., University of Silesia, Poland; M.S., Leningrad Polytechnic Institute; Cracow and Warsaw Technical Universities, Poland.

Dr. Michalski is Professor of Computer Science and Medical Information Science, and Director of the Artificial Intelligence Laboratory, Computer Science Department, University of Illinois at Urbana-Champaign.

Before he came to the U.S.A (1970), he was a Research Scientist at the Polish Academy of Sciences in Warsaw.

Dr. Michalski has authored over 90 articles and three books. Co-editor of the book, *Machine Learning: An Artificial Intelligence Approach*; co-editor of the journal, *Machine Learning*.

Research interests include: knowledge acquisition, expert systems, inductive inference, databases, modeling of human plausible reasoning, automated pattern discovery, classification theory, and many-valued logics and applications of computer science to life sciences, particularly to medicine and agriculture.

Machine Learning

MITCHELL, Dr. Tom

Ph.D. (1978), M.S. (1975), Stanford University; B.S., MIT, 1973. Associate Professor of Computer Science at Rutgers University.

Dr. Mitchell is the recipient of the 1983 IJCAI Computers and Thought Award in recognition of his research on machine learning, and of a 1984 NSF Presidential Young Investigator award. He has taught Artificial Intelligence at Rutgers University and in tutorial courses for the past 6 years, and is co-editor of the book, *Machine Learning: An Artificial Intelligence Approach*.

His current research lines in the areas of learning heuristics through experimentation, knowledge-based aids for circuit design, and frameworks for incorporating learning into knowledge-based systems.

Autonomous Vehicles, Parallel Architecture, Expert Systems

General Manager
Eastern Operations
Advanced Information & Decision Systems

Project Leader
Signal Understanding and EW Resource Planning, AI&DS

MITOLA, Dr. Joseph III

Ph.D. candidate, Computer Science, University of Maryland.

General Manager, Eastern Operations, Advanced Information & Decision Systems (AI&DS), Arlington, Virginia Division. Project Leader, signal understanding and EW resource planning; key contributor in autonomous vehicle planning, and object-oriented modeling of naval systems. He manages research in defense applications for the AI&DS Washington office. Previously, he directed AI and related research of E-Systems.

Initiated project to apply MYCIN model diagnostic problem solving to EW. Currently, at the University of Maryland, his research interests include: story understanding, diagnostic problem solving, and parallel computer architectures.

Lecturer on intelligent data fusion, the application of advanced AI techniques to information integration.

Autonomous Vehicles, Robotics, Visual Recognition, Expert Systems, AI Research, AI Hardware

Founder
Vuebotics Corporation

Director of Technology
Vuebotics Corporation

MURRAY, Lawrence A.

B.S., Physics, University of Notre Dame, 1953.

Founded Vuebotics Corporation (1981), Carlsbad, California, a machine vision company, where he is Director of Technology. Independent consultant on machine vision, fiber optics and photoelectronics (1976–1981).

Set up Vactic, St. Louis (1972), an integrated circuit company. Worked on development of lasers, research developer at RCA (1958–1964).

Developed the VBI machine vision system for Vuebotics and its application in real-time automated hybrid circuit inspection.

Special AI interest lies in development of a hardwired hierarchical AI structure to put into vision systems. This will lessen or severely curtail the need for application programming of the vision system for each new task. Associated AI interests lie in development of intelligent vision (3-D) for autonomous vehicles.

In the process of publishing a book with Marcell Dekkar Publications, Inc., New York, entitled *Intelligent Vision Systems for Industry*. Mr. Murray has over 60 publications (see bibliography).

Robotics, Finger and Tendon Multiprocessor-Based Control in

NARASIMHAN, Sundar
Research Staff, Artificial Intelligence Laboratory, MIT.

Research interests include: design and construction of a multiprocessor-based system controlling robotic fingers and tendons.

Robotics

Director
Robotics Laboratory
Stanford Research Institute International

NITZEN, Dr. David
Ph.D. and M.S., Electrical Engineering, University of California at Berkeley; B.S., Electrical Engineering, Technion, Haifa, Israel.

Director of the Robotics Laboratory at Stanford Research Institute International, Menlo Park, California. For the past 15 years, Dr. Nitzen has worked in robotics, including visual and range perception of 3-D objects, and programmable industrial automation.

Senior member of the IEEE, member of AAAI, and a member of The Research Society of America.

Machine Learning, Theory, Algorithms

NUDEL, Bernard
Ph.D. (in progress), Computer Science, Rutgers University; M.S., Bio-Engineering, University of Tel Aviv; B.S. (with honors), Physics, Monash University, Melbourne, Australia.

Contributing author, *Machine Learning: An Artificial Intelligence Approach* (Tioga, 1983).

Research interests include: learning theory and designing algorithms for general constraint satisfaction problems.

Robotics, Compliant Motion Studies in

O'DONNELL, Patrick A.
Research Staff, Artificial Intelligence Laboratory, MIT.

Research interests include: compliant motion planning, obstacle avoidance, aiming at automatic synthesis of robot programs from high-level task specifications.

Robotics

PAUL, Dr. Richard
Ph.D., Stanford University, 1972; M.S.E.E., Stanford University, 1968; B.S.E., McGill University, 1963.

Professor of Robotics, School of Electrical Engineering, Purdue University (1976).

Research interests include: robotics.

Robotics, Expert Systems, AI Software Lanuguage, Natural Language

POE, Michael D.
Ph.D. candidate, Computer and Information Science, University of Massachusetts at Amherst; M.S., Computer and Information Science, University of Massachusetts at Amherst, 1978; B.S., Psychology, Reed College, 1975.

Research interests include: expert systems, AI software languages, natural language, tools, AI research, workstations, other hardware, resources, voice recognition, robotics, and visual recognition. (See bibliography.)

Robotics, Specialized Parallel Processors in

RAIBERT, Dr. Marc

Ph.D. Faculty, Departments of Computer Science and Robotics, Carnegie-Mellon University.

Research interests in balance and dynamic stability in legged locomotion systems, and dexterous robot manipulation, including: a one-legged running machine, to research versatile walking machines and animal sensory-motor control; VLSI applied to dexterous robot manipulation, constructing sensors with specialized parallel processors that can interpret sensory information and use the results for control, giving robot manipulators information between a manipulator's hand and objects in the environment, to create a device that is a special-purpose parallel computer and a high-resolution tactile array sensor.

Robotics, Supercomputers, Distributed Parallel Systems

REDDY, Dr. D. Raj

Co-founder
Carnegie Group, Inc.

Chief Scientist
of the World Center
for Computer and
Human Resource
Paris, France

Director
Robotics Institute
Carnegie-Mellon University

Ph.D., Computer Science, Stanford University, 1966. Previously attended the University of Madras, India and the University of New South Wales, Australia.

Professor of Computer Science and Director of the Robotics Institute at Carnegie-Mellon University, where he has been active in teaching and research in AI for 15 years. Dr. Reddy is co-founder of Carnegie Group, Inc. He is also the Chief Scientist of the World Center for Computer and Human Resource in Paris.

Dr. Reddy's research interests in computer science are in the areas of AI research, man-machine communications, and signal understanding systems. He is working on speech input to computers, visual input to computers, robotics, graphics, distributed sensor networks, and computer architectures.

He is on the editorial boards of Spectrum, Proceedings of the IEEE, IEEE Transactions on Pattern Analysis and Machine Intelligence, Computer Vision, Graphics and Image Processing.

Dr. Reddy was Program Chair of the International Joint Conference on Artificial Intelligence (IJCAI-77) and the General Chair for IJCAI-79. He is a fellow of the IEEE and the Acoustical Society of America, and a member of the National Academy of Engineering. Dr. Reddy was awarded the Knighthood of the Legion of Honor, France's highest honor, for his work as Chief Scientist of the World Center for Personal Computation and Human Resources. He led a successful DARPA speech project culminating in HEARSAY-II, a cooperative problem-solving environment, and HAPPY, the first 1000-word 95%-accurate continuous speech recognizer that introduced the use of beam search.

Dr. Reddy's research interests at Carnegie-Mellon in 1985 include: supercomputers, various parallel decompositions of speech and vision algorithms, and systems that can run on large multiprocessor and distributed parallel systems; learning from examples in robotics, automatic generation of programs for assembly. Current research includes distributed speech understanding systems with a 10,000-word vocabulary, a microprocessor implementation on VAXs and PERQs (on a ARPA Strategic Computing Program grant); user-friendly interfaces, various components of the Spice system to evaluate each subsystem along various dimensions of ease of use, intelligent help facilities, consistency, and consciousness of the user interfaces.

Robotics, System Architecture, AI Software Technology

General Manager
Microelectronics Center
General Electric

RUSSO, Dr. Paul M.
Ph.D., Computer Science, University of California, Berkeley; M.S., Electrical Engineering, University of California, Berkeley; B.A., Engineering Physics, McGill University.

Dr. Russo is General Manager of Microelectronics Center, General Electric Company, where he directs research efforts in CAD/CAM, graphics, advanced controls, robotics, factory communications, system architecture, and software technology. Microsystems research at RCA Laboratories — involved in development of the RCA 1802 microprocessor and microprocessor-based consumer and manufacturing systems.

Dr. Russo holds five patents.

He has been awarded the RCA Laboratories' Outstanding Achievement Award twice and the Meritorious Award of the IEEE. He is a fellow of the IEEE, Vice President of the IES, and an AdCom member of the IEEE CAS Society. He has served on the Computer Science faculty at the University of California, Berkeley. Publications (see bibliography).

Research interests include: robotics, system architecture, AI software technology, advanced controls, and AI research.

Robotics, Manipulator Trajectory Planning in

SAHAR, Gideon
Research Staff, Artificial Intelligence Laboratory, MIT.

Research interests include: minimal time path in relation to actuator constraints in manipulator trajectory planning; and graph search, where nodes are obtained by a tesselation of joint-space positions and velocities, and where arcs are the minimum movement times between adjacent nodes.

Robotics, Design and Control of Articulated Hands

SALISBURY, Dr. Kenneth
Ph.D. Faculty, Artificial Intelligence Laboratory, MIT.

Research interests include: design and control of articulated hands, multiple degrees-of-freedom end effectors, design of sensors for augmenting articulated hand manipulation, and LISP-based user environment for effecting and interpreting motions of the hand.

Robotics

Director
Marketing
Vektronics

Founding Chairman
Robotics International
of SME

SAVERIANO, Jerry W.
Director of Marketing, Vektronics Manufacturing, Inc. Ten years involvement in marketing and applications of industrial robots.

Formerly Industrial Editor of *Robotics Age Magazine*. Robotics consultant to management groups in the United States, Europe, Japan, and South America.

Founding Chairman of Robotics International of SME, Southern California. Recently served as Vice Chairman of the Robots West Conference.

Robotics

SEERING, Dr. Warren
Ph.D. Faculty, Artificial Intelligence Laboratory, MIT.

Research interests include: advanced computational capability to enhance robot performance; controller networks to optimally process input from sensors for use in robot control; robot dynamic performance modeling, including resonant phenomena and design of control algorithms to interact with models in real time to maximize system performance; alternate manipulator design; air-powered robot; and cooperating sets of robots.

Robotics, Finger Coordination Microprocessors in

SIEGEL, David M.
Research Staff, Artificial Intelligence Laboratory, MIT.

Research interests include: large-array tactile sensors based on capacitance sensors defined by conductive strips screened onto thin rubber sheets, circuited to distinguish materials by thermal conductivity measurements.

Robotics

SMITH, Dr. Stephen F.
Ph.D., 1980, M.S., 1977, Computer Science, University of Pittsburgh; B.S., Mathematics, Westminster College, 1973.

Research Scientist, Intelligent Systems Laboratory, Robotics Institute at Carnegie-Mellon University. Prior to joining the faculty at the Robotics Institute, Dr. Smith was Assistant Professor of Computer Science at the University of Southern Maine.

Research interests include: machine learning, hierarchical and distributed problem solving, knowledge-based systems, and adaptive learning techniques.

Machine Learning

SMITH, Dr. Donald
Ph.D., Rutgers State University. Faculty, Rutgers State University at New Brunswick, New Jersey (1985).

Research interests include: machine learning and computer-aided instruction.

Robotics Algorithms for Redundant Arm Control

SUH, Ki Choon
Research Staff, Artificial Intelligence Laboratory, MIT.

Research interests include: developing control algorithms for redundant arms that resolves the redundancy by minimizing the torque loading at the weaker joints. The method involves the use of generalized inverses for accelerations, rather than formulation of generalized inverses for velocities, and substitution of accelerations into inverse dynamics.

Machine Learning, Knowledge Representation, Learning Theory

SUTTON, Richard S.
AI Researcher, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: machine learning, knowledge representation, and animal learning theory.

Robotics
Machine Learning

UTGOFF, Paul E.

Ph.D. (in progress), Computer Science, Rutgers University; M.S., Rutgers University, 1979; B.Mus., Oberlin College, 1974.

Contributing author, *Machine Learning: An Artificial Intelligence Approach* (Tioga, 1983) and co-author of several publications (with Dr. Thomas Mitchell, Rutgers University).

Research interests include: machine learning and methods for improving the bias that drives a generalization process.

Robotics

Co-founder and *President*
Automatix, Incorporated

Co-founder
Computervision

VILLER, Philippe

M.S., Massachusetts of Technology; B.A., Harvard University.

Mr. Villers is co-founder and President of Automatix, Incorporated, which develops, produces, markets, and services industrial robotic systems. Before 1980, Senior Vice President, Computervision Corporation (which he also co-founded); Manager of advanced products at Concord Control, Inc.; Program Manager at Singer Link Division; and Program Engineer at Perkin Elmer and at Barnes Engineering.

Mr. Villers is a member of three Massachusetts Institute of Technology Visiting Committees: the Department of Mechanical Engineering, the Department of Electrical Engineering and Computer Science, and the Laboratory for Manufacturing and Productivity. Member, National Bureau of Standards Evaluation Panel for Manufacturing Engineering. His professional activities include membership in ASME, IEEE, SME, ACM, and RIA.

Research interests include: robotics and AI research.

Visual Recognition

Allebach, Dr. Jan P.	Herman, Dr. Martin	McKeown, Dr. Dave	Srihari, Dr. Sargur N.
Badler, Dr. Norman	Herman, Dr. Gabor	Morris, Ian G.	Swain, Dr. Phillip H.
Baird, Dr. Michael	Horn, Dr. Berthold	Nakatani, Hiromasa	Swonger, C. W.
Bajcsy, Dr. Ruzena	Howe, Dr. James	Piankian, Robert A.	Troxel, D.
Bloch, Carl J.	Kak, Dr. Avinash	Poggio, Dr. Tomaso	Ullman, Dr. Shimon
Binford, Dr. Thomas	Kashyap, Dr. Rangasami	Rifkin, Alfred	Wagner, Gary
Chandrasekaran, Dr. B.	Kulikowski, Dr. Casimir	Riseman, Dr. Edward M.	Walters, Dr. Deborah K. W.
Cobb, Judy	Landgrebe, Dr. David A.	Runsheng, Wang	Webb, Dr. Jon A.
Elliott, Howard	Laurent, Louis A.	Shafer, Dr. Steven	Weiss, Richard
Fu, Dr. King-Sun	Lesser, Dr. Victor R.	Shillman, Dr. Robert J.	Wishner, Dr. Richard P.
Fukunaga, Dr. Keinosuke	Lim, J.	Spinelli, Dr. D. N.	Wogrin, Dr. Conrad A.
Hanson, Dr. Alan	Metzger, Robert J.	Spoto, Vincent J.	Zuech, Nello

Image Processing

ALLEBACH, Dr. Jan P.

Ph.D., Princeton, 1976; M.S., Princeton, 1975; B.S., University of Delaware, 1972. Associate Professor, School of Electrical Engineering, Purdue University, 1983.

Research interests include: image processing, communications, and signal processing.

Vision Systems

BADLER, Dr. Norman

Ph.D., Toronto. Associate Professor of Computer and Information Science, University of Pennsylvania.

Research interests include: integrated systems for language and vision, image processing, computer-aided design, and computer graphics languages for representing movement and motion.

Visual Recognition, Robotics, AI Research

Vision Group Leader
Artificial Intelligence Center
FMC Corporation

Founder
Digital Vision

BAIRD, Dr. Michael

Ph.D., Information and Computer Science, Georgia Institute of Technology, 1973; M.S., Information Science, Georgia Institute of Technology, 1971; B.S., Industrial Engineering (Electrical Engineering minor), General Motors Institute, 1969.

Dr. Baird is Vision Group Leader in the Artificial Intelligence Center (Electronics Engineering and Computer Science) at FMC Corp. in Santa Clara, California. Previously, he was Vice President of Applications Development, and Director of West Coast Sales, Service and Applications Development at Billerica (1984–1985); Automation Manager, Senior Scientist, and Key Technologist at Fairchild Laboratory for Artificial Intelligence Research (now Schlumberger Palo Alto Research Lab) (1981–1984); President, Director, and Founder of Digital Vision (1983–1984); Project Manager and Senior Research Scientist at General Motors Research Laboratories (1973–1981); Instructor, Wayne State University (1975–1977); Researcher, Georgia Institute of Technology (1970–1973); Peace Corp Volunteer (1969); Consultant in computer vision, robotics, and automation.

Research interests include: visual recognition, robotics, and AI research.

Author and co-author of over 30 publications and more than 100 presentations. Presentations in 1985 given at SPIE Optical Microlithography Conference, IEEE Robotics and Automation Conference, and Test and Measurement World Conference. Membership in ACM (SIGART), IEEE (Computer Society), IEEE Pattern Analysis and Machine Intelligence Editorial Committee and Robotics Council, Robotics International, Society of Manufacturing Engineers (Machine Vision Association), Society for Photo-Optical Instrumentation Engineers (SPIE), International Society for Optical Engineering, AAAI, Sigma Xi, and American Association for the Advancement of Science.

Computer Vision

BAJCSY, Dr. Ruzena

Ph.D., Stanford. Associate Processor of Computer and Information Science, Pennsylvania University.

Research interests include: computer vision, satellite and biomedical image processing, 3-D imaging, and integrated systems for language and vision.

Visual Recognition

Vice President
Engineering
Cognex Corporation

BLOCK Carl J.

M.S., Physics, University of Michigan.

Vice President, Engineering, Cognex Corporation.

Mr. Block has 17 years of experience in computer systems and communications technology. Prior to joining Cognex in 1982, he was a senior scientist at Battelle Memorial Institute, Columbus, Ohio. He served as project manager for optical character recognition, image processing, and artificial intelligence projects. Led a technical investigation into optical character recognition equipment for automatic translation of Slavic texts into English for the United States Air Force.

Computer Vision

BINFORD, Dr. Thomas

Ph.D., Wisconsin, 1965. Professor of research in Computer Science, Department of Computer Science, Stanford University.

Research interests include: computer vision and robotics.

Visual Recognition

CHANDRASEKARAN, Dr. B.

Ph.D., Moore School of Electrical Engineering, University of Pennsylvania, 1967. Professor of Computer Science, Ohio State University, 1969.

Research Scientist, Philco-Ford Corporation, Blue Bell, Pennsylvania, pattern-recognition research (1967–1969).

Research interests include: visual recognition and knowledge-based problem solving.

Visual Recognition

COBB, Judy

Ms. Cobb holds the position of Marketing Communications Specialist at Cognex Corporation, Needham, Massachusetts.

Stochastic Image Processing

ELLIOTT, Howard
AI Researcher, Department of Electrical and Computer Engineering, University of Massachusetts at Amherst.

Research interests include: stochastic image processing, development of algorithms for computer vision (image segmentation in particular), and use of statistical models for Markov random fields to develop robust algorithms for segmentation and analysis of noisy and textured images. Also, research in nonlinear adaptive control of robots, both theoretical and experimental.

Pattern Recognition

FU, Dr. King-Sun
Ph.D., University of Illinois, 1959; M.S., University of Toronto, 1955; B.S., National Taiwan University, 1953. Professor and Gauss Professor of Engineering, School of Electrical Engineering, Purdue University, 1960.

Research interests include: pattern recognition, automata theory, and formal languages.

Pattern Recognition

FUKUNAGA, Dr. Keinosuke
Ph.D., Kyoto University, 1962; M.S., University of Pennsylvania, 1959; B.S., Kyoto University, 1953. Professor, School of Electrical Engineering, Purdue University, 1966.

Research interests include: pattern recognition, learning computer control systems, and information processing systems.

Machine Vision, Inference, Knowledge-Based Systems

Associate Director
Laboratory for Computer Vision
University of Massachusetts

HANSON, Dr. Allan
Ph.D., Cornell. Associate Professor, Computer and Information Science Department, University of Massachusetts; Associate Director of the Laboratory for Computer Vision Research, University of Massachusetts.

Twenty years of activity in the field of machine vision. Co-editor of *Computer Vision Systems*.

Computer Vision, Image Understanding

HERMAN, Dr. Martin
Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Research interests include: computer vision and image understanding, the acquisition and use of models of objects and scenes. Such models may be acquired automatically or interactively from visual input, and may be used for interpretation, descriptive and navigation tasks. Current research includes the 3-D MOSAIC System, acquiring and using scene description. Also, interfacing vision with computer-aided design 3-D models. (For a description of the 3-D MOSAIC System, see section on AI Schools, Carnegie-Mellon University.)

Vision

HERMAN, Dr. Gabor
Ph.D., London. Professor of Computer and Information Science, and Professor of Radiology, University of Pennsylvania.

Research interests include: computer vision, biomedical image processing, and mathematical modeling.

Visual Recognition, Robotics

HORN, Dr. Berthold

Ph.D., 1970, M.S., 1968 MIT; B.Sc. Engineering, University of Witwatersrand, 1965. Professor of Computer Science, Artificial Intelligence Laboratory, Massachusetts Institute of Technology.

Developed direct parsive navigation method, 1985. Developed extended Gaussian image, 1984. Developed method for recovering optical flow, 1981. Developed reflectance map, 1977. Developed drip alignment system using vision, 1974. Developed method for recovering shape from shading, 1970.

Teaches robotics courses at MIT, including special one-week seminar course. Publications include: *LISP*, co-authorized with Patrick Winston (Addison-Wesley) and *Robot Vision* (MIT Press/McGraw-Hill).

Visual Recognition, AI Software Languages, AI Research

Director
Artificial Intelligence
Department
University of Edinburgh
England

HOWE, Dr. James

Ph.D., Experimental Psychology, University of Cambridge, England, 1964; M.S. (Honors Class 1), Psychology and Political Economy, University of St. Andrews, 1960.

Dr. Howe is Professor and Director of the Artificial Intelligence Department at the University of Edinburgh, England (1978–1985).

Research interests include: the use of AI techniques in human learning, machine vision, the design and development of languages and tools for symbolic model building, AI software languages, AI tools, visual recognition, and AI research.

Founding Member, Department of Artificial Intelligence, University of Edinburgh, 1967; Researcher in human visual perception, Cambridge University; Chairman of the Society for the Study of Artificial Intelligence and Simulation of Behaviour; Chairman of the Alvey IKBS Advisory Committee.

Image Processing

KAK, Dr. Avinash

Ph.D., Indian Institute of Technology, Delhi, India; B.E., University of Madras, India, 1966. Professor, School of Electrical Engineering, Purdue University, 1970.

Research interests include: image processing and computed imaging.

Pattern Recognition

KASHYAP, Dr. Rangasami

Ph.D., Harvard University, 1965; M.E., Indian Institute of Science, 1962; B.S., University of Mysore, India, 1958. Professor, School of Electrical Engineering, Purdue University, 1966.

Research interests include: pattern recognition, database management systems, system identification and time series.

Visual Recognition, Medical Expert Systems

Associate Director
Computer Science Research
Laboratory
Rutgers University

KULIKOWSKI, Dr. Casimir

Ph.D. Professor of Computer Science and Associate Director, Laboratory for Computer Science Research, Rutgers University.

Research interests include: pattern recognition, expert system applications of pattern recognition, and medical expert systems.

Pattern Recognition

Associate Dean
of Engineering
Purdue University

LANDGREBE, Dr. David A.
Ph.D., 1962, M.S., 1958, B.S., 1956, Purdue University. Professor and Associate Dean of Engineering, Purdue University, 1956.

Research interests include: pattern recognition applications, signal representation, image data processing, and remote sensing systems.

Visual Recognition

Vice President
Printing and Packaging
Business Groups
Cognex Corporation

LAURENT, Louis A.
Vice President, Printing and Packaging Business Groups, Cognex Corporation.

Mr. Laurent joined Cognex in 1985, bringing with him over 18 years of market and sales development, and management experience within the Printing and Publishing Industry. Previously, he was the Director of Marketing for Commercial, Corporate and Videotex Publishing Markets for Atex, Inc.

He has successfully managed his own marketing consulting firm and has held several management positions with Compugraphic Corporation and Eastman Kodak Company.

Image Processing, Speech Processing, Digital Signal Processing

LIM, J.
Faculty, Department of Electrical Engineering and Computer Science, Purdue University.

Research interests include: image processing, including image restoration, enhancement and coding; speech processing, including analysis/synthesis, enhancement, coding, and time scale modification of speech; and theories of digital signal processing.

Image Understanding Assistants, Aerial Photo Interpretation via

McKEOWN, Dr. Dave
Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University.

Research interests include: image understanding with applications to aerial photo interpretation, interactive photo-interpretation assistants, and expert systems for automated analysis. Research includes: (1) MAPS, Image/Map Database Systems, DARPA IUS project image/map database system for the Washington, DC area. Users are able to interact with a high-resolution image display and query the database for the names, descriptions, and spatial relationships between natural and man-made map entities (see section on AI Schools, re: Carnegie-Mellon University, for a more complete MAPS project description); (2) SPAM, Expert Systems for Aerial Photo-Interpretation. One application underway is interpretation of airport scenes in the Washington, DC area; and (3) Computer Graphics for Digital Cartography.

Visual Recognition

Vice President
Operations
Cognex Corporation

METZGER, Robert J.

Mr. Metzger came to Cognex in 1983 from his successful management consulting business. His firm, founded in 1979, specialized in working with emerging high-technology companies in the Eastern Massachusetts area. Previously, he served as Vice President of Financial Planning for M/A-COM, a telecommunications and microwave company; and Controller for Disston, Inc., a tool company; and held numerous management positions at General Electric Company.

Visual Recognition

Vice President
Electronics and Industrial
Business Groups
Cognex Corporation

MORRIS, Ian G.
M.Sc., Electrical Engineering, B.Sc., Mechanical Engineering, Liverpool University, England. Vice President, Electronics and Industrial Business Groups, Cognex Corporation.

Mr. Morris has had over 20 years of marketing and management experience in the process control and manufacturing automation industries. Prior to joining Cognex in 1984, he was a management consultant for manufacturing automation and for process control ventures.

He also served as a Business Segment Manager and Systems Marketing Manager for the Foxboro Corporation, and Vice President of Operations for Transitron Special Products Division.

Machine Vision, Distributed Problem-Solving

LESSER, Dr. Victor R.
Ph.D. Professor, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: machine vision and distributed problem solving.

Image Processing (with emphasis on Perspective Effects)

NAKATANI, Hiromasa
AI Researcher, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: image processing with emphasis on perspective effects.

Visual Recognition

Vice President
Manufacturing
Cognex Corporation

PIANKIAN, Robert A.
M.S.E.E., Sloan School of Management, MIT; B.S., Electrical Engineering, Cooper Union for the Advancement of Science and Art. Co-founder and Vice President, Cognex Corporation.

Mr. Piankian has been with Cognex since its founding in 1981. Previously Director of Computer Hardware Engineering, Massachusetts General Hospital. He also served as a staff member of the Research Laboratory of Electronics at MIT, and was a lecturer in the Electrical Engineering Department, MIT.

Computer Vision, Biophysics of Computational Systems

POGGIO, Dr. Tomaso
Ph.D. Faculty, Artificial Intelligence Laboratory, MIT.

Research interests include: edge detection, spatio-temporal interpolations, stereo vision, motion, surface reconstruction, multigrid algorithms, computation of spatial properties, intelligent signal processing, biophysics of computational systems; application of regularization analysis to stereo matching structure-from-motion, and edge detection, aimed at understanding the computational mechanisms used by nervous systems, to show that single neurons are likely to be highly parallel devices performing hundreds of independent analog operations on their inputs.

Visual Recognition

Vice President
Corporate Accounts
Cognex Corporation

RIFKIN, Alfred
Vice President, Corporate Accounts, Cognex Corporation.

Mr. Rifkin joined Cognex in January 1982, before the company's first product had been delivered. He brought to Cognex over 20 years of management experience. Prior to joining Cognex, he was Vice President and General Manager of Identicon, a manufacturer of barcode systems. He was previously General Manager, International Division, Burroughs Corporation.

Parallel Associative Architecture for Vision

Chairman
Computer and Information Science Department
University of Massachusetts

Director
Computer Vision Laboratory
University of Massachusetts

RISEMAN, Dr. Edward
Ph.D., Cornell University. Professor and Chairman of the Computer and Information Science Department, University of Massachusetts.

Research interests include: knowledge-based vision, image segmentation, expert systems techniques for image interpretation, and parallel associative architecture for vision. Co-editor of *Computer Vision Systems.*

Computer Vision, Image Sequence Analysis

RUNSHENG, Wang
AI Researcher, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: computer vision and image sequence analysis.

Visual Shape Understanding

SHAFER, Dr. Steven
Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University.

Research interests include: shape understanding, studying mathematical models that show the relationships between object shapes, surface reflectance properties, illumination and images, developing realistic models of visual phenomena, optical modeling, and computer graphics and vision systems.

Visual Recognition, Intelligent Systems Applications of

Chairman, President, and *Co-founder*
Cognex Corporation

Founder
Pencept, Inc.

SHILLMAN, Dr. Robert J.
Ph.D., Electrical Engineering and Computer Science, MIT, 1974. Chairman and President, Cognex Corporation.

During his doctoral research, Dr. Shillman investigated human visual perception with the goal of building intelligent vision systems which emulate human sight. After receiving his degree, Dr. Shillman was appointed to the MIT faculty as a lecturer. At the same time, he began a consulting career in the field of automation.

Dr. Shillman has founded two high-technology companies. Cognex Corporation was established in 1980 with the goal of developing and marketing vision systems for industrial applications. Cognex's first product, DataMan, is capable of reading letters, numbers, and symbols directly from the surfaces of objects ranging from semiconductor wafers to rubber tires.

In 1978, Dr. Shillman founded Pencept, Inc., which manufacturers and markets a data entry terminal which has no keyboard. Penpad recognizes handprinted information as it is being generated.

Prior to his business ventures, Dr. Shillman pursued consulting in the fields of pattern recognition and artificial intelligence. He has been a consultant to Honeywell, Battelle Memorial Institute, The Forum Broadcast Information Service, and the Foreign Technology Division of the United States Air Force. In addition, he has provided technical and marketing assistance to Fortune 500 companies on a confidential basis.

He has assisted major corporations and the U.S. Government in automating data entry tasks such as mail sorting and the translation of documents written in Russian.

Dr. Shillman has authored numerous technical papers. (See bibliography.)

He is a member of the Systems, Man, and Cybernetics Society and the Biomedical Pattern Recognition Committee of the IEEE; and a member of numerous honorary societies.

Visual Systems Modeling, Experience Traces in Visual System

SPINELLI, Dr. D. N.

Ph.D. Professor, Computer and Information Sciences, University of Massachusetts at Amherst.

Research interests include: experience and memory traces in the visual system, neurophsiology of visual systems, adaptive network simulation and neural modeling, visual system modeling, visuomotor coordination, and instrumentation for biological research.

Visual Recognition

Vice President
Sales
Cognex Corporation

SPOTO, Vincent J.

Vice President, Sales, Cognex Corporation.

In January of 1985, Mr. Spoto was named to the new position of Vice President of Sales. As Print Market Manager for Cognex during 1983–1984, he worked with printers and office equipment manufacturers to solve quality problems using Cognex automatic inspection systems. Prior to joining Cognex, he held senior marketing and sales positions at Data Forms Co., and was President of Desk Data, a manufacturer of optical character recognition systems for office use.

Computer Vision

SRIHARI, Dr. Sargur N.

Ph.D., Ohio State University. Associate Professor, New York State University at Buffalo.

Research interests include: computer vision, expert systems, and spatial knowledge representation.

Parallel Image Processing

SWAIN, Dr. Philip H.

Ph.D., 1970, M.S., 1964, Purdue University; B.S. Lehigh University, 1963. Associate Professor, School of Electrical Engineering, Purdue University, 1970.

Research interests include: parallel image processing, pattern recognition, image processing, and remote sensing.

Visual Recognition, Expert Systems, AI Research

Director
Intelligent Machine Technology,
Infra-Red and Optic Division
Environmental Research
Institute of Michigan

Technical Council Chairman
Research and Development
Machine Vision Association,
SME

SWONGER, C. W.

M.S.E.E., Electrical Engineering, Massachusetts Institute of Technology, 1959; B.S.E.E., Electrical Engineering, Tufts University, 1957.

Director of Intelligent Machine Technology in the Infra-Red and Optics Division of the Environmental Research Institute of Michigan, where he directs research in image understanding, advanced MISD architectures for vision (recirculating pipelined cellular-array processors), languages for knowledge-based and morphological vision algorithm development, and 3-D radar-based robotic-vision. Previously, he directed development of algorithms and systems for 3-D machine vision for automotive and durable goods industries at Perceptron, Inc. (1981–1984). Directed development of mixed-font OCR systems, fingerprint image recognition systems, automatic target recognition systems, and self-organizing evolving automata, Cornell Aeronautical Laboratory — now Calspan Corp. (1961–1978).

Patents in fingerprint identification. Technical Council Chairman for Research and Development of the Machine Vision Association of the SME. Former national board member, National Computer Graphics Association. Consultant in machine vision and artificial intelligence. Numerous publications (see bibliography).

Research interests include: visual recognition, expert systems, and AI research.

Image Processing

TROXEL, D.

Faculty, Department of Electrical Engineering and Computer Science, Purdue University.

Research interests include: Image processing, applications of digital systems, and computer graphics.

Computer Vision

ULLMAN, Dr. Shimon

Ph.D. Faculty, Artificial Intelligence Laboratory, MIT.

Research interests include: developing a theory of computational vision relating biological and machine vision.

Visual Recognition

Vice President
Marketing
Penn Video, Inc.

Director
Automated Vision Associates

WAGNER, Gary

Vice President of Marketing, Penn Video, Inc., Akron, Ohio. Development and execution of marketing and sales; corporate planning and operations. Product development, market forecasting, market and sales development for a subsidiary company, Inspection Technology, Inc.

Developed three computer vision patents.

Professional associations: Director, Automated Vision Associates, Robotic Industries Association (RIA); Member, Machine Vision Associates, Society of Manufacturing Engineers.

Research interests include: visual recognition.

Computational Vision, Interactive Image Processing

WALTERS, Dr. Deborah K. W.
Ph.D., University of Birmingham, England. Assistant Professor, New York State University at Buffalo.

Research interests include: computational vision and interactive image processing.

Vision, High-Speed Parallel Processor for Vision

WEBB, Dr. Jon A.
Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Research interests include: vision, high-speed parallel processor for vision, and visual algorithms.

Image Processing and Understanding

WEISS, Richard
AI Researcher, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: image processing and understanding, and applications of differential geometry to three-dimensional shape description.

Visual Recognition, Expert Systems, Robotics

Co-founder and *President*
Advanced Information and Decision Systems

WISHNER, Dr. Richard P.
Ph.D., Electrical Engineering, 1960; M.S., Electrical Engineering, 1957; B.S., Electrical Engineering, 1956; University of Illinois.

Dr. Wishner is President and Co-founder of Advanced Information and Decision Systems (AI&DS) in Mountain View, California. AI&DS is focused on AI research and applications. Dr. Wishner's fields of specialization include radar, sonar, signal processing, computer science, and control.

Research interests include: visual recognition, expert systems, robotics, and determining the requirements and solutions to information processing and control problems.

His early research included the development and analysis of time and space processing for target detection; the development of optimal tracking, guidance resource allocation and emitter location algorithms; and the synthesis and analysis of advanced computer architectures. His recent work includes research and supervision of programs in artificial intelligence, image understanding, software engineering, decision-making, and estimation and control theory.

Visual Recognition, Expert Systems, Robotics

Director
University Computer Center
Computer and Information Sciences Department
University of Massachusetts at Amherst

WOGRIN, Dr. Conrad A.
Ph.D. Professor and Director of the University Computer Center, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: image processing, performance evaluation, and computer-aided instruction.

Visual Recognition

President
Vision Systems International

Board of Directors
Machine Vision Association, SME

ZUECH, Nello

M.B.A., City University of New York; M.B.E., New York University; B.E.E., Catholic University of America.

Mr. Nello is President of Vision Systems International, a machine vision application consulting firm, and conducts seminars on the subject of machine vision. Formerly Marketing Director, Object Recognition Systems; National Sales Manager, EMR-P/Schlumberger; Program Manager, National Science Foundation. Member of Machine Vision Association/SME (Board of Directors), IEEE Computer Group; Tau Beta Pi; Society of Machine Intelligence. Lectured widely in U.S. on machine vision.

Mr. Nello has been engaged in the field of machine vision, electro-optics, and factory automation for more than 15 years. He has been involved in the application of advanced manufacturing technology in a wide variety of manufacturing industries and their product processes — incoming inspection, forming and assembling operations, testing, packaging, warehousing, and work-in-process monitoring. He is experienced in installations of both dedicated and flexible machine vison.

Cognitive Modeling

Anderson, Dr. John
Lehnert, Dr. Wendy G.
Malin, Shlomo
Simon, Dr. Herbert

Cognitive Modeling and Architecture, AI Research

ANDERSON, Dr. John

Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Books include: *Human Association Memory*, with B. Bower (Erlbaum, 1973); *Language Memory and Thought* (Erlaum, 1976); *Cognitive Psychology and Its Implications* (Freeman, 1980); *Cognitive Skills and Their Acquisition* (Erlbaum, 1981); and *The Architecture of Cognition* (Harvard, 1983).

Memberships include: Psychonomic Society, American Psychological Association, Cognitive Science Society, and AAAI.

Dr. Anderson is a Walter Van Dyke Bingham Professor of Psychology and Computer Science.

Research interests include: cognitive modeling, skill acquisition, LISP and geometry tutors, language acquisition, and human-computer interaction.

Cognitive Modeling, Natural Language Processing, Knowledge Representation

LENHERT, Dr. Wendy G.

Ph.D. Associate Professor, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: cognitive modeling, natural language processing, and knowledge representation.

Cognitive Modeling, Expert Systems, Decision Support Systems

MALIN, Shlomo

M.A., Psychology, University of Minnesota, 1983; B.A., Statistics, University of Haifa, Israel, 1974.

Software and Knowledge Engineer, Human Edge Software. Co-author of knowledge-based microcomputer software.

Research interests include: cognitive modeling, expert systems, and decision support systems.

Cognitive Modeling

SIMON, Dr. Herbert

Ph.D. Faculty, Computer Science and Psychology Departments, Carnegie-Mellon University.

Research interests include: use of computers to simulate human thinking and learning; modeling expert and novice skills; programs that discover theories in data, such as the BACON program, that discovers regularities in empirical data; learning programs; and thinking-aloud protocols as data.

Heuristics, Inference, Reasoning

Heuristics, Mathematical Models of Problems and Inductive Logic

BANERJI, Dr. Ranan B.
Ph.D., Physics, University of Calcutta.

Dr. Banerji is a Professor of Mathematics and Computer Science at St. Joseph's University, Philadelphia, Pennsylvania.

Author of two books on heuristics.

AI interests include: mathematical models of problems and inductive logic for heuristic problem-solving. Additional interests include: ionospheric physics and propagation, coding theory, and languages and automata theory.

Heuristics, Expert Systems, Knowledge Representation

COHEN, Dr. Paul R.
Ph.D. Assistant Professor, Computer and Information Science Department, University of Massachusetts at Amherst.

Research interests include: expert systems, knowledge representation, cognitive science, and nonnumeric methods for reasoning about uncertainty.

Reasoning Under Uncertainty, Knowledge Representation

DING-YI, Tan
AI Researcher, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: reasoning under uncertainty and knowledge representation.

Reasoning, Decision Making, Heuristics

DOYLE, Dr. Jon
Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Research interests include: reasoning maintenance systems, nonmonotonic logic, decision making, and heuristic methods.

Problem Solving, Expert Systems, Inductive Inference

QUINLAN, Dr. J. R.
Ph.D., University of Washington, 1968; B.Sc., Sydney, 1965.

Senior Lecturer, Department of Computer Science, University of Sydney, Australia. Visiting Professor, Carnegie-Mellon University, Pittsburgh, Pennsylvania, 1968–1969.

Research interests include: problem solving, expert systems, and inductive inference.

Computational Inference Methods, Computer Vision

REYNOLDS, George D.

AI Researcher, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: computational inference methods, computer vision, knowledge representation, and hierarchical algorithms.

Computational Strategies in Reasoning, Knowledge Domains

RISSLAND, Dr. Edwina L.

Ph.D. Assistant Professor, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: computational strategies in reasoning, learning, explaining, structure of complex knowledge domains like mathematics, case-based reasoning and example generation, legal reasoning, intelligent user interfaces, and online explanation facilities.

Design and Implementation of Mechanical Procedures

ROBINSON, Dr. J. A.

Ph.D., Philosophy, Princeton University, 1956; M.A., Philosophy, University of Oregon; B.A., Classics, Corpus Cristi College, Cambridge, 1952.

Distinguished University Professor of Logic and Computer Science, Syracuse University, and Visiting Research Fellow, University of Edinburgh.

Formerly with E. I. du Pont de Nemours and Company as an operations research engineer; Postdoctoral Fellow, University of Pittsburgh; Faculty, Rice University, 1961; Professor of Computer Science, Rice University, 1963–1967.

Author of *Logic, Form, and Function* (Edinburgh Free Press, 1978).

Research interests include: design and implementation of mechanical deduction procedures.

Specialized AI Architectures, VLSI, Distributed Computation, Robust Concurrent Processing, Parallel Algorithms

Parallel Computation

APOSTOLICO, Dr. Alberto

Dipl. Perf., Computer Science, University of Salerno, Italy, 1976; Dr. Engineering, Electronics Engineering, University of Naples, Italy, 1973.

Associate Professor of Computer Sciences, Purdue University.

Before going to Purdue University, Dr. Apostolico was an Associate Professor of Computer Science at the University of Salerno, Italy. He has visited extensively at U.S. institutions, including Carnegie-Mellon University, the University of Illinois at Urbana-Champaign, and Renssalaer Polytechnic Institute, often teaching courses.

His research interests are currently in the areas of algorithmic analysis and design, computational complexity, data structures, parallel computation, combinatorics, and coding. His recent work deals with algorithms and data structures suitable for efficiently carrying out some manipulations on strings that are relevant to text editing, data compression, and picture processing. (See bibliography.)

Multiprocessor Architectures, Distributed Systems

ARVIND, Dr.

Faculty, Department of Electrical Engineering and Computer Science, Purdue University.

Research interests include: multiple processor architectures based on data flow concepts, functional programming languages, and distributed systems.

Parallel Computation

ATALLAH, Dr. Mikhail J.

Ph.D., Johns Hopkins University, 1982.

Assistant Professor of Computer Sciences, Purdue University (1982).

Research interests include: parallel computation, computational geometry, analysis of algorithms, and data structures. (See bibliography.)

Distributed Computation, Knowledge Embedding in, Heuristics in

BARBER, Dr. Gerald

Ph.D., M.S.E.E., B.A., University of Idaho. Faculty, MIT, Cambridge, Massachusetts.

Research interests include: the impact of distributed computational systems, knowledge engineering and reasoning systems in distributed computing environments, and knowledge-based office systems.

Robust Concurrent Processing

Founder
IEEE CS's Symposium on Reliability in Distributed Software and Database Systems

BHARGAVA, Dr. Bharat

Ph.D., Electrical Engineering, Purdue University, 1974.

Associate Professor of Computer Sciences, (1984).

Dr. Bhargava is interested in both theoretical and systems aspects of database and software design. He is investigating system structure and semantics that lead to robust concurrent processing in distributed systems. He is studying algorithms for concurrency control, site failure and network partition treatment, transaction commitment, and integrity checking. He is developing a prototype system (RAID) with facilities for specifying and evaluating various recovery control mechanisms.

Dr. Bhargava is the Founder of the IEEE CS's Symposium on Reliability in Distributed Software and Database Systems and a member of the Program Committee of the 1985 ACM SIGMOD Conference. (See bibliography.)

Highly Parallel Computation, Parallel Programming Languages

CUNY, Dr. Janice E.

Ph.D. Assistant Professor, Department of Computer and Information Science, University of Massachusetts at Amherst.

Research interests include: highly parallel computation and high-level parallel programming languages.

Parallel Processing, Distributed Database Systems

DAVIDSON, Dr. Susan

Ph.D., Princeton University.

Research interests include: parallel processing, distributed database systems, and analysis of algorithms.

Computer Systems Architectures, Concurrent Computation

DENNING, Dr. Peter J.

L.D., Honoris Causa, Concordia University, 1984; Ph.D., Electrical Engineering, MIT, 1968; M.S., Electrical Engineering, MIT, 1968; B.S.E.E., Manhattan College, 1964.

Adjunct Professor of Computer Sciences, Purdue University (1972).

Dr. Denning served as President of the Association for Computing Machinery (ACM) in 1980–1982. He earlier served as Vice President, Board Chairman, and and Member of Council. He has been Editor-in-Chief of ACM's Computing Surveys (1977–1978), Editor-in-Chief of the Communications of the ACM (1983–present), Consulting Editor for the MIT Press Computer Science Series (1983–present), and Associate Editor of various journals. He is a fellow of the IEEE and the AAAS.

Dr. Denning's primary research areas are computer systems architecture, performance modeling, and operating systems theory. Much of his early work dealt with optimal multiprogrammed memory management. He has also studied operational analysis, a new approach to performance

evaluation that deals with models of measured data rather than (untestable) models of the system that generated the data.

More recently, as Director of the Research Institute for Advanced Computer Science (RIACS) at the NASA Ames Research Center, he has initiated projects dealing with visual specification of highly concurrent computations and with intelligent systems that aid scientists in constructing solutions for problems using concurrent systems as components.

He is co-author of *Operating Systems Theory* (Prentice Hall, 1973) and *Machines, Languages, and Computation* (Prentice Hall, 1978). He is working with W. F. Tichy and J. P. Bouhana on *Computer Languages and Architecture* (to be published by Addison-Wesley). (See bibliography.)

Distributed Systems

DERTOUZOS, M.

Faculty, Department of Electrical Engineering and Computer Sciences, Purdue University.

Research interests include: distributed systems, computer graphics, and personal computers.

Massively Parallel AI Architectures

FAHLMAN, Dr. Scott

Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Research interests include: special, massively parallel architectures for AI; and Spice LISP and Common LISP.

Content Addressable Parallel Processors, Computer Architecture

FOSTER, Dr. Caxton C.

Ph.D. Professor, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: content addressable parallel processors, computer architecture, operating systems, performance measurements, and microprocessors.

Distributed Computation, Algorithm Analysis

FREDERICKSON, Dr. Greg N.

Ph.D., Computer Science, University of Maryland, 1977; M.S., Computer Science, University of Maryland, 1976; A.B., Economics, Harvard University, 1969.

Associate Professor of Computer Sciences, Purdue University (1982).

Before going to Purdue University, Dr. Frederickson was an Associate Professor of Computer Science at Pennsylvania State University. He is currently on the editorial board of *SIAM Journal of Computing.*

His interests include the analysis of algorithms, computational complexity, data structures, distributed computation, and graph algorithms. His work includes approximation algorithms for NP-hard problems, algorithms for selection in succinctly presented sets, space-efficient data structures, data structures for graph problems, data structures for online updating of solutions, and parallel algorithms for distributed networks. (See bibliography.)

Parallel Architecture, Computer Vision, Image Processing

GUERRA, Dr. Concettina
Dr. Sc., Mathematics, University of Naples, Italy, 1972.

Assistant Professor of Computer Science, Purdue University (1984).

Before going to Purdue University, Dr. Guerra was a Research Scientist with the University of Rome, Italy, and a visiting scientist with Carnegie-Mellon University.

Research interests include: computer vision and image processing, with emphasis on parallel architecture and algorithms. (See bibliography.)

Parallel Computation and Algorithms, Special-Purpose VLSI Chips

HAMBRUSCH, Dr. Susanne E.
Ph.D., Computer Science, Pennsylvania State University, 1982; M.S., Computer Science, Technical University of Vienna, 1977.

Assistant Professor of Computer Science, Purdue University (1982).

Dr. Hambrusch's primary research interests are in the area of parallel computation and VLSI layouts. She is interested in the complexity and the design of special-purpose VLSI chips and the development of efficient parallel algorithms. She is also investigating theoretical issues arising in placement and routing of VLSI layout systems. (See bibliography.)

Computer Architecture, Parallel Processing, VLSI Computations

HWANG, Dr. Kai
Ph.D., University of California, Berkeley, 1972; M.S., University of Hawaii, 1969; B.S., National Taiwan University, 1966.

Professor, School of Electrical Engineering, Purdue University (1974).

Research interests include: computer architecture, parallel processing, data flow computer, and VLSI computations.

AI Architectures, Massive Parallel Processor Networks, VLSI

KNIGHT, T.
Faculty, Department of Electrical Engineering and Computer Science, Purdue University.

Research interests include: architectures and programming languages for artificial intelligence applications, image and auditory perception, networks of massively parallel processors, and VLSI design and simulation tools.

Parallel Processing

LEE, Dr. Insup
Ph.D., Wisconsin. Assistant Professor of Computer and Information Science, University of Pennsylvania.

Research interests include: parallel processing, computer networks, compilers, operating systems, and programming languages.

Parallel Computation, VLSI

LEISERSON, C.
Faculty, Department of Electrical Engineering and Computer Science, Purdue University.

Research interests include: parallel computation, VLSI theory, analysis of algorithms, computer organization, and graph theory.

Parallel Implementations of Adaptive Numerical Algorithms

LUCIER, Dr. Bradley J.
Ph.D., Mathematics, University of Chicago, 1981; B.Sc., Mathematics, University of Windsor, 1976.

Assistant Professor of Mathematics and Computer Science, Purdue University (1981).

Dr. Lucier studies problems in scientific computation and the numerical and mathematical analysis of time-dependent partial differential equations. He is particularly interested in the numerical approximation of equations modeling fluid flow, such as the Euler equations of gas dynamics. He has achieved significant results with adaptive algorithms to solve fluid problems with shocks. Some of his recent efforts have been directed toward finding parallel implementations of adaptive numerical algorithms. (See bibliography.)

Distributed Computing

LYNCH, N.
Faculty, Department of Electrical Engineering and Computer Science, Purdue University.

Research interests include: theory of distributed computing; formal models, specification, algorithm design, complexity analysis, verification; distributed data management, synchronization, resource allocation, reliability; and complexity theory.

Parallel Processing

MA, Dr. Yuen-Wah, Eva
Ph.D., University of California, Berkeley.

Assistant Professor of Computer and Information Science, University of Pennsylvania.

Research interests include: parallel processing, computer architecture, analysis of algorithms, and computer networks.

Parallel Program, Mathematical Analysis of

MAYR, Dr. Ernst W.
Ph.D., Munich, 1980.

Assistant Professor of Computer Science, Computer Science Department, Stanford University.

Research interests include: mathematical analysis of parallel programs and systems, analysis of algorithms, and integrated circuits.

VLSI

McCRACKEN, Dr. Don
Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University.

Research interests center around how to design and build VLSI implementations, such as ZOG, a general human-computer interface for providing many different functions, such as project management, document production, database storage and retrieval, and mail and bulletin boards. There is currently a ZOG-based application running on a network of 29 PREQ personal computers onboard the USS Carl Vinson, one of the Navy's newest nuclear-powered aircraft carriers. (For a more complete description of ZOG, see AI Schools, re: Carnegie-Mellon University, ZOG project.)

Other research interests include: converting ZOG to SPICE, ZOG as a programming environment, and statistical analyses of ZOG usage.

Parallel Architectures, Parallel Algorithm Verification, VLSI

MELHEM, Dr. Rami G.

Ph.D., Computer Science, University of Pittsburgh, 1983; M.S., Computer Science, University of Pittsburgh, 1981; M.A., Mathematics, University of Pittsburgh, 1981.

Assistant Professor of Computer Sciences, Purdue University (1984).

Dr. Melhem's primary research area is parallel computation. He is particularly interested in the design of special-purpose parallel architectures, the formal verification of parallel algorithms, and the study of synchronization mechanisms for VLSI computing networks. (See bibliography.)

Parallel Processing

MOWBRAY, Dr. Thomas

Ph.D., University of Southern California, 1983; M.S.E.E., Stanford University, 1979; B.S.E.E., University of Illinois, 1978.

Assistant Professor, School of Electrical Engineering, Purdue University (1983).

Research interests include: parallel processing, data flow computers, programming languages, and computer architecture.

Parallel Processing

NEMES, Dr. Richard M.

Ph.D., CUNY. Faculty, Rutgers State University at New Brunswick, New Jersey (1985).

Research interests include: parallel programming.

Distributed Systems

RAMAMRITHAM, Dr. Krithivasan

Ph.D. Assistant Professor, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: distributed systems.

Vector Computing, Computer Organization, Performance Evaluation

Director
University Computing Center
Purdue University

Founder
Communications of the ACM
Association of Computing Machinery

ROSEN, Dr. Saul

Ph.D., University of Pennsylvania, 1950.

Professor of Mathematics and Computer Sciences and Director of the University Computing Center, Purdue University (1962).

Dr. Rosen has been awarded an ACM Distinguished Service Award for his work in founding the "Communications of the ACM." He is editor of the *Annals of the History of Computing*, and edited the book *Programming Systems and Languages* (McGraw-Hill, 1967). (See bibliography.)

Research interests include: vector computing, computer organization, operating systems, performance evaluation, programming languages, and the history of computers.

Cognitive Architectures, Connectionist Systems

ROSENBLOOM, Dr. Paul

Ph.D., Carnegie-Mellon University, 1983.

Assistant Professor, Department of Computer Science, Stanford University.

Research interests include: cognitive architectures, cognitive psychology, connectionist systems, learning, and memory.

Parallel Processing

SIEGAL, Dr. Howard

Ph.D., 1977, M.S.E., 1974, M.A., 1974, Princeton University; B.S., MIT, 1972.

Associate Professor, School of Electrical Engineering, Purdue University (1976).

Research interests include: parallel processing, multi-microprocessor systems, computer architecture, and image and speech processing.

Distributed Operating Systems, High-level Database Design

STEMPLE, David W.

Ph.D. Associate Professor, Computer and Information Sciences, University of Massachusetts at Amherst.

Research interests include: distributed operating systems, high-level database design, verification applied to database systems, and human factors in computer-user interface.

Specialized AI Architectures, Hardware, Expert Systems, Voice Recognition

Project Head and *Principal Architect*
DADO Parallel Computer Project
Columbia University

STOLFO, Dr. Salvatore J.

Ph.D., Computer Science, 1979; M.S., Computer Science, Courant Institute of Mathematical Sciences, 1976; B.A., Computer Science and Mathematics, Brooklyn College of the City University of New York, 1974.

Project Head and Principal Architect of the DADO Parallel Computer Project at Columbia University. The DADO machine is a large-scale parallel machine designed for expert systems and speech recognition tasks. Co-developer of the ACE expert system for telephone cable maintenance marketed by AT&T Technologies. Honored with the IBM Faculty Career Development Award (1984–1985).

Consulting and professional activities: Chief Scientific Advisor, Fifth Generation Computer Corporation (1985–present); Session Chairman, Expert Systems in Government Conference, IEEE (1985); Bell Laboratories (1980–1985), Consultant on the Knowledge-Based Expert Systems Project, Whippany. Implemented with Bell Laboratories staff a working expert system, called ACE, that has developed into an AT&T product. The system is offered for sale.

The DADO computer is a special-purpose machine based on thousands of small processing elements to accelerate AI computation. Large-scale funding has been acquired for the development of DADO prototype machines over the past several years.

Reviewer: Parallel Processing Conference, NSF proposals, and various technical workshops and symposia.

Numerous publications (see bibliography).

Research interests include: specialized parallel architectures for AI, knowledge engineering, and machine learning.

Massive Parallel Computing Systems, Knowledge Representation in

TOURETZKY, Dr. David

Ph.D., Computer Science, Carnegie-Mellon University, 1984; B.S., Computer Science, Carnegie-Mellon University, 1979; B.A. (Cum Laude, Henry Rutgers Scholar), Computer Science, Rutgers University.

Dr. Touretzky is a Research Associate in the Computer Science Department at Carnegie-Mellon University. He is working on a formal semantics for the NETL knowledge representation language designed to run on a marker propagation machine type of parallel architecture; to research parallel inference algorithms.

Author of *Lisp: A Gentle Introduction to Symbolic Computation* (Harper & Row, 1984) and other publications. (See bibliography.)

Honors include Phi Beta Kappa and Sigma Xi; he was a Fannie and John Hertz Foundation Fellow (1978–1983).

Additional research interests include: cooperative computation in neural networks and biochemical computation.

Distributed Computation

TSITSIKLIS, J.

Faculty, Department of Electrical Engineering and Computer Science, Purdue University.

Research interests include: distributed computation, large-scale systems and decentralized control, and stochastic control.

Parallel Processes, Programming Applications and Modeling

VAN EMDEN, M. H.

Ph.D. Associate Professor, Department of Computer Science, University of Waterloo, Canada.

Dr. van Emden has pursued AI research at the University of Edinburgh, the IBM T. J. Watson Research Center, and the Mathematical Center in Amsterdam.

Research interests include: applications of logic programming, logic modeling of software systems in databases, parallel processes, and programming methodology and language design.

Parallel Computation

WAGSTAFF, Jr., Dr. Samuel S.

Ph.D., Cornell University, 1970.

Associate Professor of Computer Science, Purdue University (1983). Before going to Purdue University, Dr. Wagstaff taught at the Universities of Rochester, Illinois, and Georgia. He spent a year at the Institute for Advanced Study in Princeton.

At present, he and J. W. Smith of the University of Georgia are building a special processor with parallel capability for factoring large integers. (See bibliography.)

Research interests include: cryptography, parallel computation, and analysis of algorithms, especially number theoretic algorithms.

Parallel Processing Architecture, Distributed Networks

WAH, Dr. Benjamin W-S

Ph.D., 1979; M.S., University of California, Berkeley, 1976; M.S., 1975, B.S., 1974, Columbia University.

Assistant Professor, Department of Electrical Engineering, Purdue University (1979).

Research interests include: parallel processing architecture, distributed computers and networks, and distributed database systems.

Concurrent Control in Distributed Systems

WEIHL, W.

Faculty, Department of Electrical Engineering and Computer Science, Purdue University.

Research interests include: distributed systems, especially concurrency control and fault tolerance; programming methodology; software tools and environments; programming languages; and formal specification.

Parallel Problem Solving

WIEDERHOLD, Dr. Gio

Ph.D., Medical Information Science, University of California, San Francisco; B.S. (Cum Laude), Aeronautical Engineering; TMS Technicum, Rotterdam, Holland.

Dr. Wiederhold is Associate Professor (Research) of Medicine, Computer Science, and Electrical Engineering at Stanford University. He is currently Principal Investigator of projects in knowledge-based management systems (ARPA/DOD), database logic (SRI International), and knowledge extraction from medical databases (NLM/DHHS). Also, he is presently a consultant for the National Center for Health Services Research, the United Nations Development Program, the National Academy of Science, Artificial Intelligence and Decision Systems, the Institute for Defense Analysis, Apple Computers, Think Technologies, and U.S. Air Force VHSIC Data Management Task Force.

Previously, he was project manager in Medical Information Systems at the University of California, San Francisco (1974–1975); Staff Consultant, Stanford University Hospital (1971–1973); Manager, Systems Design at Multi-Access Systems Corporation (1970); Director of Program and Terminal Development, Reeves Telecom (1969–1970); Lecturer, Computer Science, Stanford University (1965–1976); Director of Advanced Computer for Medical Research and Associate Director of the real-time facility at the computation center at Stanford University (1965–1970); Head of Programming, University of California (Berkeley) Computer Center (1961–1965); Programmer and Senior Programmer, IBM Service Bureau (1958–1961); Technical Assistant, SHAPE Air Defense, Technical Bureau, The Hague, Holland (1958)

Dr. Wiederhold is the recipient of numerous honors and awards, and serves on the editorial boards of *TODS (ACM Transactions on Database Systems*, *IEEE Computer Magazine*, and *MD Computing*. Also, he is Chairman of the Board, Pacific Software. His professional associations include ACM, AAAS, AIAA, ACL, IEEE, TIMS, and the Combustion Institute.

He is the author and co-author of extensive publications, including three books: *Database Designs* (McGraw-Hill, 1977), *Databases for Health Care* (Springer Verlag, 1981) and (with L. Fagan), *An Introduction to Medical Computer Science* (Addison-Wesley, work in progress). (See bibliography.)

Research interests include: parallel problem solving, system design (databases and distributed systems) and applications in medicine, planning, and business.

Development Tools for Concurrent Systems, Software Design

WILEDEN, Dr. Jack C.

Ph.D. Associate Professor, Computer and Information Sciences Department, University of Massachusetts at Amherst.

Research interests include: development tools for concurrent systems, software specification and design, software development environments, programming methodology, and programming languages.

AI Workstations, AI Hardware

AI Workstations, AL Software Languages

Manager
Aerospace Division
LISP Machine, Inc.

CARLETON, David

Manager, Aerospace Division, LISP Machine, Inc. Previously Engineering Manager in Control System Research at Northrop Aircraft, where he worked with high-order languages for real-time programming.

AI Workstations

Manager
Advanced Planning
LISP Machine, Inc.

CREEGER, Morris J.

M.S., Artificial Intelligence, University of Maryland.

Mr. Creeger is Manager of Advanced Planning at LISP Machine, Inc. (LMI). He has worked on database validation and plan synthesis for the Naval Research Laboratory and Jet Propulsion Laboratory. Also, he was Project Manager at Honeywell.

Intelligent Workstations

Co-founder
Daisy Systems Corporation

FINEGOLD, Aryeh

B.S., Electrical Engineering, Technion-Israel Institute of Technology.

Mr. Finegold co-founded Daisy Systems Corporation in order to design the LOGICAN, a computer workstation for VLSI design. Prior to 1980, Mr. Finegold worked at Intel, where he was responsible for input/output architecture in the product line architecture department. Directed logic design and prototyping of the 8089 input/output processor; developed an application system for the 8089.

Research interests include: intelligent workstations.

AI Workstations, AI Software Languages, AI Tools, AI Systems

Co-founder
LISP Machine, Inc.

GREENBLATT, Richard

Co-founder of LISP Machine, Inc. (LMI), a company that develops LISP machine computers and software, where he is currently Technical Director of Engineering.

Researcher, Artificial Intelligence and Computer Science Laboratory at Massachusetts Institute of Technology, where he co-founded the LISP Machine Project. Developed chess-playing programs and computers, notably MACK HACK VI, the first chess program to compete successfully against humans.

Research interests include: AI software languages, AI workstations, AI tools, AI system design, AI resources, AI hardware, AI research, expert systems, natural language, voice recognition, robotics, and visual recognition.

AI Workstations, Marketing and Sales

Vice President
Marketing and Sales
LISP Machine, Inc.

JOHNSON, Kenneth
B.S., Business Administration, DePaul University.

Vice President, Marketing and Sales at LISP Machine, Inc. (LMI). Before joining LMI, Mr. Johnson was Product Marketing Manager at Xerox Computer Services and later the National Manager for Sales Support.

AI Workstations

Vice President
Manufacturing
LISP Machine, Inc.

MEAD, Robert D.
B.S., University of Lowell; B.A., San Jose State College.

Vice President, Manufacturing at LISP Machine, Inc. (LMI). Previously, 10 years with IBM and 5 years as Product Group Manufacturing Manager with Digital Equipment Corporation.

AI Workstations

Vice President and *CFO*
LISP Machine, Inc.

MILLER, Steven
M.B.A., Business Administration, University of California, Los Angeles; B.A., Business Administration, University of California, Los Angeles.

Mr. Miller is Vice President and CFO at LISP Machine, Inc. (LMI). Before joining LMI, he gained over 17 years of experience in corporate finance, including 10 years with Occidental Petroleum Company as Assistant Treasurer in Occidental Finance Corp., and earlier as Director of Financial Planning.

AI Workstations

Vice President
Process Systems Division
LISP Machine, Inc.

MOORE, Dr. Robert
Ph.D., Electrical Engineering, Massachusetts Institute of Technology; M.S., Electrical Engineering, Massachusetts Institute of Technology.

Mr. Moore is Vice President of Process Systems Division at LISP Machine, Inc. (LMI). Previously, he was President of the U.S. subsidiary of Sentrol Ltd.,Director of Engineering and Manufacturing for the Measurement Systems Division of Gould, Inc., and Principal Engineer of the Digital Systems Division of Foxboro Company.

AI Workstations, AI Tools, AI Hardware, AI Software Languages

President and *Founder*
Symbolics

Co-founder
Pertron Controls, Inc.

NOFTSKER, Russell
B.S.E.E., Electrical Engineering, New Mexico State University.

Mr. Noftsker is President and Founder of Symbolics, Inc. Consultant during the company's organization period for General Motors in computer resistance welding controls. Previously, Mr. Noftsker co-founded Pertron Controls, Inc., a manufacturer of programmable microcomputer resistance welding controls; Chief Engineer and General Manager, Massachusetts Institute of Technology Artificial Intelligence Laboratory (1965–1974).

Research interests include: AI workstations, AI tools, AI hardware, AI software language, expert systems, and AI research.

Workstations, AI Software Languages, AI Tools

Marketing Manager
AI Technical Products Division
Data General

PIPER, Charles
Mr. Piper is Marketing Manager, AI, Technical Products Division, Data General, Englewood, Colorado.

AI Workstations

Vice President
Customer Service
LISP Machine, Inc.

RANDO, Ron

Vice President, Customer Service at LISP Machine, Inc. (LMI). Previously in customer support at Digital Equipment Corporation and Apollo Computer, Inc., where he was manager of North American Customer Support.

AI Workstations

President and *COO*
LISP Machine, Inc.

SPITZNOGLE, Dr. Frank

Ph.D., Physics, University of Texas; M.B.A., Business Administration, University of Dallas.

Dr. Spitznogle is President and Chief Operating Officer at LISP Machine, Inc. (LMI). Before joining LMI, he was Manager of Strategic Analysis in Corporate Strategic Planning at Texas Instruments and Manager of Advanced Systems in the Digital Systems Division at Texas Instruments.

Research interests include: AI workstations.

AI Workstations

Vice President
Engineering
LISP Machine, Inc.

THOMAS, Dan

Oklahoma State University.

Mr. Thomas is Vice President of Engineering at LISP Machine, Inc. (LMI). He has been in engineering management for over 35 years.

Supercomputers

Supercomputers, Software Applications for

Director
Purdue Center for
Parallel and Vector Computation
Purdue University

GANNON, Dr. Dennis B.

Ph.D., Computer Sciences, University of Illinois, 1980.

Assistant Professor of Computer Sciences, Purdue University (1980); Director, Purdue Center for Parallel and Vector Computation (1985).

The focus of current work is development of software systems for applications of supercomputer technology. The work involves applications and operating system software for a 64-processor MIND prototype of the CHiP architecture and the Cyber 205 supercomputer. Applications include the numerical solution of partial differential equations, computer graphics, and combinatorial problems. A variety of programming language design projects are also underway. One goal of his work is to aid in the design of computing systems built from large arrays of processing elements implementable with VLSI technology. His earlier research involved the study of self-adaptive methods and software for the numerical solution of partial differential equations, and the study of differential topology and mathematical physics. (See bibliography.)

Supercomputers, Parallel Computing, Relational DB Management

HILLYER, Bruce K.

Ph.D. Candidate at Columbia University; B.S., Computer Science, Columbia University; B.A., Mathematics, Princeton University.

Mr. Hillyer has been involved with NON-VON Supercomputer Project since its inception. His thesis research concerns large rule-based expert systems on VLSI parallel "next generation" supercomputers.

Research interests include: supercomputers, parallel computing, relational database management, and AI production systems.

Supercomputers, Vision Systems for; Cognitive Modeling

HINTON, Dr. Geoffrey

Ph.D. Faculty, Departments of Computer Science and Psychology, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Research interests include: stochastic parallel computation in vision and representation of shapes. Interests also include: models of knowledge representation that use distributed patterns of activity rather than single units of hardware to represent individual items.

Supercomputing, Cross-Omega Connection Machine

Project Leader
Cross-Omega Connection
Machine Project
Artificial Intelligent Laboratory,
MIT

KNIGHT, Dr. Thomas

Ph.D. Faculty, Artificial Intelligence Laboratory, MIT.

Leader of the Cross-Omega Connection Machine Project in the AI Laboratory at MIT.

Research interests include: intelligent supercomputing and integrated circuit design.

Supercomputer and Multiprocessor System Programming Languages

MEHROTRA, Dr. Piyush

Ph.D., Computer Science, University of Virginia, 1982; M.Phil., Computer Science, J. L. Nehru University, India, 1978; M.S., Physics, University of Delhi, India, 1976.

Assistant Professor of Computer Sciences, Purdue University (1984). Before going to Purdue, Mr. Mehrotra was a staff scientist at the Institute for Computer Applications in Science and Engineering, NASA Langley Research Center in Hampton, Virginia. His primary research area is programming languages for supercomputers and multiprocessor systems. He is currently involved in designing parallel programming language for scientific computations.

Research interests include: multiprocessing in general, ranging from architecture and operating systems and algorithms for such architectures. (See bibliography.)

Supercomputers, Intelligent Architectures, Algorithm Discovery

NEWELL, Dr. Allen

Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University.

Member of the Committee on Social Science Research in Computing.

Research interests include: intelligent architectures, such as SOAR, that embody a large number of critical mechanisms for a general intelligent agent; supercomputers, production system machines; algorithm discovery; user-computer interaction; and social and organizational phenomena surrounding computers (social effects of computers).

Supercomputers, Numerical Methods for Parallel Computation

Founder
ACM Transactions on Mathematical Software

RICE, Dr. John R.

Ph.D., California Institute of Technology, 1959. Professor of Mathematics and Computer Sciences, Purdue University, 1964.

Professor Rice is Founder and Editor-in-Chief of *ACM Transactions on Mathematical Software*, and on the editorial boards of *Information Sciences* and *Acta Informatica*. He was previously Chairman of the ACM Special Interest Group on Numerical Mathematics (SIGNUM) and was the George Forsythe Lecturer in 1975.

His work in approximation theory for the past 25 years has touched upon almost all facets of this area.

In the area of ordinary and partial differential equations, Dr. Rice has developed high-order efficient methods and made method performance evaluations.

For the past 10 years, Dr. Rice has been analyzing numerical methods for parallel computers, especially for approximation, quadrature and partial differential equations. He is active in software systems and languages for supercomputers and large-scale scientific computation.

In the 1960's, Dr. Rice supervised the design and implementation of the language NAPSS — a Numerical Analysis Problem Solving System, which included symbolic and numerical facilities. Recently, he designed the PROTRAN language and system to extend FORTRAN to include problem-solving facilities from the IMSL library. He is active in other language projects and problem-solving environments for scientific computing, especially for parallel computation and array processing.

The specialty of mathematical software was launched at Purdue by Professor Rice in 1970. His work in this area has involved creating a general methodology for performance evaluation of mathematical software and developing the ELLPACK software system for elliptic partial differential equations. An active program of software performance evaluation is continuing using the ELLPACK system.

Dr. Rice has published 13 books, three in approximation theory, six elementary texts for computer science, one in numerical methods, and three in mathematical software. The most recent are: *Solving Elliptic Problems with ELLPACK* (Springer-Verlag, 1984), *Numerical Methods, Software, and Analysis* (McGraw-Hill, 1983), and *Matrix Computation and Mathematical Software* (McGraw-Hill, 1981). (See bibliography.)

Research interests include: piecewise polynomials, splines, and adaptive methods.

Supercomputer Test-Bed Architectures, Parallel Computation

SEGALL, DR. Zary

Ph.D. Faculty, Department of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

Research interests include: large-grain parallel computation; parallel computers; parallel computer architectures; parallel computer programming techniques; multiprocessor performance evaluation — study of parallel algorithms and their implementation, parameterization of multiprocessor systems, study of cost-per-feature in distributed architectures and operating systems, study of methodology for instrumenting a multiprocessor; supercomputer test-bed architecture; parallel programming and instrumentation environment (PIE).

Supercomputers

Director
NON-VON Supercomputer Project
Columbia University

SHAW, Dr. David Elliot

Ph.D. and M.S., Computer Science, Stanford University.

Associate Professor, Columbia University Computer Science Department and Director of NON-VON Supercomputer Project. This is a next-generation machine based on custom VLSI chips.

The NON-VON Supercomputer Project is currently building NON-VON 3, one of the fastest computers ever built in terms of peak aggregate throughput.

Also served 3 years as President of Stanford Systems Corporation.

Networks

Comer, Dr. Douglas E.

Networks

Director
TILDE Network Research Scientist
Pennsylvania State University

COMER, Dr. Douglas E.

Ph.D., Pennsylvania State University, 1976. Professor of Computer Sciences, 1976.

Dr. Comer is currently Director of the TILDE Network Service Research Project. He was formerly Director of the Purdue CSNET Project and Manager of the departmental research computing facilities.

He has supervised many software design and implementation projects. He is the author of *Operating System Design: The Xinu Approach* (Prentice-Hall, 1983). (See bibliography.)

His research interests span a variety of areas, including computer networks, operating systems, algorithm analysis, data storage and retrieval, and programming languages.

Students' and Researchers' Guide to AI Schools, AI Labs and Thinktanks

AI Schools

Carnegie-Mellon University
Department of Computer Science

Ph.D. Faculty with AI research interests are shown below:

Faculty	Research Interests	Research Projects
Anderson, J.	Cognitive Modelng	ACT; Human/Computer Interaction
Andrews, P.	Automated Theorem Proving	ETPS; TPS
Berliner, H.	Knowledge Representation	Chess Machine, SWIMR
Bisiani, R.	Speech Recognition	DSN; Speech Understanding; VLSI
Carbonell, J.	Robust Natural Language Interface, Knowledge Representation	ARIES; Machine Learning; Natural Language, World Model; XCALIBUR
Doyle, J.	Reasoning, Decision Making, Heuristics	TEX
Ellison, R.	Design and Programming Environments	GANDALF
Eshelman, L.	Knowledge-Based Financial Planning	PFP (Personal Financial Planning)
Fahlman, S.	Massively Parallel AI Architectures	Boltzmann Machine; LISP; NETL; SPICE
Forgy, C.	Rule-Based Programming Languages for Parallel Implementations	OPS; Production System Machine
Hayes, P.	Natural Language, Knowledge Representation	COUSIN, Robust Natural Language Processing; SPICE
Herman, M.	Computer Vision, Image Inderstanding	Image Understanding, 3-D Mosaic
Hinton, G	Supercomputers, Vision Systems for	Boltzmann Machine
Kahn, G.	Drilling Fluids Expert Systems	MUD; MORE
Kanade, T.	Robotics, 3-D Robot Vision	Direct-Drive Arm; Image Understanding
Kant, E.	Automating Algorithms Design	Designer
Kulich, K.	Natural Language, Expert Systems	ILOG; XESL
Mason, M.	Robotics	
McCracken, D.	VLSI	ZOG
McDermott, J.	Expert Systems	CAT; MUD; PFP; PTRANS; SPAM; XSEL
McKeown, D.	Image Understanding Assistants, Aerial Photo Interpretation	Image Understanding; MAPS; SPAM
Newell, A.	Supercomputers, Intelligent Architectures, Algorithm Discovery	CSSRC; GCA; MINT; Production System Machine; SPICE; Supercomputer; ZOG
Raibert, M.	Robotics	Legged Locomotion, VLSI
Reddy, R.	Robotics	DSN; Speech Underwriting
Rudnicky, A.	Speech Recognitoin, Speech Synthesis	Speech Understanding
Segall, Z.	Parallel Computation	Parallel Air Traffic Control; Programming and Instruction; Supercomputer; TRAM
Shafer, S.	Visual Shape Understanding	Image Understanding
Siewiorek, D.	Multiprocessor Architecture	Supercomputer
Simon, H.	Cognitive Modeling	
Touretzky, D.	Massively Parallel Computing Systems, Knowledge Representation	Boltzmann Machine; NETL
Webb, J.	Vision, High-Speed Parallel Processor for	DSN; Image Understanding

AI projects and associated AI researchers are briefly discussed below.

CARNEGIE-MELLON AI PROJECTS

ACT: Anderson

Theory of human cognition, embodied as a computer simulation program with a production-system interpreter operating on a semantic network database. The production system embodies cognitive skill. The semantic network provides a long-term memory of facts. The system is intended to provide a general model of human cognition and has been applied successfully to the simulation of human learning, memory, reasoning, language processing, and problem solving. Current research includes skill acquisition.

ARIES: Carbonell

Analogical Reasoning and Inductive Experimentation System. A process model of problem solving by analogy, based on means-ends analysis, that assumes when the problem solver encounters a new problem, it is reminded of past situations similar to the current problem, then recalls past problem-solving behavior. Then the recalled past experience is mapped into a plausible solution to the present problem. Relevant aspects of new behavior increases the problem solvers repertoire of problem-solving experience for future situations. A rudimentary form of experimental learning occurs as a byproduct of the analogical problem-solving paradigm.

Boltzmann Machine: Fahlman; Hinton; Touretzky

Pertaining to massively parallel networks of neuron-like processors, a new type of computation based on the use of statistical mechanics as a tool for analyzing the behavior of large networks of stochastic computing elements.

CAT: McDermott

Will monitor and assess threats to the aircraft carrier USS Carl Vinson and recommend possible actions to counter those threats. A major focus is to explore ways of dealing effectively with massive amounts of uncertainty.

Chess Machine: Berliner

A chess machine designed to examine a large number of alternative chess positions in a short period of time, existing on a host, and having a number of machines doing different tasks in parallel under the supervision of a microcoded supervisor machine. The design of a move generator chip in VLSI has been completed (by Carl Ebeling). The speed of this move generator will be greater than that achieved by any other previous designs. These chips will make up the move generator machine.

Common LISP: Fahlman

Code has formed the basis for several other Common LISP implementations, including VAX, under VMS and Unix, and for the DEC-20 system.

COUSIN: Hayes

COoperative USer INterface project aims to develop an interactive user interface more advanced and more friendly than those now existing, and application independent.

CSSRC: Newell

Committee on Social Science Research in Computing, looking at social and organizational effects of a CMU-IBM agreement for a campus-wide microcomputer network.

Designer: Kant

Goals of the project are to implement an AI program that designs a variety of algorithms and programs from specifications of the inputs and desired outputs; and to gain a better understanding of the human design process. The initial focus in on creating an algorithm sketch from input-output specifications rather than on transforming high-level algorithm descriptions into program code.

Distributed Sensor Networks (DSN): Reddy; Webb

A multiprocessor implementation on VAXs and PREQs for speech and visual recognitin projects.

ETPS: Andrews

A varient of TP5, Educational Theorem Proving System, is used as an interactive aid in logic courses. TPS is a computerized approach to automated theorem proving.

GANDALF: Ellison

An integrated system to support development. Includes a language-oriented editor, an incremental compiler and loader, and a structure for managing the project and maintaining system consistency among multiple programmer. Knowledge processing is to be included.

Generalized Cognition Architecture (GCA): Anderson

A special program to use cognitive models of the computer user to guide design of computer systems and education of users.

ILOG: Kulich

A preliminary attempt to transfer the XSEL explanation generation technique and code to another expert system, ILOG.

Image Understanding: Herman; Kanade; McKeown; Shafer; Webb

3-D Mosaic System. Interfacing vision with CAD 3-D models. The Image Understanding Systems (IUS) project is a DARPA-sponsored project to develop systematic methods for automating vision; i.e., understanding a scene from images. Related to knowledge-based and computational approaches to vision, rather than simple picture-data processing approaches. Image understanding includes a range of issues from low-level signal processing to high-level intelligent use of knowledge and reasoning. Projects include: Shape Understanding; Incremental 3-D Mosaic; Vision Algorithms on WARP.

Legged Locomotion: Raibert

Legged-running machine; currently building a full three-dimensional one-legged device to lead to more versatile walking machines.

Machine Learning: Carbonell

Modeling aspects of human learning, such as incrementally improving natural language understanding capabilities, acquiring problem-solving strategies, and utilizing a reactive environment to continuously test and monitor the learning process.

MAPS: McKeown

Image/Map Database System, Map-Assisted Photo-Interpretation System; developed as part of the DARPA IUS project, is a image/map database system for the Washington, DC area, which contains approximately 100 high-resolution aerial mapping images, a digital terrain (elevation) database, and map databases from United States Geological Survey (USGS) and Defense Mapping Agency (DMA). Users are able to interact with a high-resolution image display and query the database for the names, descriptions, and spatial relationships for natural and man-made map entities. Current research involves the application of spatial knowledge to navigate through a map database, and support for complex queries that arise in cartography.

MORE: Kahn

Knowledge acquisition system, elicits domain information from an expert then maps this information into a causal model and generates corresponding diagnostic rules.

MUD: Kahn; McDermott

Monitors the state of oil well drilling fluids, diagnoses the causes of any problems which arise, and recommends treatment. A major focus of this project was to gain a better understanding of the strengths of an evidential as opposed to a causal approach to diagnostic reasoning.

NETL: Fahlman, Touretzky

NETL architecture, a sort of semantic network machine in which each entity and relationship is represented by its own very simple hardwire element, and in which certain essential searches and deductions are performed by the parallel flow of single-bit markers through this network. The NETL knowledge representation language is designed to run on a parallel architecture known as a marker propagation machine.

Net Generation Air-Traffic Control

OPS: Forgy

OPS languages and production systems.

PFP: Eshelman; McDermott

Personal Financial Planning knowledge-based expert system. Given a client's financial goals and an initial set of client data, PFP uses its financial expertise and additional information solicited from the client to explore opportunities that help the client achieve financial goals. A major focus of this research has been to explore ways of representing and integrating large amounts of diverse, incomplete, and uncertain sources of knowledge in order to produce intelligent recommendations of varying degrees of concreteness.

Production System Machine: Forgy; Newell

Supercomputers, production-system architectures, special processor architectures, parallelism, and high-speed technology.

Programming and Instrumentation: Segall

PIE; research in parallel processing programming environments; and in monitoring parallel processing.

PTRANS: McDermott

Assists with managing the manufacture and distribution of DEC's computer systems; ability to generate plans and then modify plans in response to unexpected events.

Robust Natural Language Processing: Carbonell; Hayes

Flexible construction-specific parsing; error recovery and negotiation; conversational modeling.

SPAM: McDermott; McKeown

Assists with the interpretation of high-resolution aerial photographs, using an image/map database, a collection of image processing tools, and a rule-based system whose domain of expertise is airports.

Speech Understanding: Bisiani; Reddy; Rudnicky

Distributed speech understanding systems effort, under the ARPA Strategic Computer Program, has a goal of building a 10,000-word vocabulary speaker-independent speech recognition system capable of taking dictation. Involves a multiprocessor implementation on VAXs and PREQs.

SPICE: Barbacci; Fahlman, Hayes; Newell

SPICE Ada+ programming environment, designing and implementing Ada+ for the SPICE environment. Ada+ is standard Ada with some extensions. Aspects of Ada+ include: the tools in the environment (compiler, linker, debugger, version/configuration managers) operate on compilation units translated into an intermediate form and stored in the program library; only the compiler sees raw text, and its main task is to perform semantic and syntactic checks and translate the compilation units into the intermediate form.

SPICE LISP: Fahlman

SPICE project in personal computing, to develop a LISP system within SPICE. SPICE LISP is now available on the PERQs, and work is underway to port SPICE LISP (along with the rest of SPICE), to much more powerful machines.

Supercomputer: Kanade; Kung; Newell; Segall; Siewiorek

Multiprocessor Architecture. A Supercomputer Workbench (SCW), being co-designed with industry. Projected to outperform a Cray-1, to serve three purposes: (1) a high-performance design environment for special-purpose architectures, such as systolic arrays; having traditional tools, such as parallel versions of register transfer and circuit-level simulators; including synthetic workload generators and distributed status monitors for the researching problem decomposition; (2) to serve as host system for other special-purpose supercomputers; host to provide input/output program preparation capabilities; special-purpose supercomputers will require a supercomputer to load and extract information in real time; (3) a supercomputer in its own right, programmed to handle such applications as image recognition, image processing, and control of complex robots. In sum, the SCW will be a tool to bring parallel processing to the nonexpert user.

PSC (Programmable Systolic Chip. A microprocessor chip to be used as a processing element in systolic arrays for signal and image processing applications. A system with nine PSCs is currently operating.

Warp Processor. A flexible, high-performance systolic array processor capable of 32-bit floating-point computations. For example, a 10-cell processor can perform a 1024-point complex Fast Fourier Transform (FFT) in 0.6 ms. Can also be programmed to perform other computations in signal and image processing, including two-dimensional convolution and complex matrix multiplication, at a rate of 100 million floating-point operations per second (100 MFLOPS). Hardware is currently under design.

Supercomputer Test-Bed Architecture. Research purpose is to define concepts and the architecture of special-purpose multiple processor systems. A test-bed oriented toward supporting the development of special-purpose supercomputers (the Supercomputer Workbench) is in design and early implementation stages. The system is equivalent to 64 VAX 11/780's with a very large shared memory, and high degrees of instrumentation: CAD tools, implementation tools, and performance prediction and evaluation tools.

See PIE.

SWIMR: Berliner

SWIMR environment, a study in learning the distinction between perceived and actual, has been created to examine what, by analogy, a creature that has simple needs and simple actions must learn to survive. This structure of learning includes: a set of simple modular units that combine to adapt to complex situations; such units may be combined and their outputs used in serial/parallel combination to produce adaptive postures.

TEX: Doyle

Knowledge representation, reasoning, decision making, reason maintenance, systems and heuristics.

TPS: Andrews

Automatic theroem-proving in interactive mode, handles theorems of type theory and first-order logic. Used as an interactive aid in logic courses.

3-D Mosaic Herman; Kanade

Incremental 3-D mosaic, given multiple images of a scene, building a symbolic 3-D map representation (unlike patching of images in the conventional mosaic technique) to include spatial reasoning, wide-angle stereo analysis, structural feature extraction, and 3-D change detection.

TRAM: Segall

Research associated with large-grain parallel computation and parallel computers.

Validation of Fault-Free Behavior: Segall

VLSI: Bisiani; Raibert

VLSI applied to robot manipulation. VLSI technology research directed toward constructing sensors with specialized parallel processors that can process sensory information for control applications. Custom VLSI for giving robot manipulators information about contact between a manipulator's hand and objects in the environment. To create a device which is a special-purpose parallel computer and a high-resolution tactile array sensor.

Speech, vision, and high-level robot control microelectronic applications have in common: a small-to-medium knowledge database (100,000 to 1,000,000,000 bits), often accessed randomly; a large number of simple, repetitive operations; real-time response; and low cost.

VT: McDermott

Assists with the configuration of elevator systems. A major focus is to understand how to develop a generic system for constructive tasks, as opposed to diagnostic tasks.

World Modelers: Carbonell

A simulated real-time reactive environment to investigate learning mechanisms, learning of real-time planning, communication, perceptual recognition, and goal-directed behavior.

XCALIBUR: Carbonell

Robust parsing in well-defined domains. Generates cognizant explanations in the context of the XSEL expert system.

XSEL: Kulich; McDermott

Assists DEC customers in selecting the processor and the particular set of system components that best fits their needs. XSEL has an explanation capability that explains to the user why each component is necessary.

ZOG: McCracken; Newell

A human-computer interface now used for providing many different functions, such as document production, database storage and retrieval, programming environments, mail and bulletin boards, and project management. A ZOG-based application running on a network of 29 Perq personal computers onboard the USS Carl Vinson, one of the Navy's newest nuclear-power aircraft carriers, supports a variety of applications onboard the ship: (1) management of routine tasks at the upper levels of command; (2) electronic mail for the Commanding Officer and several of his department heads; (3) online and hardcopy documentation of standard ship's procedures; (4) training and maintenance documentation for the ship's elevator systems, including an online interface to video disc material; and (5) user interface and database for an expert system called AirPlan, which assists the Air Operations Officers in the launch and recovery of aircraft, and makes status information available to others on the ship (including the Commanding Officer on the bridge).

Massachusetts Institute of Technology (MIT) Artificial Intelligence Laboratory

Patrick H. Winston, *Director*

The primary goal of the Artificial Intelligence Laboratory is to understand how computers can be made to exhibit intelligence. Two corollary goals are to make computers more useful and to understand certain aspects of human intelligence. Current research includes work in the following areas:

- Computer Robotics
- Natural Language Understanding
- Expert Systems
- Computer Architecture
- Learning and Common-Sense Reasoning
- Supercomputing

The Laboratory's 155 members include 13 faculty members, 10 academic staff, 55 research and support staff, and 75 graduate students active in research activities funded by the Defense Advanced Research Projects Agency, System Development Foundation, Office of Naval Research, Air Force Office of Sponsored Research, National Science Foundation, Atari, Digital Equipment Corporation, International Business Machines, Martin-Marietta, Bendix, and NL Industries, Inc.

Faculty, staff and researchers and areas of research include:

- **ROBOTICS**

  An, Chae Hun
  Atkeson, Christopher
  Bagley, Stephen
  Brady, Dr. Michael
  Braunegg, David
  Brock, David
  Brou, Dr. Philippe
  Bruss, Dr. Anna
  Chi, Stephen
  Connell, Jonathan
  Donald, Bruce
  Erdmann, Michael
  Fearing, Donald
  Garabieta, Ignacio
  Grimson, Eric
  Heide, Scott
  Hildreth, Dr. Ellen
  Hollerback, Prof. John
  Horn, Prof. Berthold

- **ROBOTICS** *(Continued)*

  Illman, Prof. Shimon
  Jones, Joseph
  Kass, Michael
  Kock, Dr. Christoper
  Larson, Noble
  Lozano-Perez, Prof. Thomas
  Mason, Prof.
  Narasimhan, Sundar
  Negahdaripour, Shahriar
  Nisihara, Dr. Keith
  O'Donnell, Patrick
  Poggio, Prof. Tomaso
  Ponce, Jean
  Prendergast, Karen
  Sahar, Gideon
  Salisbury, Prof. Kenneth
  Schnuck, Dr. Brian
  Seering, Prof. Warren
  Siegal, David
  Suh, Ki Choon
  Terzopoulos, Dr. Demetri
  Yuille, Dr. Alan

- **INTELLIGENT APPRENTICES**

  Davis, Prof. Randall
  Oppenheim, Alan
  Shrobe, Dr. Howard
  Simmons, Reid

- **EXPERT SYSTEMS**

  Agre, Philip
  Berlin, Andrew
  Ressler, Dr. Andrew
  Roylance, Gerald
  Sussman, Gerald
  Taft, Jonathan
  Weise, Daniel

- **MUSIC COGNITION**

  Amuedo, John
  Fry, Christopher
  Leavitt, David
  Minsky, Henry
  Minsky, Prof. Marvin
  Saslav, David

- **LANGUAGE AND LEARNING**

  Berwick, Prof. Robert C.
  Doyle, Richard
  Winson, Prof. Patrick

- **COMMON-SENSE REASONING**

  Batali, John
  Forbus, Kenneth
  Haase, Kenneth
  McAllester, David
  Rich, Dr. Charles
  Waters, Dr. Richard

- **INTELLIGENT SUPERCOMPUTING**

  Amsterdam, Jonathan
  Bawdem, Alan
  Cerrato, James
  de Jong, Peter
  Hewitt, Carl
  Katz
  Knight, Thomas
  Leiberman, Henry
  Manning, Carl
  McEntree, Mark
  Millgram, Elijah
  Mui, Chun Ka
  Reinhardt, Thomas

- **INTEGRATED CIRCUIT DESIGN**

  Knight, Prof. Thomas
  Sussman, Prof. Gerald

New Mexico State University
Computing Research Laboratory

New Mexico has launched a new program to enhance the state's leadership in science and technology. The Rio Grande Research Corridor (RGRC) consists of the national laboratories, universities and industries located along the 300-mile stretch of the Rio Grande from Los Alamos to Las Cruces. As a part of the RGRC initiative, the Computing Research Laboratory (CRL) has been founded.

CRL is dedicated to interdisciplinary research on knowledge-based systems. the laboratory pursues parallel programs of basic applied research in such areas as knowledge representation, natural language understanding, distributed processing, models and simulation, human/computer interactions, machine sensory systems, and knowledge-based control.

Computing facilities include SUNS, Symbolics machine, and special-purpose robotics and vision hardware. In addition, access to supercomputers and parallel machines is available through the RGRC connection. PDP-11/23 running UNIX, VAX-11/750, PDP-11/44, VT220 terminal connected to the VAX, and a PRO350 workstation, PROLOG compiler, also available.

AI research programs are described briefly below — researchers are indicated.

KNOWLEDGE REPRESENTATION AND REASONING

Pilot Decision Making

Schvaneveldt, R., Goldsmith, T.

Prototype I

Air Force funded project, computer system that displays the state of two fighter aircraft in computer graphic displays and selects appropriate fighter maneuvers given position, heading, and speed of the aircraft; dynamic flight equations, mapping of the maneuvers onto the inputs of the flight equations; updating of airspace as a result of decision, displaying new airspace; ongoing decision support and airspace mapping.

ROBOTICS

Knowledge-Based Sensory Robots

Burke, M.; Kamat, S.

ARC Merlin

ARBASIC installed for easier programming of the arm and flexible access to the system ports for interfacing to external devices. IRI P256 vision system integrated with the robot arm. Vision system can see an object, analyze it into a feature list, and send features to the robot controller. the LORD tactile sensor is interfaced with a single board computer. An operational prototype is a three-fingered, multi-jointed generic gripper that has been completed and demonstrated with a manual controller. Robot control of camera viewing angle, zoom, and focus for real-time visual servoing of the robot arm is in progress. Research includes an Intel 80286-based supervisory computer vision system, robot controller, camera controller, tactile sensor, ultrasonic ranging sensor, and generic gripper, each to be interfaced through individual single board computers in the 80286 mainframe; a high-speed data link with a Symbolics machine aids the supervisory computer in planning tasks.

Adaptive Cognitive Robots

Partridge, D.; Johnson, B.

Interfacing IBM PC, MICRONEYE camera, AMDROID robot arm. Algorithm developed for hand-eye coordination so the robot can visually locate and direct the pick-up of randomly placed objects. Algorithm will permit fast recognition of objects in poor quality image situations because it can reference an object recognition knowledge base. The robot uses static knowledge (of how to recognize certain objects), and learned knowledge.

SCIENCE WORKBENCH

Conley, W.

Objectives of the Science Workbench are to design and implement a working prototype of a computing environment to serve moderate sized teams of scientific researchers; research a natural language user interface; supplement the interface with an expert system.

COMPUTER VISION SYSTEMS

Pattern Recognition Algorithms

Phillips, K.; Dearholt, D.

Research includes a program that generates a large network data structure useful for database design for vision problems, that can generate a 50-node network aimed at two to three hundred nodes, for search strategies for aircraft, insect, and other pattern recognition and identification problems. A priority application involves digitizing images of insect pests in the orientations in which they can land when dumped on a table or conveyor belt, then Fourier series algorithms to find Fourier transforms for shape analysis and identification based on Fourier coefficients to determine distinguishing features of insects to organize them into a database and search structure.

New York State University at Buffalo

Research facilities of the Computer Science Department:

VAX 11/780

- VAX 11/780 CPU
- Two RP07 512 Mb Disks
- DEUNA Ethernet Interface
- LA120 Console Printer
- CS11 Emulex 64-Port Interface
- 7 Mb of Main Memory
- TU78 1600/6250 BPI Mag Tape
- DZ11 8-Port Serial Interface
- Printronix 600 IPM Printer
- LN01 Laser Printer

VAX 11/750

- VAX 11/750 CPU
- RA81 470 Mb Disk
- DZ11 8-Port Serial Interface
- LA120 Console Printer
- 6 Mb of Main Memory
- TU80 1600 BPI Mag Tape
- DEUNA Ethernet Interface

VAX 77/750

- VAX 11/750 CPU
- RA81 470 Mb Disk
- DZ11 6-Port Serial Interface
- LA120 Console Printer
- DW750 Unibus Adapter
- 6 Mb of Main Memory
- TU80 1600 BPI Mag Tap
- DEUNA Ethernet Interface
- FP750 Floating Point Accelerator
- Grinnell $512 \times 512 \times 8$ Image Processor

LS-11/23

- Image Technology IP512 Imaging Processing System
- Two 10 Mb Winchester Disks
- Ethernet Controller

ABOUT THE SYSTEMS DESCRIBED ABOVE

The systems described above run Berkeley UNIX. Universities facilities include a CDC Cyber 170/730 with 262K words of central memory. There are 180 ports of interactive terminals running at 1200 baud, and over 200 publicly available terminals, some with graphic capabilities.

COMMUNICATIONS NETWORKS

One of the department VAXs is a node of CSNET, the network connecting major computer science departments in North America. This net has a connection to ARPANET.

AI FACULTY AND PROJECTS

Hardt, Dr. Shoshana, Assistant Professor
— Common Sense Reasoning

Rapaport, Dr. William, Assistant Professor
— SNePS Research Group

Shapiro, Dr. Stuart, Chairman & Professor
— SNePS Research Group

Srihair, Dr. Sargur, Associate Professor
— Computer Vision

Walter, Dr. Deborah, Assistant Professor
— Computational Vision

RESEARCH

Main AI research programs include: SNePS Research Group, Spatial AI, Common Sense Reasoning, and Computational Vision.

THE SNePS RESEARCH GROUP

Research in knowledge representation, inference, and natural language processing. Group is supported by National Science Foundation grants and United States Air Force grants. Research projects include:

SNePS
Semantic Network Processing System

SNIP
Inference package using simulated multiprocessing to interpret reasoning rules in the semantic network.

ATN
Augmented Translation Network; grammar interpreter/compiler which allows translation from surface sentences directly into semantic networks, and from semantic networks into surface sentences; and a lexicon system that does morphological analysis and synthesis of English words.

Spatial AI and Reasoning

Reasoning and problem-solving models in 2-D or 3-D spatial structure. Includes: computer vision; expert systems for neurological diagnosis; representation of 3-D objects, solid modeling, computer tomography images of the internal structure of the human body, recently developed method for computing topological properties from cross sections of 3-D objects.

Common-Sense Reasoning Systems with Natural Language Front Ends

Research includes knowledge structures that can support common sense reasoning in the domain of everyday physics.

Computational Vision

Research includes development of computer vision modules to perform tasks in visual processing. Modules are to be implemented using connectionist networks of single computing units. These yield massively parallel, highly connected processing techniques.

CURRENT AI GRANTS

Current grants include:

- SNePS — National Science Foundation
- Intelligent Parser for Ship Messages — United States Coast Guard
- Graphics Interface to a Rule-Based System — RADC
- Advanced Character Recognition — United States Post Office
- Selection of Image Features — NSF

Purdue University

There is Artificial Intelligence activity at Purdue in two departments:

- The Department of Computer Sciences
- The Department of Electrical Engineering and Computer Science

THE DEPARTMENT OF COMPUTER SCIENCES

The Department of Computer Sciences at Purdue University is one of the oldest and largest in the United States. Offered are B.S., M.S., and Ph.D. programs. The faculty includes 38 persons.

Department of Computer Sciences programs include:

- Computer Systems
- Decision/Information Systems
- Parallel Computing, VLSI*
- Software Engineering
- Numerical Computation
- Programming Languages
- Theory

*Very Large System Integration

Parallel Computation includes: Algorithms, Programming Languages, Architecture, VLSI Models, and Layout Systems.

The Computer Sciences Department has state-of-the-art UNIX systems, as well as direct access to the Purdue University Computing Center (PUCC). The Computer Sciences Department facility includes four VAX 11/780 systems with 4 megabytes of memory each. There are six smaller computers plus Sun and other workstations. These are connected by a 10-megabit local area network (Pronet) and by Ethernet to special-purpose laboratory equipment. The system has over 3 gagabytes of disk storage and various output and graphics devices (including letter-quality and laser printers). The machines connect through a department gateway to the DARPA Internet (ARPANET), to Telenet and CSNET.

The Purdue University Computing Center has three CDC 6000 Series machines, an IBM 3083, and a Cyber 205 supercomputer. The Computer Center provides UNIX for instruction on three VAX 11/780's and three PDP 11/70's, which are accessible from a total of 262 public terminals.

Computer Sciences Department faculty with research pursuits in Artificial Intelligence are shown below.

Faculty		Research Interests
Apostolico, Alberto	Dipl. Perf., Salerno, Italy	Parallel Computation
Atallah, Mikhail J.	Ph.D., John Hopkins	Parallel Computation, Analysis of Algorithms
Bhargava, Bharat	Ph.D., Purdue University	Robust Concurrent Processing
Comer, Douglas E.	Ph.D., Pennsylvania State	Computer Networks, Operating Systems
Denning, Peter J.	Ph.D., MIT	Architecture, Concurrent Computing
Dyksen, Wayne R.	Ph.D., Purdue University	Partial Differential Equation Expert Systems
Frederickson, Greg	Ph.D., Maryland University	Distributed Computation
Gannon, Dennis B.	Ph.D., Illinois University	Supercomputer Technology
Guerra, Concettina	Ph.D., Naples University	Image Processing, Parallel Architectures
Hambrusch, Susanne	Ph.D., Pennsylvania State	Parallel Computation, VLSI Layouts and Chips
Lucier, Bradley J.	Ph.D., Chicago University	Parallel Adaptive Numerical Algorithms
Mehrotra, Piyush	Ph.D., Virginia University	Programming Languages for Supercomputers
Melhem, Rami G.	Ph.D., Pittsburgh University	Parallel Architectures
Rice, John R.	Ph.D., California Inst. Tech.	Software Systems for Parallel Computing
Rosen, Saul	Ph.D., Pennsylvania University	Vector Computing, Operating Systems
Wagstaff, Jr., Samuel	Ph.D., Cornell University	Parallel Computation

Current sponsored Department of Computer Sciences AI-related research projects include:

Project	Sponsor
Research in Parallel Database Machines	Sperry Corporation
Parallel Algorithms and VLSI Computation	ONR
Parallel PDE Algorithms and Supercomputer Architecture	AFOSR
Studies in Parallel and Vector Computation	National Science Foundation
Mini-Workshops in Parallel and Vector Computing	ARO
Processors with Parallel Capability for Factoring Integers	National Science Foundation

THE DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

This discussion is limited to faculty and aspects of this department that are related to AI.

For descriptive information about some of the research at the Department of Electrical Engineering Advanced Automation and Speech Recognition Laboratory (AARL), please refer to the section in this book on Robotics. However, the Configuration of the Advanced Automation Research Laboratory (AARL) is described below.

The Advanced Automation Research Laboratory (AARL) at Purdue is organized around a DEC PDP-11/45 digital computer with 128K words (words = a character string or a binary element string considered as an entity) of main core memory and 96K words of secondary memory, two 1.2-million-word disk drives, one 133-million-word disk drive, a magnetic tape drive, two cassette tape drives, a line printer, and six CRT terminals. The system also includes an Optronics drum scanner for converting slide preparations to digital information, two TV signal digitizing systems, two line printers, and a Ramtek color display system consisting of a control unit, a refresh memory, and a high-quality color Tektronix monitor.

There is also a Scheinman electromechanical arm, a larger robotic Stanford arm controlled by its own onboard LSI-II microcomputer. Several research projects on computer vision and robotics are jointly administered with CIDMAC (Computer-Integrated Design, Manufacturing, and Automation Center).

The PDP-11/45 is also connected to the Purdue University Computing Center's CDC 6500, as well as to the School of Electrical Engineering PDP-11/70 computer. The 11/70 link is a 1-million-bit-per-second high-speed communications channel. The system is a host on the Electrical Engineering Computer Network and therefore can access or be accessed by any other machine in the network.

The tables below indicate AI researchers and related projects. (Also in progress at AARL is a National Science Foundation-supported project on the development of parallel algorithms and VLSI multiple computer architectures for pattern analyses and image database management, called PUMPS.)

Department of Electrical Engineering and Computer Science listing of faculty with research pursuits including Artificial Intelligence are shown below.

Faculty		Research Interests
Alleback, Jan P.	Ph.D., Princeton University	Image Processing
Fu, King-Sun	Ph.D., Illinois University	Pattern Recognition
Fukunaga, Keinosuke	Ph.D., Kyoto University	Pattern Recognition and Processing
Kashyap, Rangasami L.	Ph.D., Harvard University	Pattern Recognition
Koivo, Antti J.	Ph.D., Cornell University	Robotics, Microprocessor Control Systems
Landgrebe, David A.	Ph.D., Purdue University	Pattern Recognition Applications
Luh, Johnson Y-S	Ph.D., Minnesota University	Robot Systems, Multiple-Microprocessors
Mowbray, Thomas J.	Ph.D., USC	Parallel Processing
Paul, Richard P. C.	Ph.D., Stanford University	Robotics
Siegel, Howard J.	Ph.D., Princeton University	Parallel Processing, Image and Speech Processing
Siegal, Leah J.	Ph.D., Princeton University	Speech Analysis and Recognition
Swain, Philip H.	Ph.D., Purdue University	Pattern Recognition, Parallel Image Processing
Wah, Benjamin W-S	Ph.D., UC Berkeley	Parallel Processing Architecture, Distributed DBS

Additional Department of Electrical Engineering and Computer Science faculty with research focusing on AI include:

Faculty	Research Interests
Allen, J.	Natural Language, Speech Generation and Recognition
Arvind	Multiple Processor Architecture, Distributed Systems
Berwick, R.	Natural Language, Learning Models, Inductive Inference
Davis, R.	Expert Systems, Distributed Problem Solving
Dertouzos, M.	Distributed Systems, Personal Computers
Horn, B.	Machine Vision Products
Knight, T.	AI Computer Architectures, AI Languages, VLSI
Leiserson, C.	Parallel Computation, VLSI
Lim, J.	Image Processing, Speech Processing
Lozano-Perez, T.	Robotics
Minsky, M.	Robotis Machine Vision
Patil, R.	Expert Modeling, Knowledge-Based Tools for Hardware Design and Analysis
Sussman, G.	AI Research on Learning and Problem Solving
Szolovits, P.	Medical Decision Making, Natural Language
Troxel, D.	Image Processing
Tsitsiklis, J.	VLSI Integration
Weihl, W.	Distributed Systems, Concurrency Control
Winston, P.	Learning
Zue, V.	Speech Recognition and Processing, Acoustic Characterization

Rutgers State University at New Brunswick, New Jersey
Department of Computer Science

AI faculty and related research interests are shown below.

Faculty		Research Interests
Amarel, Dr. Saul	D.Eng.Sci., Columbia University	Knowledge Representation
Borgida, Dr. Alexander	Ph.D., Toronto	AI Research
Hedrick, Dr. Charles	Ph.D., Carnegie-Mellon University	AI Research
Kulikowski, Dr. Casimir	Ph.D., Hawaii	Pattern Recognition, Expert Systems
McCarty, Dr. L. Thorne	J.D., Harvard University	AI Research, Legal Reasoning
Mitchell, Dr. John	Ph.D., Stanford University	Expert Systems, Digital Circuit Design
Nemes, Dr. Richard M.	Ph.D., CUNY	Parallel Programming
Smith, Dr. Donald	Ph.D., Rugters University	Machine Learning
Srinivasan, Dr. Chitoor V.	D.Eng.Sci., Columbia University	Automatic Formation, Learning
Tong, Dr. Chris	Ph.D., Stanford University	Automatic Programming

Computing facilities include:

- 80 microcomputers (Macintosh and Lisa)
- DEC 2060 time-sharing system operated under TOPS20, with 80 display terminals
- Pyramid super microcomputer running UNIX
- DEC 11/44 operated under RSTS
- VAX machines
- NSA 9000 mainframe
- Color graphics plotters, terminals and tablets
- LISP machines (Dolphins and Dandelions)

Stanford University

The Computer Science Department was founded in 1965. The department offers a Masters Degree in Artificial Intelligence (C.S.A.I.).

Faculty includes professors specializing in the following areas:

- Computer Vision
- Medical Reasoning
- Cognitive Simulation
- Cognitive Psychology
- Robotics
- Chemical Reasoning
- Parallel Programs
- Parallel Problem Solving
- LISP Compilers
- Knowledge Representation
- Cognitive Architectures
- Program Languages
- Heuristics
- Inferencing
- Learning

Computer facilities include the following equipment:

- SCORE — DECSYSTEM 2060, running TOPS-20
- SAIL — DECSYSTEM 1080, running WAITS
- SUMEX — DECSYSTEM 2060, running TENEX
- Xerox ALSO personal computers, linked via Ethernet
- VAX 11/780's (3)
- Additional personal comptuers

Faculty with research pursuits including artificial intelligence are shown below.

Faculty		Research Interests
Binford, Thomas O.	Ph.D., Wisconsin	Computer Vision, Robotics
Brooks, Rodney A.	Ph.D., Stanford University	Robotics, LSIP Compilers and Languages
Buchanan, Bruce G.	Ph.D., Michigan State	Heuristics, Knowledge Representation
Feigenbaum, Edward A.	Ph.D., Carnegie-Mellon University	Cognitive Simulation, Heuristics
Genesereth, Michael R.	Ph.D., Harvard University	Knowledge Representation, Learning
Lenat, Douglas B.	Ph.D., Stanford	AI Research
Mayr, Ernst W.	Ph.D., Munich	Math Analysis of Parallel Systems
McCarthy, John	Ph.D., Princeton University	AI Research
Rosenbloom, Paul	Ph.D., Carnegie-Mellon University	Cognitive Architectures, Learning
Samuel, Arthur L.	S.B., S.M., MIT	AI Research
Wiederhold, Gio	Ph.D.	Parallel Problem Solving
Winograd, Terry	Ph.D., MIT	Knowledge Representation

University of Illinois at Urbana-Champaign

AI faculty and associated research interests are shown below.

Faculty		Research Interests
Campbell, R.	Ph.D., Newcastle upon Tyne	AI Research
Dershowitz, N.	Ph.D., Weizmann Institute	AI Research
Gajski, G.	Ph.D., University of Pennsylvania	Expert Systems
Harandi, M.	Ph.D., University of Manchester	AI Research
Michalski, R.	Ph.D., Technical University of Silesia	Robotics, Expert Systems
Michie, D.	Ph.D., Oxford University	Micro-based Robotics
Plaisted D.	Ph.D., Stanford University	AI Research
Ray, R.	Ph.D.	AI Research
Reed, D.	Ph.D., Purdue University	Parallel Processing

COMPUTER EQUIPMENT

- VAX 11/780's (2)
- VAX 11/750's (11)
- Pyramid
- PRIME 650
- Ramtek 9400
- Hewlett-Packard 1000
- PDP 11/60's (2)
- PDP 11/40's (2)
- PDP 11/35
- Xerox Dolphin
- Sun workstations (14)
- Ethernet

PARALLEL PROGRAMMING

Prometheus

Programming environment prototype researching graphical program specification interfaces (menu-driven, command-driven, and a structured program editor); a graphical program debugger; execution environments (a functional Unix shell leading to parallel architectures); program optimization.

COMPUTER INFERENCE AND MACHINE LEARNNG

Research includes: computer induction, inductive learning computer programs, development of techniques for machine generation of plausible hypotheses and discovery of regularities in data; to be used as tools for formulating decision rules for knowledge-based systems, for detecting conceptual patterns in collections of objects, and for discovering laws governing a body of observations. The conceptual patterns characterize the data in terms of logical, causal, or functional relationships, and provide an alternative to analyze data, different from traditional statistical or numerical techniques.

AQVAL, INDUCE, CLUSTER

Inductive learning computer programs used for conceptual analysis of data and learning general descriptions from specific examples; applications include: diagnosing soybean diseases in agriculture; diagnosing liver diseases in medicine; formulating rules for computer chess endgames; computer architecture; chemistry; microbiology.

EXPERT SYSTEMS

- ADVISE — A framework to develop expert systems.
- PLANT/ds — Soybean disease diagnostic tool.
- QUIN — A relational database program with inference capacity.

KNOWLEDGE-BASED PROGRAMMING ASSISTANT

This research aims to develop an intelligent programmer's workbench that is knowledgeable in program design, coding, and debugging, consisting of several expert systems, a central database, and other software tools such as program analyzers and interactive rule generators.

GPSI

Pascal-based advice language system tool for heuristic models of program design, coding, and debugging.

MICRO-BASED ROBOTICS

Research developing an inexpensive, portable micro-based hand-eye system equipped with integrated AI software. Images from a GE solid-state camera are analyzed by algorithms developed for

the CLIP parallel array processor, for induction procedures for acquisition of visual descriptions from examples. Targeted industrial applications include design for a teachable robot packer.

NUMERICAL PARALLEL COMPUTATION

Research includes development of high-speed stable numerical algorithms for general and special purpose multiprocessors: (1) solving sparse symmetric and nonsymmetric systems of linear equations that arise from the discretization of partial differential equations; (2) solving the linear lease squares problems in geodesy, signal processing, and image reconstruction; and (3) the standard and generalized eigenvalue problems for dense and sparse matrices in structural dynamics and signal processing applications.

DESIGN AUTOMATION EXPERT SYSTEMS

ARSENIC

Software tools for automatic design of digital systems, VLSI architectures; silicon assemblers, floor planners, compilers, and layout generators make up the knowledge base.

University of Massachusetts at Amherst
The Department of Computer and Information Science (COINS)

Major projects include:

- Computer Vision
- Distributed Professing
- Expert Systems
- Robotics
- Parallel Architectures
- Knowledge Representation
- Natural Language Processing
- Intelligence Interfaces
- Computer-Aided Instruction

Faculty, research assistants, and research interests are shown below.

Faculty		Research Interests
Arib, Dr. Michael A.	Professor	Robotics, Distributed Sensing Planning for
Carlson, David A.	AI Researcher	Resource Analysis Tradeoffs
Clarke, Dr. Lori	Associate Professor	Software Validation and Development
Cohen, Dr. Paul A.	Assistant Professor	Heuristics, Expert Systems
Corkhill, Dr. Daniel D.	Research Computer Scientist	AI Software Languages
Croft, Dr. W. Bruce	Assistant Professor	Office Info Document Retrieval Systems
Cuny, Dr. Janice	Assistant Professor	Highly Parallel Computation
Ding-Yi, Tan	AI Researcher	Heuristics
Djaferis, R.	AI Researcher	Robots, Nonlinear Adaptive Control of
Elliot, Howard	AI Researcher	Stochastic Image Processing
Foster, Dr. Caxton C.	Professor	Content Addressable Parallel Processors
Graham, Dr. Robert M.	Professor	Software Development Environments
Hanson, Dr. Allen R.	Associate Professor	Inference, Computer Vision
Kitchen, Leslie	AI Researcher	Computer Vision
Kulikowski, Stanley	AI Researcher	Computer Aids for the Disabled
Lawton, Daryl T.	AI Researcher	Autonomous Vehicles, Image Processing
Lehnert, Dr. Wendy G.	Associate Professor	Cognitive Modeling, Natural Language
Lessor, Dr. Victor R.	Professor	Machine Vision, Distributed Systems
MacDonald, Dr. David D.	Assistant Professor	Natural Language Processing
Moll, Dr. Robert N.	Associate Professor	Automatic Programming
Nakatani, Hiromasai	AI Research	Image Processing (with Perspective)
Ornstein, Dr. Jack A.	Assistant Professor	Data Structures, Algorithms
Pustejovsky, James	AI Researcher	Natural Language Parsing and Generation
Ramaritham, Dr. K.	Assistant Professor	Distributed Systems
Reynolds, George D.	AI Researcher	Inference, Computer Vision
Richardson, Debra	AI Researcher	Software Engineering, Program Testing
Riseman, Dr. Edward H.	Prof., Department Chairman	Parallel Associative Architectures for Vision
Rissland, Dr. Edward	Assistant Professor	Computational Strategies in Reasoning
Rusheng, Wang	AI Researcher	Computer Vision, Image Sequence Analysis
Spinelli, Dr. D. N.	Professor	Visual System Modeling, Experience Traces
Stemple, David W.	Associate Professor	Distributed Operating Systems, DB Design
Sutton, Richard	AI Researcher	Machine Learning, Knowledge Systems
Weiss, Richard	AI Researcher	Image Processing and Understanding
Wileden, Dr. Jack	Associate Professor	Development Tools for Concurrent Systems
Wogrin, Dr. Conrad A.	Prof., Director, Computer Center	Vision, Performance Evaluation, CAI
Woolf, Beverly	AI Researcher	Intelligent CAI
Yanghong, Wang	AI Researcher	Dynamic Modeling Language Parser
Zeil, Dr. Steven J.	Assistant Professor	Software Validation, Software Development

Research environment is supported by the COINS Research Computer Facility, including:

- VAX 11/780's (2) with 12 megabytes of memory and 1 gigabyte of disk storage
- VAX 11/750's (10) with 8 megabytes of memory and a 124- or 405-megabyte disk
- Sun workstations (4), Motorola 68000's
- Symbolics 3600 LISP machines (2)
- Grinnell 512×512 color display system
- Comtal 512×512 image processor with video-rate convolution
- Laser graphics printer
- Personal and laboratory computers
- 120 hardwired ports and 24 dial-in ports
- CSNET communications network link

COMPUTER VISION AND IMAGE UNDERSTANDING

Static Image Understanding

Visions research group is developing a knowledge-based system for real world interpretation of static color images. Control mechanisms for interpretation utilized information extracted from the image and stored knowledge represented in semantic network. Rule-based object-hypothesis mechanisms activate procedural interpretation strategies attached to object- and scene-schema nodes in the knowledge base.

Experiments involving centralized and distributed control on house scene images can effectively identify sky, grass, foliage, and in some cases, parts of houses, such as shutters or windows, walls, and roofs. The system architecture is being applied to the analysis of biomedical images, road scene images, remotely sensed satellite image, aerial images, and industrial images.

Dynamic Image Processing

Computer vision research has expanded to include processing dynamic image sequences produced by a sensor in motion through an environment which may also contain objects in independent motion. The major goal of motion processing is the recovery of the parameters of motion of the sensor and the independently moving objects, followed by the computation of the environmental depth of visible surfaces.

Parallel Architectures for Image Processing

Research includes parallel architectures and parallel algorithms for scene interpretation. Real-time motion processing requires more computational power than static vision. Therefore, VLSI and massively parallel machines are targeted for research. Research includes a Content Addressable Array Parallel Processor (CAAPP), to provide fast and accurate decomposition of a flow field into rotational and translational components. The algorithm is an exhaustive search procedure via a top-down parallel correlation of a set of rotational and translational flow field templates to find a component pair that most closely accounts for the motion represented by a given flow field. The CAAPP can decompose sensor motion in 1/3 second, leading to real-time processing. A 3×3 convolution across a 512×512 image can be performed in 98 microseconds; 10×10 convolution requires 30 milliseconds.

COOPERATIVE DISTRIBUTIVE PROBLEM SOLVING

Distributed Vehicle Monitoring Testbed

Testbed node architecture for decision making, simulates a network of problem-solving nodes to identify, locate, and track patterns of vehicles moving through a two-dimensional space by using signals detected by acoustic sensors. Each problem-solving node is an architecturally-complete HEARSAY-II system, extended for more sophisticated local control, and the capability of communicating hypothesis and goals among nodes.

The testbed research also includes: knowledge-based fault diagnosis, to detect and locate inappropriate system behavior; distributed task allocation; and organizational self-design.

Research also includes distributed debugging.

DISTRIBUTED SOFTWARE SYSTEMS

Includes the following AI-related research.

Formal Analysis of Concurrency

Research includes theoretical approaches to concurrency, distributed software systems and data bases; concurrency analysis, parallelism via execution modes and communication protocols with VLSI network applications and high-level programming language development.

Intelligence User Interfaces

Research includes development of a Procedure-Oriented Interface for a Supported Environment (POISE), to provide intelligent assistance to users in office tasks and also software development tasks. (This work is augmented by natural language processing and knowledge-based system research.) The POISE model is represented by a hierarchy or procedure descriptions or plans which specify typical tasks, their associated goals, and the sequences of actions (tool calls) to accomplish these goals. Given procedure descriptions, POISE can recognize the user's actions and infer the user's objectives; and aim to plan actions based on the user's goals.

POISE applications include:

- Task Automation
- Assistance in Task Execution
- Detection and Correction of Local and Global Errors
- Interfacing at Multiple Levels of Abstraction
- Agenda Maintenance
- Natural Language Interface
- Knowledge Base

NATURAL LANGUAGE PROCESSING

Research projects include: natural language interface design applications for vision processing, tutorial programs (CAI), database access problems, and an intelligent office automation environment. These applications require research in conceptual sentence analysis, memory organization techniques, question answering behavior, and mixed initiative dialogues. Research includes narrative text summarization.

UGG

Plot Unit Graph Generator, translates affect-state maps into plot unit graphs, to categorize text representations in terms of their retrieval and access requirements, in order to develop new metrics of narrative complexity.

MUMBLE

Natural language generator, specifies English texts via an expert system, drawing on linguistic knowledge of the alternative ways the elements of a specification may be realized as text, and is guided by cumulative pragmatic and grammatical constraints that avoid excessive "lookahead." Current applications of MUMBLE include text planning systems, including a machine tutor, and an intelligent interface project.

KNOWLEDGE-BASED SYSTEMS

Selected AIR research is described below.

Expert Systems Research

R1 Enhancements

DEC's knowledge-based expert system for configuring VAX 11 computer systems. R1 takes as input the hardware, CPU, cabinets, hard disks, floppys, for example, on a customer's order, and recommends the configured system. Professor Moll focused on the unibus configuration problem. He identified an underlying theory of near-optimal bin-packing and wrote a program to fit the unibus configuration problem to this theory. Prior to his work, the R1 system was a rule-based system incorporating experts' heuristic knowledge about unibus configuration. His decision to represent the problem as an instance of a bin-packing problem resulted in a shift in design from a knowledge-based system to include a theory-based system, resulting in a 50-fold speed increase over the previous configurer.

FOLIO

Professor Cohen developed an expert system for investment portfolio management, using heuristic criteria to establish investment goals for a client, and mathematical criteria imposed by a linear programming algorithm to find a portfolio to fit the inferred goals of the program.

He also is developing a knowledge-based system for mechanical engineering design, to determine whether a design is acceptable, otherwise using a heuristic criteria to redesign.

Examples and the Structure of Domain Knowledge

Constrained Example Generation (CEG)

Professor Rissland's research studying the structure and representation of example-rich knowledge in complex domains, classifying domain examples based on their use in reasoning; for example: start-up examples — easy to understand; reference examples — for textbook cases; model examples — paradigmatic; counter examples refute or limit; and anomalous examples do not quite fit a reasoning sequence.

Intelligent Computer-Assisted Instruction

MEMO

Dr. Woolf's prototype tutor that explains student Pascal programming errors.

PARALLEL ARCHITECTURES AND ASSOCIATIVE MEMORY

Computer Architecture Research Group research involves highly parallel architectures, associative or content addressable architectures, image processing and computer vision applications, metrics for evaluating highly parallel architectures, parallel algorithms, and VLSI. Specialized equipment available includes a Content Addressable Memory (CAM) with 320 words (80K bytes), analog and digital interfaces, two speech synthesis units, a color graphics display, and test equipment.

In conjunction with the Department of Electrical and Computer Engineering (ECE), there is a VLSI projects course that uses the DARPA MOSIS facility to build architecture designs into silicon.

ROBOTICS

Current research of the Laboratory for Perceptual Robotics (LPR) is to integrate dynamic sensing with distributed planning and control techniques for robots, that researches how a robot can receive continual visual, tactile and other feedback to allow it to modify its control algorithms and plans during operation. Current goal is to integrate vision and touch, involving visual location of parts, followed by grasping. Once an object is touched, its position, orientation, and local tactile features become available from the tactile sensor, for simple object classification.

TOUCH

Dr. Overton developed an elastomer-based tactile array sensor that allows monitoring an array of gray-level "forcels" to aid object recognition and to obtain feedback about position of the object relative to the gripper. The tactile array is very robust, and provides 25 tactile transducers in one square inch of sensor surface.

LAB EQUIPMENT

The LPR equipment includes two manipulators, a Stanford/JPL gripper (Salisbury hand), and a URI gripper with tactile sensing on one finger. One manipulator is a revolute joint arm, the other is a Cartesian (coordinate) machine. A GE automation camera provides data for vision. Additional equipment includes three PDP 11's and VAX access. The laboratory uses a PDP 11/23 devoted to controlling the Cartesian arm, and a PDP 11/03 for preprocessing of visual and tactile feedback. Algorithms and simple planning use a VAX 11/750. A network of 16 T-11 microcomputers control the Salisbury hand. Several LSI/11 microcomputers are available.

RESEARCH GRANTS

Research grants are from federal and private/industrial sources:

Federal	Number of Grants
National Science	17
DARPA	3
Department of Defense	1
Office of Naval Research	4
Air Force	5
National Institute of Health	1
U.S. Department of Education	1
NASA	1

Private/Industrial	Number of Grants
Martin-Marietta	1
General Electric Corporation	1
Digital Equipment Corporation	4
Atari Corporation	1
A. C. Nielsen Company	1
Control Data Corporation	1
Rome Air Development Corporation	4

University of Pennsylvania
Department of Computer and Information Science
School of Engineering and Applied Science

Artificial intelligence research emphasis is on:

- Natural Language Processing
- Integrated Systems, Vision and Language
- Mathematical Aspects of AI
- Automatic Generation of Software Programs
- Computer Vision
- Sound and Speech Synthesis
- Learning Systems
- Distributed Operating Systems

AI computer facilities include:

- PDP 11/05 and PDP 11/60 for computer vision research
- LISP machines for interactive systems
- HP 9863 workstations and a file server for distributed database search
- VAX 780's and VAX 750's for AI research, natural language processing, and robotics
- CSNET and ARPANET communications networks

Also available, UNIVAC 1100/61 time-sharing system with 1 megaword real memory, 3 billion bytes of online disk storage, and 96 ports; graphics laboratory with Ramtek GX-100B color graphics display, Vector General 3404 high-performance interactive display; Tektronix 4010 storage tube and hard copy, and Zeta plotter.

- VAX 11/780's
- VAX 11/750's
- HP 7836 workstations
- LISP machines

Specialized laboratories include: Computer Graphics Lab, Natural Language Process Lab, and Robotics Lab. Specialized graphics, vision, and robotics hardware is available.

Communication networks include: Ethernet, CSNET, and ARPANENT. Additional facilities include DEC System 10(KL), DEC System 10(KA), and IBM 4321.

Faculty with research pursuits including artificial intelligence are shown below.

Faculty		Research Interests
Badler, Norman I.	Ph.D., Toronto	Language and Vision Systems
Najcsy, Ruzena	Ph.D., Stanford University	Language and Vision Systems
Buneman, Peter	Ph.D., Warwick	Intelligent Database Systems
Carr III, John W.	Ph.D., MIT	AI Languages, Problem Solving
Davison, Susan	Ph.D., Princeton University	Parallel Processing
Finin, Timothy	Ph.D., Illinois	Natural Language Processing, Vision
Garfinkel, David	Ph.D., Harvard University	AI Techniques in Medicine
Gray, Harry J.	Ph.D., Pennsylvania	AI Learning Theories
Herman, Gabor	Ph.D., London	Biomedical Image Processing, Vision
Joshi, Aravind J.	Ph.D., Pennsylvania	Natural Language Design, Vision
Lee, Insup	Ph.D., Wisconsin	Parallel Processing and Architectures
Ma, Yuen-Wah Eva	Ph.D., UC Berkeley	Parallel Processing and Architectures
Miller, Dale	Ph.D., Carnegie-Mellon University	AI Research
Morgan, Howard	Ph.D., Cornell University	Intelligent Database Systems, DSS
Webber, Bonnie Lynn	Ph.D., Harvard University	Speech Recognition, Natural Language

AI Labs and Thinktanks

Microelectronics and Computer Technology Corporation (MCC)

Microelectronics and Computer Technology Corporation (MCC) in Austin, Texas, is a private sector joint research and development venture created to help maintain United States technological preeminence and international competitiveness in microelectronics and computers. It was formed in response to the success of Japan's focus on long-term research and development related to next-generation computers, spearheaded by Japan's Ministry of International Trade and Industry (MITI).

MCC began formal operations in January 1983, under the direction of retired Admiral B. R. Inman, Chairman, President and Chief Executive Officer. Admiral Inman spent 22 years organizing internal high-tech espionage networks for the U.S. Navy, the Defense Intelligence Agency, the CIA, and the National Security Agency, where he served as director from 1977 to 1981. He was Deputy Director of the CIA (1983).

MCC concentrates scarce financial and intellectual resources that individual companies could not or would not otherwise deploy alone. It develops technology to allow its founding and future shareholders to derive products and services of their own conception and design, and to compete in markets of their choice.

MCC's existence also helps U.S. computer and semiconductor firms meet the challenge from foreign government-supported R&D programs that have allowed firms in Japan and Western Europe to target U.S. industries.

MCC is owned by 21 American microelectronics and computer companies (listed below).

- Advanced Micro Devices
- Allied
- BMC Industries
- Bell Communications Research
- Boeing
- Control Data Corporation
- Digital Equipment Corporation
- Eastman Kodak
- Gould, Inc.
- Harris
- Honeywell
- Lockheed Missiles and Space Company
- Martin-Marietta Aerospace
- 3M
- Mostek
- Motorola
- National Semiconductor
- NCR
- RCA
- Rockwell International
- Sperry

MCC is governed by a Board of Directors composed of representatives of each shareholder company. Each MCC shareholder participates in at least one of MCC's four technology programs for a minimum of 3 years, and contributes outstanding scientists and engineers to those programs. MCC holds title to all resulting knowledge and patents, and licenses them to MCC shareholders participating in those programs. MCC technologies can be licensed to other companies, including smaller companies, up to 3 years after their availability to participating companies. Participants receive about 70% of royalty income. The remainder is used to finance further MCC research.

MCC's first four long-range advanced technology programs are intended to make significant technological advances within 5 to 10 years. The programs are under the supervision of Chief Scientist John Pinkston, formerly the Deputy Director of Research at the National Security Agency. The programs include:

Packaging

A 6-year program to advance the state-of-the-art in semiconductor packaging and interconnect technology, with emphasis placed on technologies compatible with automatic assembly at both the circuit and system level.

Software Technology

A 7-year program to develop new techniques, procedures and tools, to improve the productivity of software development processes.

VLSI/Computer-Aided Design

An 8-year program to improve computer-aided design technology and to develop an integrated set of tools for complex systems and VLSI chips from which those systems are built.

Advanced Computer Architecture

The most complex and ambitious of the MCC programs, this 10-year effort will focus on the following projects:

- *Parallel Processing.* Develop the languages and architectures to allow computers to perform tasks simultaneously instead of sequentially, with corresponding increases in speed.
- *Database System Management.* Improve database design and storage methods and capacities to permit flexible storage and faster retrieval of a broader range of more complex information.
- *Human Factors Technology.* Improve the relationship between man and computer, by simplifying the use of computers through techniques such as improved voice or character recognition systems, or natural language systems.
- *AI Knowledge-Based Systems.* Knowledge representation and expert systems applied to engineering and other applications.

RAND Corporation

RAND activities include expert system tools and applications, problem-solving and decision support systems, military tactical simulation, human–machine interfaces, and parallel processing systems.

Information for release to the public is currently being prepared by RAND, and will be available in the next edition of this book. For insight into RAND AI activities, please refer to WWAI pages 22 and 28, re: Klahr, Dr. Philip and Waterman, Dr. Donald.

Stanford Research Institute International
Engineering Research Group
Computer Science and Technology Division, AI Center

RESEARCH AND DEVELOPMENT

Research and development in:

- Planning, Problem Solving and Deduction
- Natural Language Processing
- Distributed Data Management
- Robotics
- Image Processing and Vision
- Knowledge-Based Expert Systems
- Automatic Program Synthesis

Planning, Problem Solving and Deduction

Planning, problem solving, and deduction focuses on common sense reasoning about actions and effects. Systems plan and execute action sequences for a mobile robot that interactively guide the assembly and disassembly of electromechanical equipment by an apprentice technician, and that plan and execute retrieval strategies from large, distributed databases. Efforts are underway to develop plans for execution by multiple effectors in parallel, modified interactively by human decision makers, making it possible for problem solving to be carried out by multiple independent processors.

Computer Vision

Image processing and computer vision work includes fundamental principles of vision (in animals and machines), remote sensing, cartography, medicine, and advanced automation. Basic research is concerned with recovering the three-dimensional structure of a scene from one or more images, describing and recognizing objects by shape and photometric properties, modeling the imaging process, and developing general paradigms for perceptual reasoning. Also, developing techniques and systems to automate the interpretation of aerial imagery (cartographic functions, image-to-database correspondence, identification of linear features, mensuration, and object recognition), and to provide visual capability for machines that perform manipulation and inspection.

Natural Language Processing

Natural language processing in acoustics, phonology, prosodics, syntax, semantics, discourse structure, and context of communication. Includes the integration of knowledge, beliefs, goals, and plans, as well as deductive-inference procedures and common sense reasoning. Systems have been developed for basis research on natural language dialogues, and natural language interfaces to a variety of computer software systems.

Knowledge-Based Expert Systems

Knowledge-based expert systems combine substantive knowledge bases with knowledge acquisition and management to construct specialist systems for professionals. Procedures for intelligent acquisition and management utilize rule-based representations of judgmental knowledge, partitioned semantic networks to store factual knowledge, subjective Bayesian probability theory to propagate measures of belief, and augmented transition network grammars for language processing. The AI Center has developed expert systems for mineral exploration and for electronic-warfare tasks.

Distributed Data Management

Distributed data management applies artificial intelligence techniques to the management of information stored in large, distributed databases. It incorporates techniques from common sense reasoning, automatic programming, and natural language interfaces to many different languages, and monitors information over computer networks.

Automatic Program Synthesis

Automatic program synthesis generates computer algorithms automatically from specification of the purpose of a given program. Draws upon and supports theorem-proving, automatic planning, and AI programming languages. Systems have been developed for program generation based on theorem proving, and program transformation techniques.

RESOURCES AND FACILITIES

Permanent staff of almost 40 individuals. AI Center has a wide range of computer facilities, listed below:

- DEC 1060 time-shared computer
- Symbolics LISP machines
- Online access through CRT and printing terminals to all staff
- ARPANET and TYMNET communications networks

The vision laboratory has an Optronics image scanner, and De Anza and Grenell color displays controlled by a VAX 11/780 with a high-speed link to the 2060.

Through an internal SRI computer network, the AI Center also has access to the SRI DEC PDP 11/70 UNIX time-sharing system, a B6700, and a VAX 11/780.

REPRESENTATIVE PROJECTS

SHAKEY

A mobile, computer-controlled robot used in research on problem solving.

STRIPS

A goal-oriented robot problem-solving program.

QA4 and QLISP

Special-purpose languages for writing problem-solving programs.

NOAH

An automatic system for generating hierarchical plans of parallel action.

MYSIS and ISIS

Systems for interpreting visual features in scene analysis.

HAWKEYE

An interactive aid for image analysis in cartography and photo interpretation.

Image Understanding

The development of procedures for map-guided image interpretations and perceptual reasoning.

Distributed Artificial Intelligence

Research on distributed, cooperative intelligent agents.

Speech Understanding

A system development effort under the ARPA Speech Understanding Research Program.

TDUS

A system enabling natural language communication with computers for task performance.

DIAMOND/DIAGRAM

A linguistically motivated, domain-independent language analysis procedure and grammar.

LIFER

A practical system for building natural language interfaces to a range of computer software.

LADDER

A system providing natural language access to a distributed database of naval command-control information.

MEDINQUIRY

A system offering physicians natural language access to medical data for patient management and clinical research.

PROSPECTOR

A computer-based consultant to be used by field geologists for mineral exploration.

TEAM

A transportable natural language system to access databases.

KLAUS

A system that can be instructed about specific topics through dialogue in English.

AI Job Hunter's Guide

AI Job Hunter's Guide

Companies growing AI departments include:

Advanced Information & Decision Systems
Applied Expert Systems
Arco
Atari
AT&T
Avco Everett
BDM
Becton Dickinson
Bell Labs
Boeing
Burroughs
Carnegie Group
Chemical Abstracts Service
DEC
Eastman Kodak
Eaton
EG&G
Ford Aerospace
General Electric
General Motors
Gould
Grumman-CTEC
GTE
Harris
Hewlett-Packard
Hughes
IBM
Inference Corporation
LISP Machine Inc.
Lister Hill Biomedical
Lockheed
3M
McDonnell Douglas
Martin-Marietta
Mitre
Motorola
Naval Underwater Systems
NCR
Olivetti
Perceptronics
Philips
Planning Research Corp.
RCA
Rockwell
Schlumberger/Fairchild
Shell
Siemens
Southwest Research Institute
Standard Oil
Sperry
SRI International
Syntelligence
System Development Corp.
Texas Instruments
The Aerospace Corporation
The Analytic Services Corporation
TRW
United Technologies
Verac
Wang
Xerox

Applied Expert Systems, Inc.
5 Cambridge Center
Cambridge, MA 02142
Attn: Karen Donoghue

Arco Research Technology
Plano Employee Relations
P.O. Box 2819
Dallas, TX 75221
Attn: Barbara Hough

Artificial Intelligence Laboratory, Schlumberger
3340 Hillview Avenue
Palo Alto, CA 94304

Advanced Information & Decision Systems
201 San Antonio Road, Suite 286
Mountain View, CA 94040
Attn: Cliff McCormick or Mary Morton

Avco Everett Research Laboratory, Inc.
2385 Revere Beach Parkway
Everett, MA 02149

Becton Dickinson Research Center
P.O. Box 12016
Research Triangle Park, NC 27709
Attn: R. Wilson

BDM International, Inc.
7915 Jones Branch Drive
McClean, VA 22012
Attn: H. Marcario

2227 Drake Avenue
Huntsville, AL 35805
Attn: D. Weaver

1801 Randolph Road SE
Albuquerque, NM 87106
Attn: L. Todd

Boeing Computer Services
P.O. Box 3707-FCB
Seattle, WA 98124

Carnegie Group Inc.
Manager, Human Resources
650 Commerce Court, Station Square
Pittsburgh, PA 15219

Chemical Abstracts Service
Employment Dept. R
P.O. Box 3012
Columbus, OH 43210

EG&G Idaho, Inc.
Recruiting and Employment (TD-5)
P.O. Box 1625
Idaho Falls, ID 83415

FMC AI Center
1185 Coleman Avenue, Box 850
Santa Clara, CA 95052
Attn: Perry Thorndyke

Ford Aerospace & Communications Corp.
Professional Placement, Dept. A703-001
Ford Road
Newport Beach, CA 92660
Attn: L. Scholl

General Electric Research & Development Center
University Relations and Recruiting
P.O. Box 8
Schenectady, NY 12301
Attn: Neff Dietrick, Ref 19C

General Motors Research Laboratories
Warren, MI 48090
Attn: G. Dodd, Ph.D., Head, Computer Science Dept.

Grumman-CTEC, Inc.1355 Beverly Road
Suite 200, Dept. 13
McClean, VA 22101
Attn: Tom Skinner

GTE Laboratories, Inc.
Box A, 40 Sylvan Road
Waltham, MA 02254
Attn: Cynthia Farrar

Hewlett-Packard Labs
1501 Page Mill Road
Palo Alto, CA 94304
Attn: Joan Wade

Hughes AI Center
3011 Malibu Caynon Road
Malibu, CA 90265
Attn: Arlyne Luna

Inference Corporation
5300 West Century Boulevard
Los Angeles, CA 90045
Attn: Mark Maletz

LISP Machines Inc.
Professional Staffing
1000 Massachusetts Avenue
Cambridge, MA 02139

Lister Hill National Center for Biomedical Communications
(R&D arm of National Library of Medicine)
National Library of Medicine
National Institute of Health
Public Health Service
Building 38A, Room 7S715
8600 Rockville Pike
Bethesda, MD 20209
Attn: Yvonne Reid

Lockheed Missiles & Space Company
Professional Staffing, Dept. 505CF14
P.O. Box 3504
Sunnyvale, CA 94088

3M
Staffing Dept., 3M Center, Bldg. 224-1W
St. Paul, MN 55144
Attn: G. Kiperts

Martin-Marietta Data Systems
98 Inverness Drive East, Suite 135 (P193)
Englewood, CO 80112
Attn: Bill Dalton

Martin-Marietta Denver Aerospace
P.O. Box 179, Mail #0570
Denver, CO 80201
Attn: Jack Dietzler, Rodger Schappell

Mitre Corporation
1820 Dolley Madison Boulevard
McClean, VA 22102
Attn: J. Goudarzi

Naval Underwater Systems Center
Personnel Staffing Division, AI
Newport, RI 02841

Olivetti Advanced Technology Center
Professional Employment, Dept. 8
10430 South DeAnza Boulevard
Cupertino, CA 95014

Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91367
Attn: Dee Macosko, Human Resource Manager

Philips Laboratories
P.O. Box 327, Scarborough Station
Briarcliff Manor, NY 10501
Attn: John Packard, Director of Employment

Planning Research Corporation
Government Information Systems
1500 Planning Research Drive
McClean, VA 22102
Attn: James Aquino, Senior Staffing Specialist

Rockwell International Science Center
Professional Staffing, RAI AIS/85
1049 Camino Dos Rios
Thousand Oaks, CA 91360

Shell Development Company
Research Recruitment
P.O. Box 1380
Houston, TX 77001

Siemens Corporate Research & Support, Inc.
Research & Technology Laboratories
Personnel Dept., Princeton Forrestal Center
105 College Road East
Princeton, NJ 08549

Southwest Research Institute
Personnel Dept. #129
P.O. Box 28510
San Antonio, TX 78284
Attn: Bill Brumlett, Assistant Director of Personnel

The companies listed in this table are growing AI departments in the areas indicated.

	AI RESEARCH; AI TOOLS; GENERAL	EXPERT SYSTEMS	AUTOMATIC PROGRAMMING	KNOWLEDGE REPRESENTATION	PROGRAMMING LANGUAGES & SOFTWARE	LEARNING; KNOWLEDGE ACQUISITION	NATURAL LANGUAGE	VOICE RECOGNITION	ROBOTICS; MACHINE LEARNING	VISUAL RECOGNITION	COGNITIVE MODELING	HEURISTICS; INFERENCE; REASONING	SPECIALIZED ARCHITECTURES	AI WORKSTATIONS; AI HARDWARE	SUPERCOMPUTERS	NETWORKS	AUTONOMOUS VEHICLES	MILITARY APPLICATIONS	SPACECRAFT APPLICATIONS	MEDICAL APPLICATIONS	BANKING APPLICATIONS	INSURANCE APPLICATIONS	SALES APPLICATIONS	U.S. CITIZENSHIP REQUIRED
Applied Expert Systems, Inc. (Cambridge, MA)				✓																	✓			
Arco Resources Technology (Dallas, TX)				✓																				
AI Lab, Schlumberger (Palo Alto, CA)																								
Advanced Information & Decision Systems (Mt. View, CA)		✓		✓	✓	✓	✓		✓				✓					✓						
Avco Everett Research Laboratory, Inc. (Everett, MA)		✓							✓	✓														
Becton Dickinson Research Center (Research Triangle Park, NC)		✓		✓																				
BMD International, Inc. (Albuquerque, NM)		✓						✓		✓			✓											✓
Boeing Computer Services (Seattle, WA)							✓		✓															
Carnegie Group Inc. (Pittsburgh, PA)				✓	✓	✓	✓																	
Chemical Abstracts Service (Columbus, OH)		✓					✓																	
EG&G Idaho, Inc. (Iowa Falls, ID)		✓		✓																				
FMC (Santa Clara, CA)			✓						✓	✓		✓						✓						
Ford Aerospace & Communications Corp. (Newport Beach, CA)										✓														✓
GE Research & Development Ctr. (Schenectady, NY)				✓		✓						✓												
General Motors Research Laboratories (Warren, MI)							✓		✓	✓							✓							
Grumman-CTEC, Inc. (McLean, VA)				✓			✓																	✓
GTE Laboratories, Inc. (Waltham, MA)		✓		✓		✓	✓		✓							✓								
Hewlett-Packard Labs (Palo Alto, CA)																								
Hughes AI Center (Malibu, CA)							✓			✓			✓					✓						✓
Inference Corporation (Los Angeles, CA)				✓														✓	✓					
Lisp Machine Inc. (Cambridge, MA)														✓									✓	
Lister Hill Nat. Ctr., Biomedical (Bethesda, MD)				✓			✓			✓														
Lockheed Missiles & Space Co. (Sunnyvale, CA)																								✓
3M (St. Paul, MN)				✓																				
Martin-Marietta Data Systems (Englewood, CO)		✓		✓			✓																	
Martin-Marietta Denver Aerospace (Denver, CO)		✓		✓		✓				✓							✓	✓	✓					
Mitre Corporation (McLean, VA)		✓		✓			✓		✓			✓						✓						✓
Naval Underwater Systems Center (Newport, RI)																		✓						✓
Olivetti Advanced Technology Center (Cupertino, CA)		✓		✓								✓												
Perceptronics, Inc. (Woodland Hills, CA)		✓							✓									✓		✓				
Philips Laboratories (Briarcliff Manor, NY)				✓																				
Planning Research Corporation (McClean, VA)				✓			✓			✓														
Rockwell International Science Center (Thousand Oaks, CA)									✓	✓									✓					
Shell Development Company (Houston, TX)	✓	✓		✓	✓							✓	✓											
Siemens Research & Technology Laboratories (Princeton, NJ)																								
Southwest Research Institute (San Antonio, TX)		✓		✓					✓	✓														
Sperry Corporation (Reston, VA)		✓		✓	✓				✓				✓					✓						✓
Stanford Research Institute International (Menlo Park, CA)				✓			✓						✓											✓
Syntelligence (Sunnyvale, CA)				✓	✓																✓	✓		
Systems Development Corporation (Paoli, PA)		✓					✓					✓	✓											
The Aerospace Corporation (Los Angeles, CA)			✓										✓						✓					✓
The Analytic Science Corporation (Reading, MA)		✓																						
United Technologies Research Center (Hartford, CT)		✓		✓	✓		✓																	
Verac Incorporated (San Diego, CA)																		✓						✓
Xerox Special Information Systems (Pasadena, CA)																								

Sperry Corporation
Employment Dept. BH-8/96
12010 Sunrise Valley Drive
Reston, VA 22091

Stanford Research Institute International
333 Ravenswood Avenue
Menlo Park, CA 94025
Attn: Michael Patrick

Syntelligence
P.O. Box 3620
Sunnyvale, CA 94088
Attn: Peter Hart, Dick Duda, Carole Knappe

Systems Development Corporation
Custom Products Group
P.O. Box 517
Paoli, PA 19301
Attn: Stephen Kaplan, Manager of Employment

The Aerospace Corporation
Dept. 00568, P.O. Box 92957
Los Angeles, CA 90009

The Analytic Sciences Corporation
One Jacob Way
Reading, MA 01867
Attn: Don Shanley

United Technologies Research Center
Silver Lane
East Hartford, CT 06108
Attn: M. C. Marcin

Verac Incorporation
P.O. Box 26669, Dept. 446
San Diego, CA 92126

Xerox Special Information Systems
Dept. AI, P.O. Box 7018
250 N. Halstead Street
Pasadena, CA 91109

RESEARCH KNOWLEDGE ENGINEER

SYNTEL™ SYSTEM DEVELOPER

APPLICATIONS KNOWLEDGE ENGINEER

SOFTWARE TEAM LEADER

SOFTWARE ENGINEER

DATA BASE ADMINISTRATOR

TECHNICAL SUPPORT MANAGER

TECHNICAL WRITER

FINANCIAL EXPERT SYSTEMS

SYNTELLIGENCE is the leading expert system company focusing on the assessment of large-scale financial risks. Our next generation proprietary software, SYNTEL™, blends expert system technology with advanced concepts in programming languages. This environment, coupled with a deep understanding of the judgmental basis for making financial decisions, has led to the creation of powerful and practical expert systems. Fueled by this unusual combination of technological superiority and applications insight, we are changing the way leading financial institutions do business.

Creating change in the financial services sector is Syntelligence's business, and our rapid growth is opening up opportunities for key contributors. The highly-motivated, product-oriented professionals we seek will share in the rewarding excitement of guiding technology from research through development to the marketplace.

SYNTELLIGENCE offers a competitive salary and benefits package. If you would like to be part of our growth, please contact Dick Duda, Peter Hart or Carole Knappe at: P.O. Box 3620 Sunnyvale, CA 94088 (408) 745-6666. We are an equal opportunity employer. Individuals only, please.

syntelligence

Inference Seeks Knowledge Engineers

Inference Corporation is the nation's leading developer and supplier of Artificial Intelligence software. Inference developed and markets the Automated Reasoning Tool (ART), a software tool that is used to develop expert systems.

We are currently seeking knowledge engineers to support our rapidly expanding user community. Our knowledge engineers work directly with ART customers to help develop their ART-based expert systems. This provides a challenging work environment where a knowledge engineer is constantly faced with new and exciting problems to solve. As an example, here are some of the applications that are currently being developed using ART:

- **Space Shuttle and Space Station Applications**
  - Navigation
  - Fault detection and diagnosis
  - Control
  - Monitoring
  - Mission planning
- **Planning and Scheduling**
  - Financial planning
  - Production management
  - Knowledge-based scheduling
  - C^3I systems

Inference offers extremely competitive salaries and excellent employee benefits. We are a rapidly growing firm and offer our employees tremendous career growth opportunities in an innovative work environment.

For more information, please contact:

- **Mark Maletz**
  Inference Corporation
  5300 West Century Blvd.
  Los Angeles, California
  90045
- **213/417-7997**

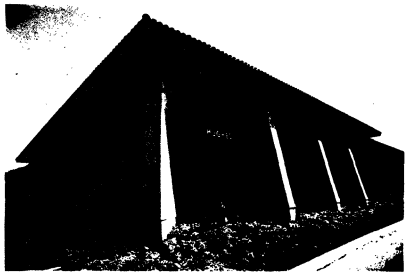
INFERENCE CORPORATION

An Equal Opportunity Employer

Hughes AI Center

The Hughes Research Laboratories AI Center is nestled at the foot of the Santa Monica Mountains in Calabasas, a quiet suburb in the San Fernando Valley. It is only minutes away from both metropolitan Los Angeles and the Malibu coastline.

Researchers here enjoy freedom in pursuing AI topics and an atmosphere that fosters an effective exchange of ideas.



The AI Center receives equal support through Company funded IR & D projects and government research contracts. The AI Center also has a firmly established working relationship with leading universities throughout the country.

Career Opportunities:

Research areas	Research Facilities	Current Application Areas
• Planning	• Symbolics LISP Machines	• Autonomous Vehicles
• Machine Perception	• VAX 11-780s	• Intelligent Vision Systems
• Natural Language Processing	• Mobile Robot Laboratory	• Decision-Support Systems
• Multi-Processor Architectures	• Vision Multi-Processor	• Knowledge Engineering

Interested Candidates with advanced degrees in Artificial Intelligence please send your resume to Arlyne Luna, Hughes Research Laboratories, 3011 Malibu Canyon Road, Malibu, CA 90265. Proof of U.S. Citizenship Required. Equal Opportunity Employer.

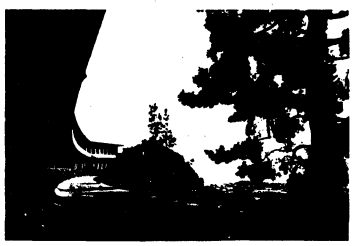
Member of the Technical Staff, Hughes Research Laboratories

Overlooking Malibu on the Pacific Ocean is Hughes Research Laboratories. Here the Artificial Intelligence emphasis is on high-performance VLSI concurrent computing systems for two-dimensional radar, sonar and computer vision applications.

Members of the Technical Staff in the Information Sciences and Computer Architecture Section participate in a wide variety of activities, including programs to build sophisticated linear algebraic processor arrays and image understanding systems.

A background in one or more of the following areas is required:
- Concurrent Symbolic and Numeric Computing Architectures
- Computer Vision
- Knowledge Based Systems
- Inference Machines
- Digital Signal Processing

Please send resume and salary history to Arlyne Luna, Hughes Research Laboratories, 3011 Malibu Canyon Road, Malibu, CA 90265. Proof of U.S. Citizenship Required. Equal Opportunity Employer.



APPLIED AI PROGRAM DIRECTOR

The Advanced Information-Technology Applications Center at SRI INTERNATIONAL is seeking an established professional to lead an applied artificial intelligence effort in the following areas:

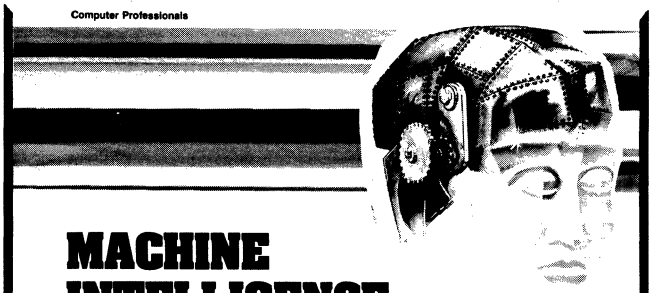
- **Knowledge-based systems**
- **Planning systems**
- **Natural language processing**

Candidates should possess a Masters Degree (minimum) or PhD in Computer Science or Electrical Engineering with a minimum of 10 years project-leader experience. This position requires extensive client interaction, proposal/program development, and management of a group of professionals working on developing AI systems. Candidate must be able to formulate and sell programs at the conceptual level and be able to direct the research and development of prototype software systems and tools.

SRI INTERNATIONAL (formerly Stanford Research Institute) is a problem solving organization performing contract research and development for a wide variety of clients. Our unique environment encourages substantial individual contribution as well as team activities based on our matrix organization. SRI is one of the largest non-profit R&D institutions with a human resource base comprised of over 110 disciplines. For immediate consideration, please send resume to Michael Patrick, Professional Staffing Dept. AI 685, Rm. EL 102, SRI INTERNATIONAL, 333 Ravenswood Avenue, Menlo Park, CA 94025. An equal opportunity employer. U. S. CITIZENSHIP IS REQUIRED.

SRI International®

Computer Professionals



MACHINE INTELLIGENCE

Significant new opportunities have been created for scientists dedicated to infusing machines with the power of thought.

Grumman-CTEC, Inc., a Grumman Data Systems subsidiary, is a leader in surveillance and communications processing software design. The Laboratory for Machine Intelligence and Correlation reflects Grumman's commitment to bolstering Grumman-CTEC's work in the evolving computing sciences.

THE LABORATORY FOR MACHINE INTELLIGENCE AND CORRELATION SEEKS SCIENTISTS IN THESE SPECIALITIES:

1. Natural Language Understanding, Computational Linguistics, Cognitive Psychology or comparable background. Ideal candidates will have substantive knowledge of natural language computer models; text parsing and understanding; and text generation.
2. Knowledge-Based Systems, Knowledge Engineering or related Computer Sciences. Ideal candidates will have substantive experience in knowledge representation; major responsibility for developing at least one significant system; be well-versed in symbolic programming; and be familiar with a broad range of "styles" of machine intelligence.

Additional considerations include your ability to contribute research results to the technical and professional literature, to establish and maintain peer recognition in the scientific and technical research communities, and to provide technical support to marketing. Required qualifications include a PhD or equivalent in Linguistics, Psychology, Applied Mathematics or Computer Science.

Other qualifications of significance: programming experience of noteworthy quality and scope; broad interdisciplinary skills to complement candidate's depth and competence in specialty areas.

For immediate consideration, please call Tom Skinner at (703) 448- 0226. Or, send your resumé in confidence to: Grumman-CTEC, Inc., 1355 Beverly Road, Suite 200, Dept. 13, McLean, VA 22101.

U.S. citizenship required. An Equal Opportunity Employer.

CUSTOM SOLUTIONS for Managing Information

GRUMMAN

Artificial Intelligence Laboratory

For Information Contact:
Dr. E. Braude – 609-866-6631

RCA Advanced Technology Laboratories

AI

EMPLOYMENT OPPORTUNITIES

Advanced Information & Decision Systems (AI&DS) invites qualified candidates to apply for research, programming and technical management positions in artificial intelligence R&D. AI&DS is a growing employee-owned company of 66 highly talented people working to develop and implement state-of-the-art solutions to real-world problems in areas such as artificial intelligence, software engineering, image understanding, information management, estimation and control, decision theory, signal processing, and cognitive science. Throughout 1985, positions will be available on projects involving:

- **Knowledge-Based and Expert Systems**
  - General Architectures
  - Knowledge Acquisition
- **Hypothesis Formation**
  - Image and Signal Understanding
  - Image Processing
  - Information Integration
- **Planning and Control**
- **Decision-Making Aids**
- **Robotics**
- **Distributed AI**
- **Intelligent User Interfaces**
- **Natural Language Understanding**
- **Software Development Aids**
- **Information Management**
  - Information Retrieval
  - Database Management
- **Systems Support**
  - UNIX Systems Programming
  - LISP Programming

Located in the beautiful San Francisco Bay Area, AI&DS offers a pleasant and supportive work environment, with expanding hardware facilities that include VAXs, Symbolics 3600s, SUNs, and a Vicom image processor linked by Ethernets and connected to the ARPANET.

To find out more about AI&DS and the positions listed above, please phone Mary Margaret Morton or Clif McCormick at (415) 941-3912, or send your resume to:

Advanced Information & Decision Systems
201 San Antonio Circle, Suite 286
Mountain View, California 94040-1270

AI&DS

An Equal Opportunity Employer
U.S. citizenship required for many projects

Knowledge Engineer/ Computer Scientist

Atlantic Richfield Corporation is one of the leaders in domestic oil and gas exploration and production. Expanding technology in exploration geophysics has created a need for knowledge-based computer systems. We are establishing an applied artificial intelligence (AI) research project in the Geophysical Research Department to advance the state-of-the-art in seismic computing technology.

ARCO Resources Technology has positions available in knowledge-based systems development at our Research Center in Plano, just north of Dallas. Candidates should have an advanced degree in artificial intelligence, and some experience in hydrocarbon exploration, signal analysis, and applications of pattern recognition techniques. The responsibilities include geophysical expert systems development, implementation and maintenance.

We offer very competitive salaries, excellent career opportunities and an outstanding benefits program.

For prompt and guaranteed confidential consideration, please send a detailed resume and salary history and copy of this ad to: **ARCO Resources Administration, Plano Employee Relations, Barbara Hough, P.O. Box 2819, Dallas, TX 75221.**

ARCO Resources Technology

An equal opportunity employer

R&D Opportunity in Expert Systems

Research Triangle Park, NC

Becton Dickinson and Company, a multinational Fortune 500 health care firm, has an opening for a computer applications professional at our Corporate Research Center in Research Triangle Park, North Carolina.

As a Scientist in our Applied Physics Department, you will provide leadership in formulation and solution of complex problems in computer applications. Your responsibilities will include:

- Establishing a technology base in expert systems, including choice of appropriate hardware, software and program development tools.
- Defining expert systems applications relevant to the interests of Becton Dickinson.
- Developing knowledge bases via interaction with domain experts.
- Implementation, testing and validation of prototype expert systems.
- Varied involvement in modeling, simulation, analysis and scientific applications of computer technology.

Your background should include an advanced degree in electrical engineering, computer science, artificial intelligence or equivalent. Proven ability to develop non-trivial expert systems is important, and industrial experience is preferred. Knowledge of Prolog or LISP, FORTRAN, C or equivalent is essential. Familiarity with VAX 11/750, Tektronix 4404 and IBM PC desirable. Some exposure to medical or biological science helpful.

We offer excellent salaries, comprehensive benefits and the opportunity to become a major contributor in a dynamic organization. Please send your resume and salary history in confidence to: Mr. F. Richard Wilson, Human Resources Department, Becton Dickinson Research Center, P.O. Box 12016, Research Triangle Park, NC 27709. An equal opportunity/affirmative action employer.

Caring for people is our business

BECTON DICKINSON

Be Part of Breakthrough Research in ARTIFICIAL INTELLIGENCE & SOFTWARE ENGINEERING

United Technologies Research Center, a recognized source for broad ranging research of the first rank, has gained wide recognition for significant achievements both in pure science and R&D. Here, you'll discover a research environment tailored to your needs....top scientific researchers....ample funding....outstanding back-up services...a scientifically-oriented management...encouragement and rewards for publication of papers.

Now is the ideal time to join us as we accelerate our Computer Science research and application activities. If you're ready for a new leadership role, consider one of the following opportunities to work on leading-edge technology:

Artificial Intelligence

You will investigate and define artificial intelligence-based approaches to problem solving in manufacturing, design, and diagnostic systems. You will provide technical/program leadership in defining/implementing systems for selected applications.

Requires a PhD in Computer Science with extensive experience in AI subfields, such as expert systems, natural language, processing and knowledge-based system implementation.

Software Engineering

You will provide technical and program leadership in research, synthesis and deployment of software engineering methodologies, Ada and Ada-support environments, and knowledge-based approaches to software development.

Requires PhD or equivalent in Computer Science with extensive experience in Ada, AI, software engineering, database/knowledge base management, operating systems, formal specifications and design language.

Find out more about your excellent career prospects that include outstanding benefit and compensation programs. Send your resume to: M.C. Marcin, United Technologies Research Center, Silver Lane, East Hartford, CT 06108.

U.S. Citizenship Required

UNITED TECHNOLOGIES RESEARCH CENTER

An Equal Opportunity Employer

HUGHES

MEMBER OF THE TECHNICAL STAFF

Southern California

This is the opportune moment to join Hughes Research Laboratories, in Southern California, and be one of the people behind the development of the most sophisticated electronics technology. At our Malibu facility, we're building high performance VLSI concurrent computing systems for two-dimensional radar, sonar, and computer vision applications. We have immediate openings for Members of the Technical Staff in our Information Sciences and Computer Architecture Section. Here, you'll find professional growth potential due to the wide variety of activities at our facility, such as participating in programs to build sophisticated linear algebraic processor arrays and image understanding systems. New challenge and excitement can be yours at Hughes.

A background in one or more of the following areas is required.

- Concurrent Symbolic and Numeric Computing Architectures
- Computer Vision
- Knowledge Based Systems
- Inference Machines
- Digital Signal Processing

A Ph.D. in Electrical Engineering or Computer Science is preferred.

We offer an ideal location, stimulating environment, and excellent employee benefits.

Please send your resume and salary history to: Arlyne Luna, Hughes Research Laboratories, Dept. IA-7, 3011 Malibu Canyon Road, Malibu, CA 90265. Proof of U.S. Citizenship Required. Equal Opportunity Employer.

HUGHES AIRCRAFT COMPANY

RESEARCH LABORATORIES

SIEMENS

Research Scientists

Knowledge-Based Systems

Siemens Research and Technology Laboratories in Princeton, N.J., is expanding its research activity in Artificial Intelligence and is seeking several exceptionally qualified individuals to work on knowledge-based design aids. Candidates should have experience in some of the following areas:

- Development of Knowledge-Based Systems
- Computer Systems Design
- Computer Aided Design
- VLSI Circuit Design

Requirements include knowledge of language representation and acquisition techniques. AI programming environment and expertise in high level AI languages (LISP PROLOG). Familiarity with LOOPS, OPS5, and UNIX* would also be helpful.

Educational level: PhD or Masters degree in Computer Science or EE.

We offer competitive salaries and a liberal benefits package that also includes dental insurance, savings plan, and relocation assistance. For prompt consideration, please send confidential curriculum vitae to: Personnel Dept. RS/TMHF.

Siemens Corporate Research & Support, Inc.

Research & Technology Laboratories

Princeton Forrestal Center
105 College Road East
Princeton, N.J. 08540

An equal opportunity employer, m/f/h/v

*UNIX is a trademark of AT&T Bell Laboratories

RESEARCH POSITIONS

Chemical Information Science

Chemical Abstracts Service (CAS), a division of the American Chemical Society, is the acknowledged world leader in chemical information services. Founded in 1907, CAS produces a variety of printed, computer-based and on-line information services. The rapid expansion of our research program, aimed at developing new and innovative information services for chemists and chemical engineers, has created several new positions.

CHEMICAL INFORMATION SCIENTIST

Candidates should have a degree in chemistry and/or computer science. Experience in computer manipulation of chemical information is highly desirable.

RESEARCH SCIENTIST
ARTIFICIAL INTELLIGENCE/ COMPUTATIONAL LINGUISTICS

Candidates should have education and/or experience that includes computer science, information science or chemistry, as well as artificial intelligence or computational linguistics. Research experience focused on expert systems and/or natural language processing would be particularly useful.

COMPUTATIONAL CHEMIST

Candidates should have an advanced degree in chemistry and some background in computer/information science. Experience in an area such as molecular modeling, chemical synthesis prediction or structure-activity correlation is highly desirable.

CAS is located in Columbus, Ohio, a growing and dynamic metropolitan area with excellent housing, cultural, recreational and transportation facilities. Our modern offices, situated in a campus-like setting, provide a professional state-of-the-art working environment.

CAS provides a complete benefits package, which includes an excellent employer-paid retirement plan, relocation assistance, tuition reimbursement and a range of insurance programs, as well as salary scales commensurate with your background and experience.

To apply for one of these positions, please write to:

CHEMICAL ABSTRACTS SERVICE
Employment Department-R
P.O. Box 3012
Columbus, Ohio 43210

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SR. A.I. APPLICATIONS POSITION

TASC has a business area applying expert systems technology in diverse areas including projects in tactical navigation, short-term weather forecasting, intelligence analysis and digital mapping. Our facilities include an artificial intelligence laboratory based on Symbolics LISP machines and a special interface connecting them to our Image Processing Laboratory. Our staff is experienced in LISP machine technology and knowledge engineering. Their experience is being applied in various projects across the corporation. We see a large potential market which we have only begun to reach. To help our business continue to grow, we want to deepen our technical staff, particularly at the senior level.

We seek a senior staff member with interest and experience in artificial intelligence/expert systems applications. We seek a senior individual with significant professional credentials and substantive prior experience who can manage projects and perform the work as we move to larger research-oriented projects.

This individual would participate in marketing presentations, proposal preparation, and technical work in the artificial intelligence lab. The potential clearly exists for project leader or line management responsibilities.

The following characteristics are essential in this candidate:

- Ph.D. in Computer Science, Electrical Engineering, or Mathematics with emphasis on Artificial Intelligence.
- 3-5 years (or more) of experience beyond the Ph.D. in R&D in applications of expert systems technology.
- Hands-on experience in LISP and other AI computer languages.
- Interest in a broad range of AI applications including defense, intelligence, and/or geophysical/environmental applications.
- Refereed publications in significant professional journals such as the AI Journal, AI Magazine, Proceedings of the IJCAI, or other publications of the American Association for Artificial Intelligence.
- An interest in marketing, proposal development, and in seeing one's own ideas put into action. We are not looking for a theoretician.

The depth and variety of our applications areas and the exceptional quality of our staff and facilities make this position unusually attractive.

TASC offers an unusually attractive compensation program including profit sharing, extensive employee benefits, and a salary philosophy which reflects the accomplishments of our Technical Staff. Please send resumes to Don A. Shanley, The Analytic Sciences Corporation, One Jacob Way, Reading, MA 01867.

TASC

The Analytic Sciences Corporation
One Jacob Way, Reading, Mass. 01867

Artificial Intelligence

at Southwest Research Institute

The Institute's program in artificial intelligence consists of basic research as well as applications of AI techniques to problems related to ongoing work in other technical fields at SwRI. These include:

- Basic research in the design and implementation of knowledge representation for expert systems in the diagnosis and repair of electronic and electro-mechanical systems.
- Basic research in the design and implementation of a multi-language bidirectional machine translation system.
- Application of expert systems technology to the problem of failure modes and effects analysis (FMEA) for complex systems.
- Application of machine vision to both robotic and non-robotic industrial work cells design and development. One such problem relates to the location and identification of fasteners on aircraft wings to enable robotic removal of certain fasteners during aircraft overhaul.
- Application of expert systems technology toward selecting optimum nondestructive test techniques for particular problem areas.
- Application of expert systems technology to the problem of automated welding.

This list provides only a sample of the wide range of areas in which we are applying artificial intelligence techniques. There is room for both basic and applied research. Positions are open at both the Ph.D. level and Master's level.

We believe we have the challenges and opportunities for professional growth that the dedicated technical professional is seeking in a unique setting in the Hill Country of Texas. Please submit your resume to the following address. All inquiries will be answered and held in the strictest confidence. U.S. citizenship is required for all positions.

Southwest Research Institute, Personnel Department #129, P.O. Drawer 28510, San Antonio, TX 78284; or inquire: Bill E. Crumlett, Asst. Director of Personnel, (512) 684-5111, Ext. 2072.

Equal Opportunity Employer M/F.

Southwest Research Institute
San Antonio

SPERRY
•the• intelligent
decision—

At Sperry we have established a Corporate Technology Center close to Washington, D.C. to perform advanced research in Artificial Intelligence and Signal Processing.

The outstanding professionals selected to join our team will enjoy an exciting research environment where their efforts will significantly contribute to the directions of Sperry's future technology developments.

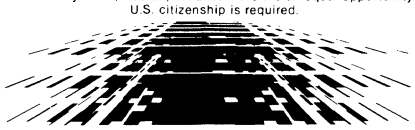
Qualified candidates will conduct advanced research in Artificial Intelligence and/or Signal Processing. They will participate in planning and justifying individual and group research programs and will actively interface with the Sperry and non-Sperry technical communities.

Current areas of interest include:
- **Knowledge Representation and Acquisition**
- **Expert Systems**
- **Machine Learning**
- **Distributed Problem Solving**
- **Software Engineering**
- **Spread-Spectrum Communications**
- **Radar Systems Analysis**
- **Parallel Algorithms and Architectures**
- **Millimeter Waves**
- **Target Identification**
- **Multisensor Fusion**

Requirements include a PhD or MS in EE or CS with comparable experience. Applicants must demonstrate a high degree of creativity, research aptitude and the ability to relate research to the technical needs of the Corporation.

Sperry in Reston offers all of the advantages of a fast-paced, high-tech environment. Only 18 miles from the nation's capital, Reston is recognized as one of the best neighborhoods in America, with easy access to the sophistication and progressive spirit of Washington, D.C.

To find out more about Sperry and Reston, send your resume to: **Sperry, Employment Dept., BH-8/96, 12010 Sunrise Valley Drive, Reston, VA 22091.** We are an equal opportunity employer. U.S. citizenship is required.



SPERRY

We understand how important it is to listen.

Ph. D. Engineers and Scientists, Recent Grads, Experienced Pros, NUSC Wants Both.

The research opportunities for Ph.D.'s at Naval Underwater Systems Center are unique and waiting for you if you have the following disciplines and special training.

Physicist who knows–Electromagnetic Theory, Scattering Theory, Acoustics–Theoretical Emphasis/Numerical, Materials Research (polymers), Electromagnetics Applied, Systems Theory & Practice, Artificial Intelligence and Classical Hydrodynamics.

Electrical Engineer knowledgeable in–Signal Processing, Underwater Communications, Radio Frequency Theory & Practice, Materials (Piezoelectricity R.f.), System Science, and Large Scale Electronic Systems.

Mechanical Engineer who knows–Hydrodynamics (Classical and Turbulence)

Engineering Mechanic with a background in–Material Science and Structural Analysis.

Applied Mathematician skilled in –Mechanics, Structures and Fluids, Numerical Hydrodynamics, and Systems Science.

Chemist familiar with–Solid fuels, Battery Chemistry, Piezoelectricity and Ceramics.

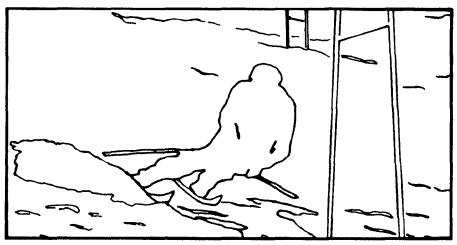
At NUSC you'll be teamed up with the Navy's principal research, development, test and evaluation center for submarine weapons systems. NUSC is the technological edge that gives the Navy the tactical and strategic edge in combat systems that are so vital to our national defense.

If you're ready for challenge, immediate responsibility and freedom to be innovative and creative, we'd like you to join the Center's laboratories at Newport, Rhode Island or New London, Connecticut.

Contact us now at Naval Underwater Systems Center, Personnel Staffing Division, AI, Newport, Rhode Island 02841-5047 or call (401) 841-3585.

An Equal Opportunity Employer U.S. Citizenship Required

AI Career Opportunities in COLORADO



GO AHEAD . . . put yourself in this picture. Whether you're on the slalom slope or the bunny hill, skiing is just one of the phenomenal recreational opportunities available in Colorado, the location of our Advanced Information Technologies Group.

We are Martin Marietta Data Systems, one of the largest full-service data processing companies in the nation investigating and developing new techniques in Artificial Intelligence and related technologies. Our emphasis is on natural language, expert systems and knowledge representation. We're seeking talented individuals skilled in these areas. Positions include:

- **AI CONSULTANT**
  Responsibilities include providing expertise on a broad spectrum of AI issues, both on a day-to-day and a long-term-basis. Will lead and coordinate future AI activities.
  PHD preferred.
- **TECHNICAL MANAGER, EXPERT SYSTEMS**
  Will direct expert and knowledge base systems activity. Must provide both technical and project manager support to existing and future projects. Advanced degree preferred.
- **TECHNICAL STAFF**
  Will actively participate in the design and development of existing and future AI and related projects. Must have at least 2 years of academic or work experience in AI.

All applicants must be able to excel in a team environment. Knowledge of LISP, C, Expert System Tools, SUN workstations and LISP machines will be considered a plus.

Come enjoy the benefits of a large corporation while working in a small independent group. We offer a comprehensive benefits package, which includes, health, dental, vision, and retirement benefits.

COME JOIN OUR ADVANCED INFORMATION TECHNOLOGIES GROUP.

For more information, contact:

Bill Dalton
MARTIN MARIETTA DATA SYSTEMS
98 Inverness Drive East, Suite 135 (P193)
Englewood, CO 80112
(303) 790-3404

MARTIN MARIETTA DATA SYSTEMS

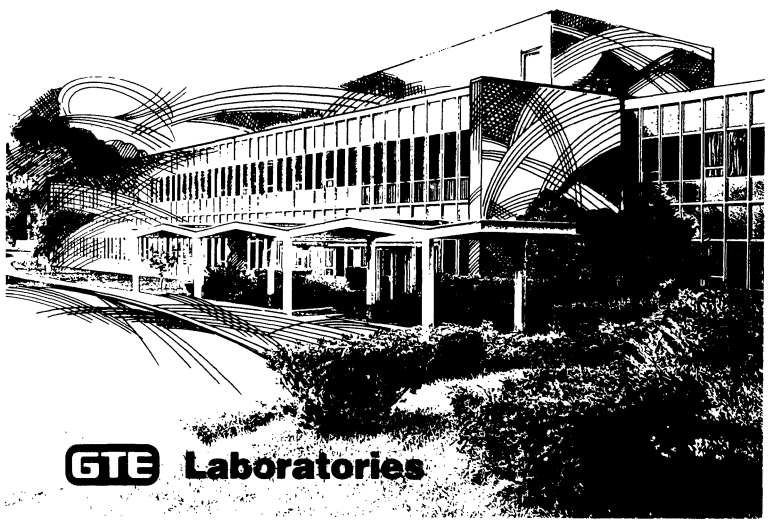
Equal Opportunity Employer M/F/V/H

ARTIFICIAL INTELLIGENCE AND KNOWLEDGE BASED SYSTEMS RESEARCH

GTE has made a strong commitment to Artificial Intelligence technology, both in research and for applications to future network telecommunication services and advanced computer systems. Our programs focus on Expert System Technology and Applications, Natural Language Processing, Knowledge Representation, and Machine Learning and cover the spectrum from highly conceptual to advanced prototype system development. Our established groups work in a state-of-the-art, professional AI environment with close ties to academia.

Located outside Boston, GTE Laboratories is the corporate research facility supporting 60 GTE subsidiaries around the world. Our continued growth has created several new opportunities for highly qualified AI professionals. Opportunities for professional growth and interactions abound, and the location also offers proximity to a variety of leisure, cultural and educational activities.

Send resume to Cynthia Farrar, GTE Laboratories, Inc., Box A, 40 Sylvan Road, Waltham, MA 02254. An equal opportunity employer, M/F/H/V.



GTE Laboratories

Philips Laboratories

Briarcliff Manor, New York

Research Management/ Knowledge-Based Systems

Philips Laboratories, the research division of the North American Philips Corporation, is located in suburban Westchester County, New York. North American Philips Corporation is a Fortune 100 company specializing in the design, manufacture and distribution of consumer electronics, electronic components, scientific and professional equipment (including medical instrumentation and lighting systems).

Philips Laboratories is currently seeking motivated individuals who are experienced in all areas of artificial intelligence research. The primary requirement is a PhD in Artificial Intelligence, Computer Science or related field. Experience in building a working system is highly desirable. Familiarity with Symbolics LISP machines, SUN and IRIS Unix workstations and VAX/Unix time-sharing would be a plus.

We have made a solid commitment to research in intelligent systems and intend to use artifical intelligence to enhance man-machine interaction and rapid prototyping.

Qualified individuals will get involved in the development, production and use of consumer and professional electronic systems, as well as have the opportunity to influence our future research directions.

We offer competitive salaries, a full benefits program and a state-of-the-art workplace. Interested candidates are invited to forward a detailed resume to: **Mr. John Packard, Director, Technical Employment, Philips Laboratories, P.O. Box 397, Scarborough Station, Briarcliff Manor, New York 10510.**

An equal opportunity employer.

North American **Philips** Corporation

Carnegie Group

AI Software Scientists and Engineers

Carnegie Group represents the largest concentration of expertise in applying AI to complex industrial problems. We develop large production systems supported by the most comprehensive package of knowledge engineering tools available.

We are seeking computer scientists and software engineering professionals to join our creative and energetic technical team and enjoy the rewards of its achievements.

Opportunities exist for:

AI Scientists
PhD in Computer Science or 4 years of experience working in one or more of these areas: Database Design, Rule Base Systems, Knowledge Acquisition, Logic Programming, Intelligent Interfaces, Natural Language Interfaces, Knowledge Representation Languages. LISP systems experience is preferred.

AI Software Engineers
MS/BS in Computer Science and LISP programming experience/AI courses. Experience with knowledge-based systems and languages is desirable.

Carnegie Group offers a supportive team environment and fosters an atmosphere of excellence. Our computing facilities consist of over twenty Symbolics™ 3600s and DEC™ VAX™ 780 and 785s, with full networking capabilities. At Carnegie Group, you can expect competitive salaries, incentive stock options, merit performance appraisals within 6 months, and a complete benefits package.

For prompt and confidential consideration, forward your resume with salary history to:

Carnegie Group Inc.
Manager—Human Resources
650 Commerce Court
Station Square
Pittsburgh, PA 15219

An Equal Opportunity Employer

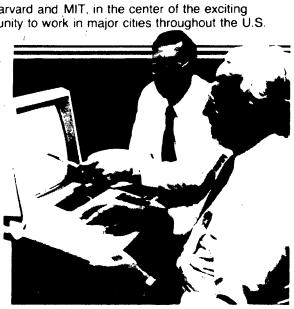
Symbolics is a trademark of Symbolics Inc. DEC and VAX are trademarks of Digital Equipment Corporation.

LMI-Work with the BEST

LMI prides itself on employing the brightest minds in the AI industry and its supporting disciplines. We hire only the best, and provide a creative environment that fosters practical innovation.

Our new Cambridge R & D facility is within minutes of Harvard and MIT, in the center of the exciting Cambridge lifestyle. Our field offices give you the opportunity to work in major cities throughout the U.S.

Our needs include:
- LISP and UNIX™ experts
- Hardware Designers
- Field Sales Representatives
- Field Technical Representatives
- AI Applications Personnel



If you are interested in helping build tools to bring AI out of the lab and apply it to real-world, practical applications, and if you are the best in your field, why aren't you working at LMI?

LMI is an equal opportunity employer. We invite you to send a brief resume in strictest confidence to:

LISP Machine, Inc.
Professional Staffing
1000 Massachusetts Avenue
Cambridge, Massachusetts 02139

We offer very competitive salaries as well as excellent equity participation opportunities.

Creative Tools for Applied Intelligence.

LISP Machine Inc.

VERAC

. . . leader in the application of advanced computer science and artificial intelligence.

At VERAC, we have created a team of computer scientists, engineers and mathematicians who are attacking challenging problems of information fusion and intelligent man-machine interaction. Our applied research activities involve the transitioning of recent advances in computer science and artificial intelligence into new system concepts for the Department of Defense. An excellent environment is provided by Verac's physical location (just northeast of University of California San Diego), by the current superior staff and ties with the research community, and by state-of-the-art computational facilities, including advanced LISP machines.

Highly qualified individuals with relevant experience interested in a position with Verac's growing applied research group are encouraged to submit a detailed resume to VERAC, INC., P.O. Box 26669, Dept. 446, San Diego, CA 92126-0669. Equal Opportunity Employer m/f/h/v. U.S. Citizenship required.

VERAC Incorporated

Faculty Position Human Factors Engineering Systems Psychology

A faculty position is available in the Engineering Administration Graduate Program starting September 1985. Position requires:

- Ability to develop and teach graduate courses in human factors engineering, man-machine interface and systems psychology.
- Ability to generate and conduct research, and work through interdepartmental and external-industrial relationships;
- Maintain close ties to the School's Institute for Artificial Intelligence.

The successful applicant will have an earned doctorate in an appropriate area of psychology (or closely related discipline), and be devoted to an academic career. Salary and academic rank will depend on qualifications. Send vita and 3 references to:

Professor Robert C. Waters
Chairman
Department of Engineering Administration
School of Engineering & Applied Science
THE GEORGE WASHINGTON UNIVERSITY
Washington, D.C. 20052

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PERCEPTRONICS

Career Opportunities In Applied Artificial Intelligence

Perceptronics, Inc. specializes in the application of AI to Human Performance Enhancement in complex Man-Machine Systems. Specifically, we combine applied AI methodologies with Human Factors Engineering to create intelligent systems. We have developed innovative approaches to the rapid prototyping of practical AI and have produced numerous stand-alone systems ranging from intelligent man-machine interfaces to training simulators, decision support systems, and expert planning systems for military and commercial product applications. These approaches have produced a rapid increase in Applied AI program sales with active contracts in wide areas of application. We are seeking individuals interested in joining our staff of AI professionals in the development of intelligent man-machine systems. We offer excellent opportunities to those with a strong applications orientation and advanced degrees in computer science, AI, applied mathematics, human engineering, or related fields. Our ongoing AI projects are in the areas of:

- **Expert Systems**
- **Planning Aids**
- **Intelligent Interfaces for Air and Land Vehicles (Cockpit Automation)**
- **Decision Aids**
- **Training Systems and Intelligent CAI**
- **Robotics and Remote Systems**
- **Medical Advisory Systems**
- **Expert Maintenance Aids**

Perceptronics, Inc. is a public company (NASDQ) offering a competitive salary, excellent benefits, opportunities for professional growth, and a stock option plan to senior technical staff. We have offices in Los Angeles, Washington, D.C., Ann Arbor, Michigan, other U.S. locations, and Tel Aviv, Israel.

Equal Opportunity Employer U.S. Citizenship Preferred Principals Only

For more details, please contact:
Dee Macosko, Human Resources Mgr.
Perceptronics, Inc.
6271 Variel Ave., Woodland Hills, CA 91367
(818) 884-7470

ENGINEERING

at Ford Aerospace in Southern California!

Ford Aerospace is a leading Southern California aerospace organization. Our state-of-the-art technology along with the exceptional lifestyle afforded by our Newport Beach coastline location will allow you a unique career opportunity. Our present openings are in the areas of:

DIGITAL SYSTEMS PROJECT DIRECTOR

Develop automatic target recognizers (ATR) and trackers based on artificial intelligence (AI) and VHSIC technologies. Provide ATR technical expertise and lead junior engineers. Specific assignments include processor architecture analysis/design, preparation of system design requirements, generation of written documents, and oral presentations, and managing VHSIC and VHSIC-like technology. BSEE or CS plus 5 years minimum experience in CAD/CAM, logic design, image processing, and processor architecture design required.

ARTIFICIAL INTELLIGENCE—SENIOR ENGINEER

You will provide technical direction and leadership for the development of real-time automatic target recognizer (ATR) algorithms. Specific assignments will include algorithm development, system architecture design, and hardware/software tradeoffs to meet real-time requirements. MS or PhD in EE, Math or Physics with a minimum of 8 years experience is required.

IMAGE PROCESSING—R&D PROJECT DIRECTOR

Provide technical direction and leadership in development and integration of operating systems, applications, diagnostics, and tools software for real-time image processing systems. You'll also participate in new projects via proposal assistance, system engineering, project planning and management. BS plus 10 years experience with real-time software design in high order and Assembly languages.

VLSI, VHSIC PROJECT DIRECTOR

Provide technical direction and leadership for the design and development of high speed digital processors used in the real-time processing of sensor data for advanced missiles and high speed aircraft. Processor technology will be VLSI and VHSIC in traditional and AI architecture. Other duties will include development of processor design requirements, functional specifications, design, fab, test; planning/scheduling project activites; and cost/performance monitoring. BSEE and 10 years experience required.

We offer highly competitive salaries, an outstanding benefits package, along with the stability and resources you'd expect from a worldwide leader. For confidential consideration, send your resume to: **Linda Scholl, Professional Placement, Dept. A703-001, Ford Road, Newport Beach, CA 92660.**

Ford Aerospace & Communications Corporation
Aeronutronic Division

U.S. Citizenship Required/An Affirmative Action Employer

Avco Everett Research Laboratory, a leading high technology research laboratory in the Boston area, is seeking qualified individuals in the following area:

ARTIFICIAL INTELLIGENCE/SIGNAL PROCESSING

Individuals will formulate, lead and manage advanced research programs in Artificial Intelligence and Signal Processing to support the business thrusts of designated Avco divisions. Areas of interest include expert system development, data fusion, digital image analysis, and pattern recognition; with applications to advanced sensors, real time target detection/identification and robotic systems.

The successful applicant should have an advanced degree (Ph.D. or equivalent) in computer science or related area with a minimum of three year's relevant experience.

Please send resume to Ms M.J. Gregoire. An Equal Opportunity/Affirmative Action Employer.

AVCO EVERETT RESEARCH LABORATORY, INC
A SUBSIDIARY OF AVCO CORPORATION
2385 REVERE BEACH PARKWAY · EVERETT, MA 02149

AVCO

AIR*

*(Artificial Intelligence Registry)

Salaries to $75,000

JDG ASSOCIATES, Ltd., recognized leader in the placement of Engineers and Computer Scientists since 1973, has developed a unique capability in identifying opportunities for Artificial Intelligence professionals. Our client base includes:

- IR&D groups of Fortune 500 firms
- Technical consulting organizations
- University-sponsored think tanks
- Innovative start-up companies

Our low-key, dignified approach to matching quality candidates with quality companies will offer you the opportunity to examine your alternatives in a confidential, systematic fashion. Openings are nationwide. Call collect, (301) 340-2210 or direct a resume to:

JDG ASSOCIATES, Ltd.
1700 Research Blvd.
Rockville, MD 20850

KNOWLEDGE ENGINEERS

The Artificial Intelligence Project at the Idaho National Engineering Laboratory (INEL) has immediate openings for knowledge engineers experienced in developing expert systems. All positions require an MS degree, or equivalent, and state-of-the-art experience in developing expert systems.

Successful applicants will work with laboratory experts in reactor operations, analysis and engineering to develop expert systems for actual use by government agencies such as the Nuclear Regulatory Commission and Department of Energy.

EG&G Idaho, Inc. offers a refreshing combination of professional opportunity and small city environment with easy access of major recreation spots and one of America's last true wilderness area.

Send resume and salary requirements to: **Recruiting and Employment (TD-5), EG&G Idaho, Inc., P.O. Box 1625, Idaho Fall, Idaho 83415.**

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We are an equal opportunity employer M/F/H/V. U.S. Citizenship Required.

EG&G

RESEARCH OPPORTUNITIES

The Computer Science Laboratory at SRI INTERNATIONAL is seeking several professionals to work on projects in program verification and functional languages for parallel architectures. Utilizing LISP on the Symbolics 3600, project efforts in these areas include highly interactive, automated theorem proving and functional programming languages.

Candidates should have experience using LISP in a research environment. A Masters degree in Computer Science or related field is preferred. Two or more years of LISP programming experience in lieu of advanced degree will be considered.

The Computer Science Laboratory, with a staff of 20 professionals, conducts research in the areas of program verification, programming environments, highly parallel architectures, computer security and fault tolerant computing. SRI INTERNATIONAL is an independent, non-profit, problem-solving organization providing research and consulting for business and government clients worldwide. For immediate consideration, please send resume to Michael Patrick, Professional Staffing, Dept. AI685-2, SRI INTERNATIONAL, 333 Ravenswood Avenue, Menlo Park, CA 94025. An equal opportunity employer.

SRI International®

Artificial Intelligence Research at the General Electric Research & Development Center

The Environment

The R&D Center – one of the world's leading laboratories linking basic research to real world problems – has openings for innovative talent. Superb facilities include a large computer network of VAX machines utilizing VMS and UNIX operating systems, Symbolics LISP machines and other personal workstations. Not only is this an opportunity to work with a top interdisciplinary team, but our upstate New York location offers unusual recreational, cultural and cost-of-living advantages. The three urban centers of Boston, New York and Montreal are within a few hours drive as are the recreational opportunities afforded by the Adirondack Mountains, Lake George, Lake Champlain and Cape Cod.

The Challenge

General Electric's Research and Development Center is expanding upon its Computer Science and Knowledge-Based Systems' efforts to build a new research program in AI. At GE, one can create, develop, and apply the most advanced AI concepts to important technical problems, with excellent facilities and staff support to extend concepts into real systems. Unique opportunities exist to influence the present and future direction of information systems in one of the most diversified high technology companies in the world, with businesses in space systems, medical systems, power systems, automation systems, and industrial and consumer products.

The R&D Center's Information Systems Laboratory stresses research and advanced development in: expert systems, VLSI CAD tools and system architecture, knowledge-based systems architecture, programming environments, logic programming and theorem proving. The new AI program will expand the research emphasis on:

- Artificial Intelligence Systems
- Man-Machine Interface
- Learning
- Knowledge Representation
- Inference and Reasoning
- Development Environment

Professional Opportunities

We have immediate openings in research and systems activities at the engineer/scientist, project leader, and program manager levels in our Artificial Intelligence Research Program. Scope of assignments range from theoretical studies to development of generic systems. Opportunities exist for candidates with either MS or PhD degrees in Computer Science and specialization or experience within Artificial Intelligence.

Contact

Investigate excellent salaries, benefits, and growth prospects by sending your confidential resume to Mr. Neff T. Dietrich, Ref. 19C, University Relations and Recruiting, General Electric Research & Development Center, P.O. Box 8, Schenectady, NY 12301.

The future is working at General Electric.

GENERAL ELECTRIC

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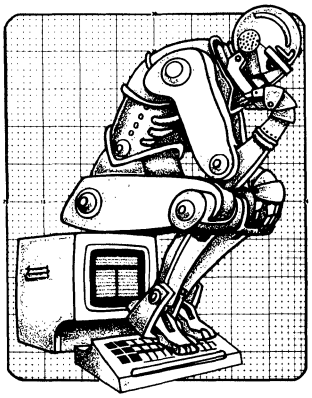


Opportunities in Creative Knowledge Engineering

Help create the SOUL OF A NEW TECHNOLOGY in a company where entrepreneurship has not been dampened by its size. We see the technology of Knowledge Engineering becoming a fundamental underpinning for a wide range of present and emerging products . . . from medical devices to office systems.

3M is actively looking for Masters and PhD's in Computer Science with training in Knowledge Engineering. Experience would be helpful, but is not required. Enthusiasm and internal drive are essential!

You'll be joining a 3M Division whose charter includes the development of new technologies in a broad range of disciplines, and the application of those technologies to new 3M products and manufacturing processes. You'll be joining a company highly regarded for its entrepreneurial spirit and the fair treatment of its employees. You'll be living in the "Twin Cities" of Minnesota, where a high "quality of life" and high technology professional environment go hand-in-hand. We call it "high technology without the hassle"!

Equal Opportunity Employer

Interested candidates may inquire by sending their resume to:

G. B. Kiperts
Staffing Department
3M Center (Building 224-1W)
St. Paul, Minnesota 55144

3M

A Chance for Artificial Intelligence Professionals to Lead the Field.

High technology growth in the Pacific Northwest has resulted in significant expansion of the intellectual community. Major research and development facilities have been established.

One of the most exciting of these is the Artificial Intelligence Center of the Boeing Computer Services Company, a division of The Boeing Company.

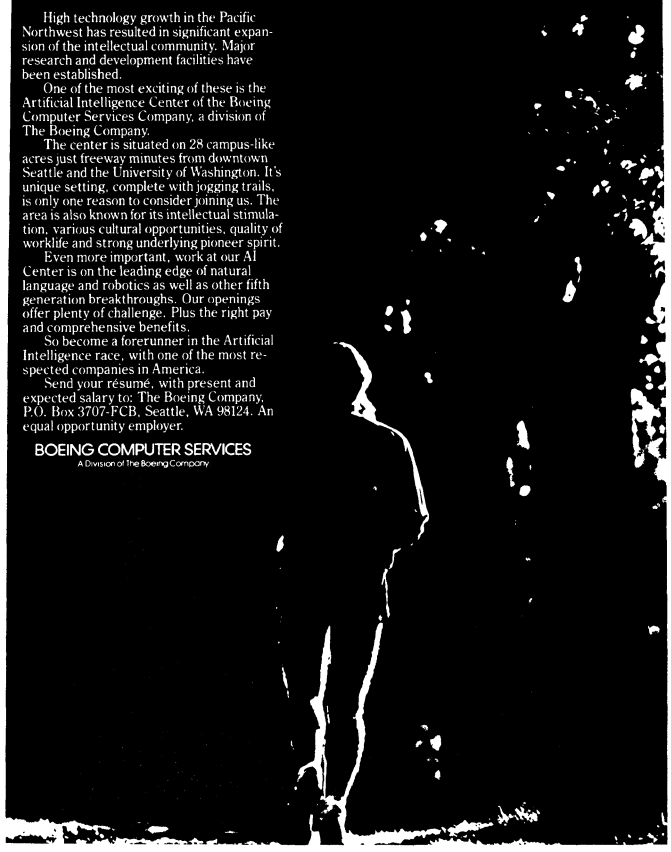
The center is situated on 28 campus-like acres just freeway minutes from downtown Seattle and the University of Washington. It's unique setting, complete with jogging trails, is only one reason to consider joining us. The area is also known for its intellectual stimulation, various cultural opportunities, quality of worklife and strong underlying pioneer spirit.

Even more important, work at our AI Center is on the leading edge of natural language and robotics as well as other fifth generation breakthroughs. Our openings offer plenty of challenge. Plus the right pay and comprehensive benefits.

So become a forerunner in the Artificial Intelligence race, with one of the most respected companies in America.

Send your résumé, with present and expected salary to: The Boeing Company, P.O. Box 3707-FCB, Seattle, WA 98124. An equal opportunity employer.

BOEING COMPUTER SERVICES
A Division of The Boeing Company



ARTIFICIAL INTELLIGENCE

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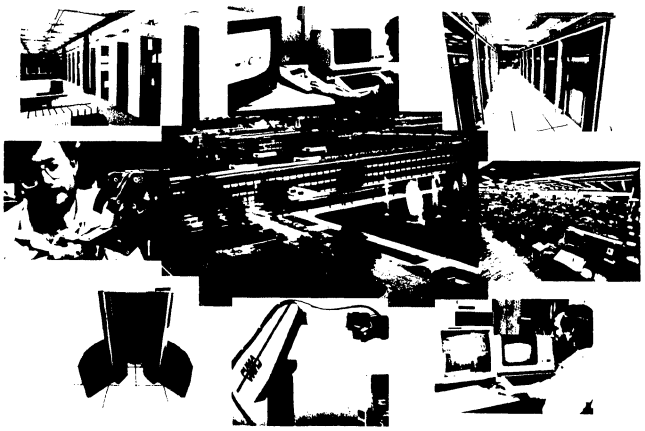
Opportunities for Research

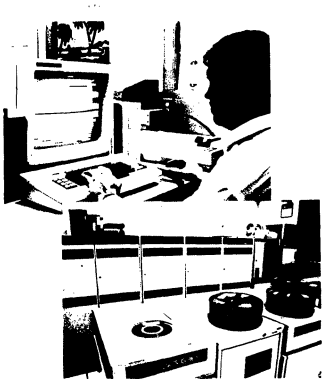


GM General Motors Research Laboratories
Computer Science Department

GM Research Laboratories is one of five technical staffs in the GM Technical Center, an 800 acre complex located in Warren, Michigan. The attractive buildings on the site surround a 22 acre lake in a campus-like setting designed by world-renowned architect Eero Saarinen. The Laboratories concentrate on fundamental investigations in a quest for new knowledge and technology which will allow GM to produce higher quality products more effectively in the future.

Our Computer Science Department conducts research programs in artificial intelligence, autonomous mobile robots, computer vision, intelligent robotic assembly, geometric modeling, computer graphics, VLSI design automation, manufacturing automation, and other areas, to provide a scientific foundation for the use of high technology throughout GM. Individual initiative of research professionals is valued.

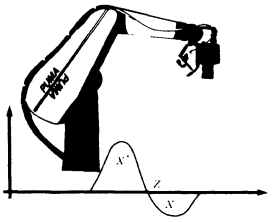
ARTIFICIAL INTELLIGENCE



GM Research Laboratories has a strong and growing program in Artificial Intelligence. Research projects include natural language understanding, expert systems, planning and reasoning and intelligent computer-aided instruction. Several years of natural language research has yielded a system called DATALOG. Advances have been made in isolating domain dependent knowledge and providing cooperative English responses and pronoun references in a dialog of queries and replies. Researchers have challenging opportunities in applying artificial intelligence techniques to solve previously intractable problems for one of the largest manufacturing operations in the world. In addition to modern computing networks, a variety of specialized AI software tools and personal workstations such as DEC MicroVAXs, Xerox and Symbolics Lisp machines support AI researchers. GM needs creative scientists who can develop new approaches for understanding and creating intelligent systems in all of the above areas.

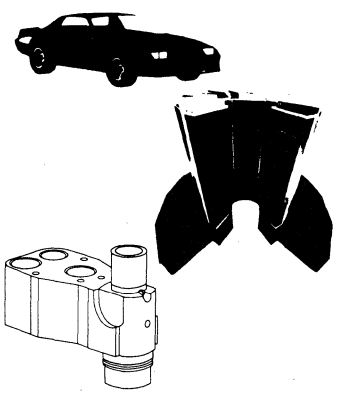
VISION & INTELLIGENT ROBOTICS

Our accomplishments in computer vision and sensor-based robots go back over 15 years and are known world-wide. Past research has defined the state-of-the-art in practical vision systems. But fundamental scientific advances are necessary before the potential benefits of automation can be fully realized. Current research in computational and biological vision, image understanding, manipulator dynamics and control, and robot planning are focussed on two of AI's most fundamental and paradigmatic problems: intelligent sensor-based robotic assembly, and autonomous mobile robots. Openings exist for qualified professionals in navigation, control, and planning systems for intelligent mobile robots, and in model-based vision, task-level planning, and flexible control systems for robotic assembly.



The Machine Perception Lab includes a variety of DEC VAX and PDP-11 computers, LISP machines and micro-VAX workstations, custom and commercial image acquisition and display facilities, a variety of solid state cameras, two PUMA-560 robots, a dextrous 3-fingered hand designed by Ken Salisbury, a mobile platform, and a wide array of optical, mechanical, and electronic instrumentation.

DESIGN AUTOMATION



The Geometric Modeling and Planning Group is known for GMSolid, a comprehensive 3-D solid modeling system, and RoboTeach, an off-line robot programming system based on GMSolid. Current research projects focus on surface representation and combining geometric modeling with modern AI methods to solve important problems in manufacturing planning and spatial reasoning.

Image synthesis techniques are now being used to create very realistic representations of both mechanical assemblies and surface models. Current research focuses on combining realistic image synthesis with techniques for surface manipulation to develop an environment for aesthetic expression.

Because GM is the 3rd largest captive IC manufacturer in the world, IC design automation is receiving increased attention. A wide variety of software and hardware aids are now used to carry out both fully custom and semi-custom designs. Research topics include functional design tools and silicon compilation. New machine architectures are being explored for application-specific integrated circuits.

OPPORTUNITIES

Since the early days of computers, the Computer Science Department at GM Research Laboratories has conducted leading research in computation and computer systems. Researchers in the Computer Science Department developed the first operating system for a computer and built the first graphics system used for computer-aided design. Early research work in database systems influenced the Codasyl Database Task Group report and the first relational database system used in industry was developed in the Computer Science Department at GM Research Laboratories. Research in Artificial Intelligence began in the late 1960's with pioneering work in machine vision.

The facilities and organization of GM Research Laboratories and the productive environment of the Computer Science Department provide excellent opportunities for research in all areas of science and engineering that relate to computers, automation, and manufacturing productivity. General Motors will be the premier arena for industrial automation and the Research Laboratories will continue to be a source for insights and solutions to fundamental scientific problems. GM Research Laboratories offers unparalleled opportunities for research.

Interested candidates should contact:

Dr. George G. Dodd, Head
Computer Science Department
General Motors Research Laboratories
Warren, Michigan 48090-9057
(313) 575-3101

Candidates must have citizenship or visa status which permits them legally to accept permanent employment under U.S. Immigration laws.

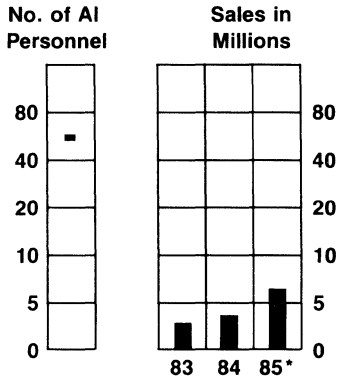
AN EQUAL OPPORTUNITY EMPLOYER

GM General Motors Research Laboratories

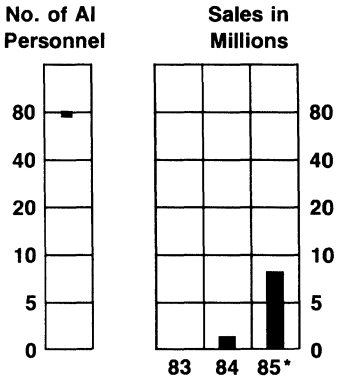
Growing Markets Ensure Prosperity

Growing Markets Ensure Prosperity

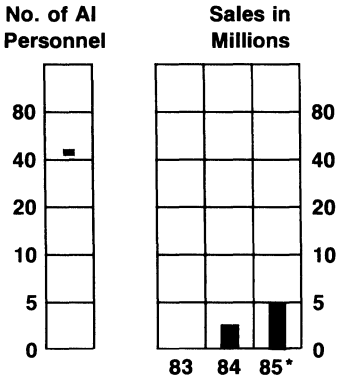
Advanced Information & Decision Systems
(Mountain View, CA) Founded: 1979
Privately held. Military AI knowledge-based applications.



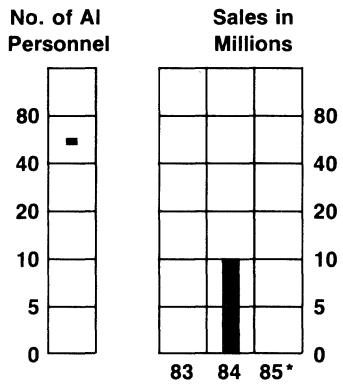
Carnegie Group, Inc.
(Pittsburgh, PA) Founded: 1983
Privately held. Knowledge-based banking and insurance applications.



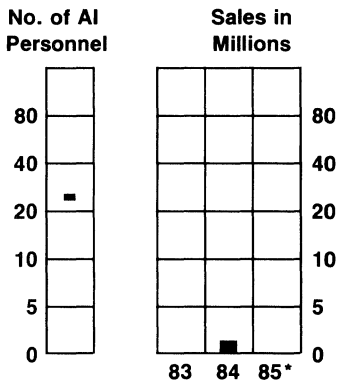
Software Architecture and Engineering
(Arlington, VA) Founded: 1978
Privately held. Expert system development applications.



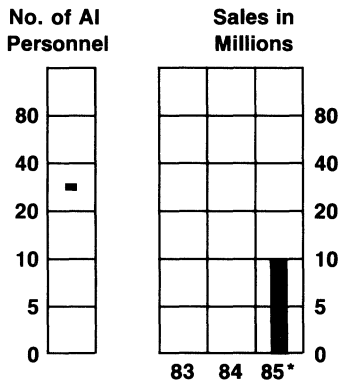
Artificial Intelligence Corporation
(Waltham, MA) Founded: 1975
Privately held. Natural language software for the financial marketplace.



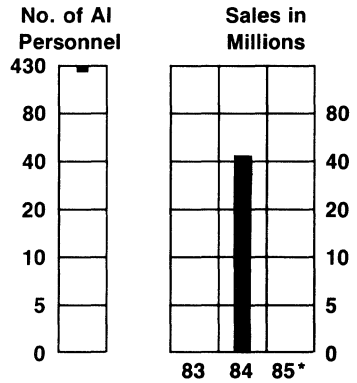
Cognitive Systems, Inc.
(New Haven, CT) Founded: 1979
Privately held. Natural language and knowledge-based financial systems.



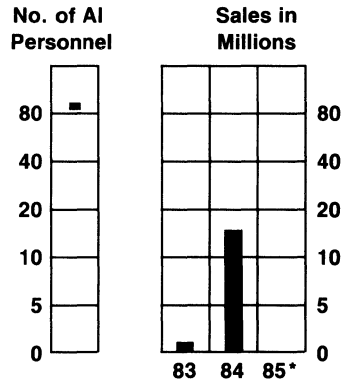
Cognex Corporation
(Needham, MA) Founded: 1982
Privately held. Visual recognition systems.



Symbolics, Inc.
(Cambridge, MA) Founded: 1980
Public company. AI workstations.



LISP Machine, Inc.
(Los Angeles, CA) Founded: 1980
Privately held. AI workstations.



**Projected Sales*

Syntelligence (Sunnyvale, CA). Founded 1983. Privately held. Knowledge-based banking and insurance financial applications. 45 employees. Very well-funded company. First products in 1986.

Kurtzweil Applied Intelligence (Waltham, MA). Founded 1982. Voice recognition products. 40 employees. Very well-funded company. Talkwriter (typewriter that takes dictation) product release aimed in 1986.

Selected Bibliography for AI Students and Researchers

Selected Bibliography for AI Students and Researchers

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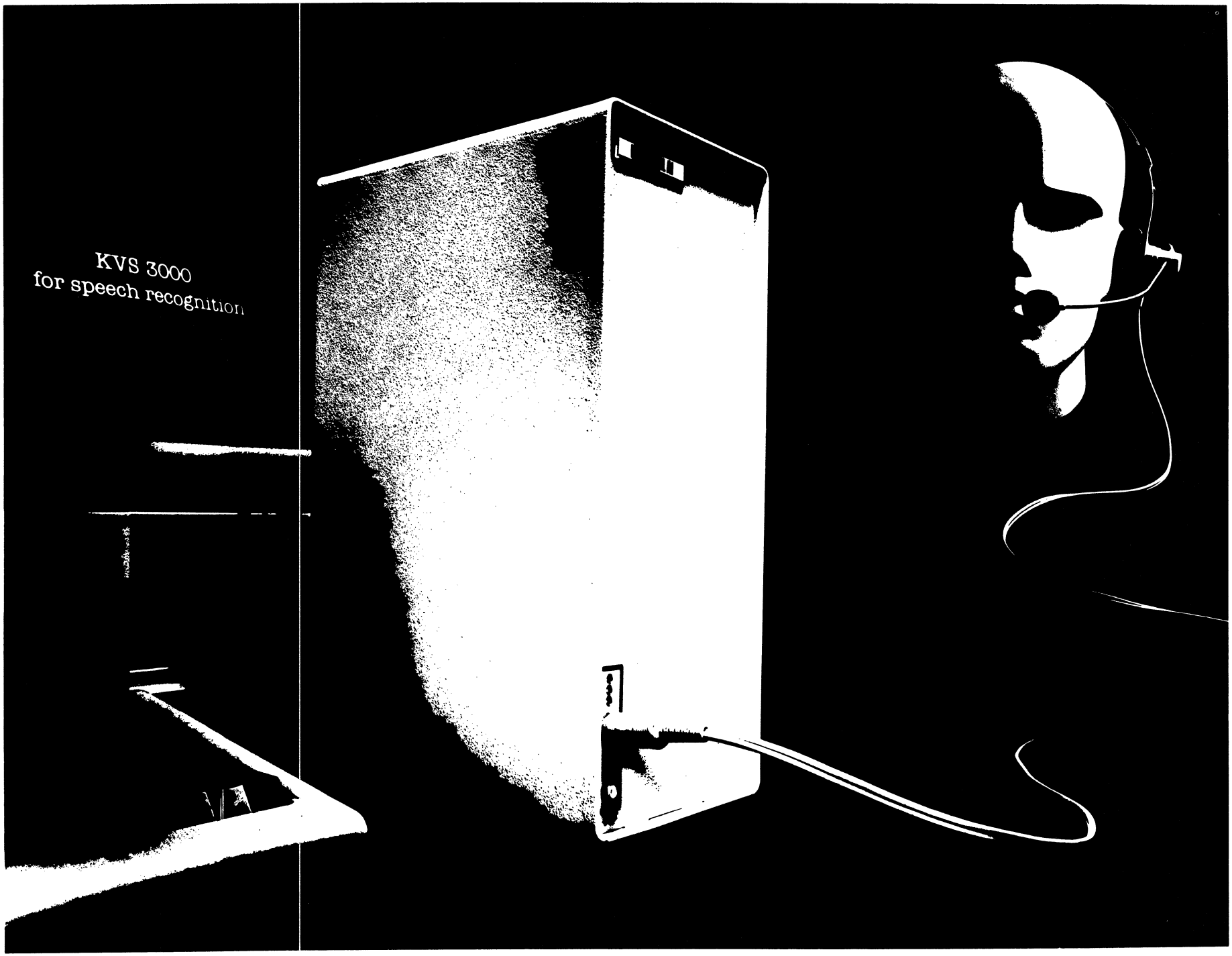

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Company Omnibus

TECHNOLOGY BACKGROUND
AUTOMATIC SPEECH RECOGNITION

Automatic Speech Recognition: History and Market

Recognition of human speech by computer devices is one of the most eagerly awaited breakthroughs in the computer industry today. Development of a voice-activated typewriter (VAT) with a 10,000 word vocabulary is a top priority for Japan's much discussed "Fifth-generation" computer effort. Teams at IBM, Bell Labs, and Japan's Nippon Electric Co. (NEC) have mounted major pushes to create voice-activated typewriters and other speech-recognition devices by the end of the decade. In late 1982 the race to achieve a practical VAT was spurred by Raymond Kurzweil, a leading authority on applied artificial intelligence and pattern recognition technology. Kurzweil, best known for his invention in 1976 of the only print-to-speech reading device capable of handling virtually any printed text, the Kurzweil Reading Machine for the blind, has launched a comprehensive effort to develop a VAT by the end of 1985.

Why is automatic speech recognition (ASR) the object of so much attention? A long-standing difficulty in the relationship between man and machine has been communication -- finding a means to enter data and instructions into a computer or even into a mechanical information system like a typewriter. The typewriter and computer terminal keyboard today remain the primary means for capturing both words and data. However, keyboards are relatively slow even for trained typists, and awkward to use for anyone who isn't.

Voice, by contrast, is the easiest and most natural way for people to communicate. Human beings are brought up to express information verbally. Virtually everyone can speak, compared to the relatively few who are adept in the use of typewriter-style keyboards.

Devices which could recognize the human voice would open up whole new realms of product possibilities -- typewriters which could create typed text at the rate of human speech, computers responding to spoken command, voice-controlled manufacturing operations,telephone access to data bases, automated reservations systems, voice mail, and voice-interactive teaching terminals are among the more immediate possibilities. Market studies differ but many project that speech recognition devices could represent a multi-billion dollar market by the 1990's, with voice activated typewriters accounting for a substantial share of the total amount.

Attempts to create machines that can recognize human speech go back over 40 years, to a toy dog called "Radio Rex", which was designed to respond to its own name. It didn't work very well. It wasn't until the 1960s that the first successful efforts were made to recognize more than a handful of words in English. By the seventies, there were several commercial products capable of recognizing a few dozen words at any one point in time that could be used for specialized communications and industrial applications. But when it came to the much more difficult problem of recognizing large numbers of words as they occur in typical English sentences, most devices had something in common with Radio Rex. They didn't work very well either.

The Technological Challenge

There is a fundamental difficulty in the recognition of typical English speech. No two people pronounce words the same way, and even the same person

never pronouces a word exactly the same way twice. The sound of a word changes if the speaker is tense or has a cold. Vowel length and stress change depending on the meaning of the word expressed, and even change depending on the word sounds preceding and following it.

Several strategies can be used, depending on the intended application of the ASR device, to reduce the complexity of this problem. The simplest solution is to create a device that can only recognize a very limited vocabulary, adequate for doing tasks like controlling industrial equipment or providing very basic information to a computer or telecommunications systems. The problem can also be simplified -- as it is by most existing devices -- by requiring the speaker to separate his or her words by very slight pauses, instead of slurring words together as we ordinarily do. Human factors studies have shown that most people can learn to separate their words in this way with little difficulty, and still speak at a normal rate.

Finally, the recognition problem can be made much more manageable by reducing the number of people's voices that the system must recognize. Such a "speaker-dependent" system could be calibrated on-site to the voices of, say, a few dozen users and would be more than adequate for most office or professional environments.

The ASR market, then, can be broken up into two broad segments. In one segment are devices designed to understand virtually anyone without training (or "speaker-independent"), and which can at present recognize only a few dozen words at best out of a total "library" of some hundreds of words. The other potential market segment, as yet untapped, is "speaker-dependent" systems, designed to recognize large vocabularies (5,000 to 10,000) in typical sentences. These latter are the systems that would be suitable for the voice-activated type-

writer. Even with limitations on the number of speaker's voices to be recognized, though, successful large vocabulary ASR has remained elusive.

Large Vocabulary ASR

Large vocabulary ASR is the most difficult problem in speech recognition because it most closely approximates what a human being does in making sense of everyday words, sentences, and syntax. As such, it is one of the more complex artificial intelligence problems facing scientists today. Perhaps the best way to get a sense of what is involved in large vocabulary ASR is to compare the steps a computer must take in recognizing speech to what actually happens in the human ear and brain.

First, the human listener must convert sound waves to a form that can be processed by the brain. Tiny bones, membranes, and hairs in the ear are agitated by sound waves and excite nerve impulses, which provide a coded version of the sounds which can be interpreted by the brain.

Similarly, an automatic speech recognition system must process the sound received through a microphone and a set of analog or digital filters. These filters provide coded data about the sound. One of the challenges in ASR is to determine what and how much information about the sound must be extracted and coded from the sound wave. The three most critical variables in a sound wave are its frequency, the changes in frequency over time, and the variations in intensity. Recent advances in sound spectroscopy utilized at Kurzweil Applied Intelligence make it possible to visualize all three variables at once.

Two basic processes must take place in the brain in order to recognize the words that are heard. One is to match the sound of the words captured by the ear to the models for the word sounds in the listeners' memory. The

second is to guess at the identity of the word from the context of the conversation and the context of the sentence or phrase being spoken. In fact, some studies have shown that by listening to the context of a spoken message, we can narrow down our guesses as to the identity of a given word from one in 100,000 to one in ten or fifteen! Identifying a word by its sound is much easier when it must be matched against only a dozen or so words instead of against tens of thousands.

Automatic speech recognition devices must also use both "acoustic identification" and "context analysis" to successfully identify spoken words. Each poses significant artificial intelligence and computer design problems.

Acoustic Identification. Since words are never pronounced exactly the same way twice, even by the same person, a successful ASR system must find some kind of underlying and constant pattern unique to each word. (This is called the "invariance problem" by ASR researchers.)

Several speech recognition research teams have succeeded in recognizing words, given enough computer time to do the computations. The real hurdle, however, is to be able to do these computations in "real time" -- so that the computer can recognize the words as quickly as they are spoken. The authors of a 1981 article in Scientific American on speech recognition calculated that it would take, using either of those approaches, 10 billion computations per second to achieve effective large vocabulary ASR. Assuming continued rapid gains in computing power, they extrapolated that it would not be until the year 2020 that large vocabulary ASR could successfully be tackled.

According to Ray Kurzweil, president of Kurzweil Applied Intelligence, they were correct given their assumptions. There were, however, significant alternatives that the authors of the Scientific American article overlooked.

Two alternatives involved the actual capabilities of computer hardware. The 1982 article assumed standard speeds for the use of computer microprocessors. In actuality, it is possible to increase the speed of microprocessors manyfold by custom-designing the chip for specific applications. In addition, the article assumed the use of traditional serial-processing techniques, in which computer computations are processed one at a time. It happens that one of the most intensely pursued areas of research in the computer industry now is on ways to permit simultaneous computation...an important requirement of the so-called "fifth generation" of computers.

Successful "parallel processing" in standard microprocessors may be years away. Kurzweil scientists, however, have determined that the computations involved in ASR are of a type that lend themselves readily to parallel processing and have already designed what is called an array processor to handle these computations at very high speeds.

Kurzweil is a leading authority on how to analyze and extract relevant features from complex patterns in order to identify them. In 1976 he developed the first optical scanning system capable of reading virtually any typeface -- a feat which has not yet been duplicated despite many competitive efforts. This pattern recognition expertise is now being applied to the analysis of spoken words.

Another artificial intelligence technique mastered by Kurzweil distinguishes between significant and insignificant information about patterns -- such as sound waves -- and then compresses the data to a manageable length. He has recently used this technique to make possible the first digital keyboard that can accurately recreates the sound of acoustic instruments such as the grand piano. Similar data compression techniques also can reduce the computational load required to achieve large vocabulary ASR.

Context Analysis. A variety of artificial intelligence techniques have been explored to determine how to efficiently narrow down the possibilities of what any given word might be. These techniques involve the use of expert systems, or elaborate computer programs which replicate the kind of analytic judgements made by a human being. Some expert systems "nominate" probable candidates for a given word based on the other words occurring in the phrase or sentence. For example, the middle word in the phrase "a _____ reply" would probably be "brief," "lengthy," etc. Expert systems not only help recognize words, they help solve another of the difficulties of ASR, distinguishing between homonyms like "to", "too", and "two".

Feedback and User Interface

A certain amount of ambiguity is built into human speech. Even human beings use feedback to check on the meaning of unclearly pronounced or difficult words -- usually by saying "what?" or "come again?" ASR devices must also use feedback to check on questionable words, via a video terminal or synthetic voice.

There are many alternatives for designing the interface between user and device. The user could spell out, or key in words, the device is uncertain of. The ASR device could signal its confusion by scrolling words on a screen and highlighting words or phrases which do not exceed, say, a 99% certainty threshold. (In fact, the certainty threshold could be adjustable, allowing faster recognition if first-time accuracy is less essential -- the equivalent of draft-typing on a word processor.)

In addition to clarifying doubtful words, there is another reason for an ASR device and its user to have two-way conversations -- to train the device

to understand the individual user's pronunciation. Training might proceed by having the user read a standard text covering most typical sounds and key words. An intelligent system could then continue to "learn" to understand a given user by redefining a word model each time it is corrected according to the way the word is pronounced by the user (a similar training system was used by Kurzweil in the omni-font Kurzweil Data Entry Machine).

Finally, an intelligent system could re-evaluate the use of its memory periodically, dropping out words that are never used and opening up "slots" for the inclusion of specialized words required by specific users. In addition, of course, different word "libraries" could be offered for different applications, such as business, engineering, and law.

Impact of Speech Recognition Systems

Over the course of this decade, ASR devices will find wide application in manuscript creation and transcription, in telecommunications, and in work station control. ASR, though, will have its most visible (or audible) impact in the long-term , as it becomes the preferred means for man to communicate with the evermore ubiquitous computer.

# # #

COMPANY BACKGROUND

KURZWEIL APPLIED INTELLIGENCE, INC. AND AUTOMATED SPEECH RECOGNITION

Background

Since its invention over 100 years ago, the typewriter keyboard has been the "state-of-the-art" interface between people and the printed page. Almost anyone who has come into contact with an office environment takes the necessity for the keyboard for granted. But, the typewriter keyboard has some obvious disadvantages.

First, it is a fairly slow way to create text -- no faster than the operator's typing speed. Even the fastest typist can only produce a few characters per second. Second, it is restrictive -- only trained operators can use a typewriter keyboard efficiently, which often causes "bottlenecks" in the generation of typed text in most offices. Third, people who don't type are generally reluctant to use a typewriter-style keyboard for any purpose. As a result, many executives, professionals, and small businessmen are discouraged from using computers, which require input via a keyboard, or from generating typed text without the aid of a typist.

The simplest and most direct way to communicate text to a typing system, word processor, or computer would, of course, be through the human voice. Computers or computerized typewriters that could recognize and print out text directly from human speech are not merely the stuff of science fiction. They are the subject of several intensive industrial research and development efforts today.

The most desirable application of this technology to today's marketplace is a system that can output typed text in "real time" as it is dictated (known as a voice-activated typewriter or VAT). Such a system could be up to three times faster than most professional typists and ten times faster than handwriting.

A second major application would be in the so called "executive work station" market. A shift in emphasis in the office computer equipment market from clerical to executive productivity has been predicted for several years by most industry observers. The resistance of executives and professionals to mastering a keyboard system has obstructed this shift. Automated speech recognition (or ASR) would permit executive personnel to operate computer work stations through voice commands, very likely accelerating the acceptance of executive work stations.

Effective computer speech recognition would also make possible many new elecommunications services. These include remote inquiry for information from computer data banks, telephone order placement, fully automated reservations, and voice mail. Other applications are expected to include voice control for manufacturing operations and military equipment, computer-assisted teaching, and consumer products such as "smart" toys, automobiles, and household appliances.

While the current market for speech recognition technology remains small, due to a dearth of commercially useful products, independent market studies have projected that the sales of ASR products could reach several billion dollars by the end of the decade. VAT sales are expected to represent a sizable portion of that total market. As the initial source for accurate, large-vocabulary ASR

technology, Kurzweil AI hopes to capture a substantial share of this nascent multi-billion dollar industry.

A significant proportion of the company's financing has been provided by Wang Laboratories and Xerox Corporation. These principal investors have non-exclusive agreements with Kurzweil AI to market its speech recognition technology.

(In 1980, Xerox Corporation purchased Kurzweil Computer Products, a company founded by Mr. Kurzweil in 1974. KCP manufactures pattern recognition based equipment that scans books or documents in virtually any typeface, and either reads them aloud or converts them to computer code for storage in data bases.)

Kurzweil AI's Speech Recognition Technology

Despite the extensive research efforts of many manufacturers, it has proven difficult to develop a computer system that can accurately and efficiently recognize more than a few words of human speech. Full commercial use of ASR requires that a computer "understand" English speakers with many regional accents and speech patterns, and that the fairly large vocabulary utilized in normal written communication (roughly 10,000 words) be recognizable. Until now there has been limited success, resulting in systems which can recognize up to a few hundred words. Because of their small vocabulary and high cost, these systems are useful only for limited applications, such as voice-controlled machinery, that only require a few simple, repeatable commands.

To tackle the problem of large-vocabulary ASR, Kurzweil Applied Intelligence has put together a team of outstanding authorities from the fields of signal

processing, speech analysis, parallel processing and linguistic analysis. Raymond Kurzweil, the company's founder, pioneered the commercial application of artificial intelligence techniques to problems involving the recognition and analysis of both printed and spoken word patterns. Successful ASR products depend, in large measure, on the successful integration of such pattern recognition and analysis technology with these other disciplines.

Kurzweil AI scientists have developed a unique multi-branched approach to achieving commercial quality ASR, involving dedicated VLSI hardware, pattern recognition techniques and linguistic expert systems.

These approaches have already been successfully implemented, resulting in the demonstration in late 1984 of a non real-time 10,000 word prototype speech recognizer that is 97% accurate. By the end of 1985, the company expects to begin site tests of its real-time system, and plans to ship first production units of the Kurzweil Voicewriter™ in 1986. A smaller vocabulary (1000 words) speech recognition peripheral designed for use with virtually any host processor will be introduced in mid 1985. Other by-products of Kurzweil AI's speech project include a highly accurate (24-bit) digital filter chip component for signal processing applications now being marketed, and a high-speed array processing system developed for the Voicewriter.

KVS 3000- The first speech recognition device from Kurzweil AI represents an important advance in the technology, with regard to its vocabulary size, flexibility and price/performance. Aimed primarily at OEM's (original equipment manufacturers), the KVS 3000 is a programmable device that can handle up to 1,000 spoken words - and can be interfaced to virtually any host processor.

The system compares spoken input with 3,000 speech tokens or sample utterances. This allows for an average of three samples for each word or phrase to be recognized, providing accurate recognition of 1,000 words from a single speaker (speaker dependent operation). These 3,000 tokens may also be applied to storage of additional variations in pronunciation necessary for speaker independent operation. In this speaker-independent mode, the KVS 3000 is expected to handle vocabularies of up to several hundred words accurately.

The KVS 3000 will allow direct voice communication with computers for many applications, including data entry, CAD/CAM, command of many finanical and word processing software programs, and a host of reporting applications, ranging from insurance forms to medical reports to quality control and inspection. The KVS system can be used to recognize foreign languages and highly specialized vocabularies.

Kurzweil AI Personnel

Raymond Kurzweil, president and founder of Kurzweil AI, successfully developed and marketed the only commercial technology for computer recognition of text regardless of typeface (omni-font optical character recognition). He is chairman of Kurzweil Computer Products, the company he founded in 1974 to manufacture equipment based on this technology. KCP has experienced 40% to 100% revenue growth each year for the past seven years and currently has 20% of the $70 million OCR market.

In 1983, Mr. Kurzweil founded Kurzweil Music Systems, where he successfully developed a digital keyboard instrument that employs artificial intelligence techniques to accurately recreate the sounds of the grand piano and

other orchestral instruments. This state of the art digital synthesizer, called the Kurzweil 250, has been in production since mid-1984. It offers musicians and composers exciting possibilities for electronic sound modification and control.

Mr. Kurzweil was selected the "Outstanding Young Computer Scientist of 1978" by the Association for Computing Machinery (ACM); he was admitted to the Computer Industry Hall of Fame in 1982, and has received special recognition from Presidents Johnson and Reagan. In 1984 he was keynote speaker at the I.E.E.E. annual conference on computer design.

Aaron Kleiner, Kurzweil AI vice chairman, was a co-founder of Kurzweil Computer Products. He has also served as manager of organization development and training for the Research and Development Division of Johnson & Johnson, and has an M.S. from M.I.T.'s Sloan School of Management. Kleiner is a co-founder of the M.I.T. Enterprise Forum.

Michael G. Tomasic, chief operating officer, was the founder and president of Massachusetts Computer Corporation (MassComp), a manufacturer of scientific workstations. Prior to founding MassComp, Tomasic served at Digital Equipment Corporation for ten years. While at Digital he held a number of positions including corporate product planning manager, group product manager for the VAX-11 and PDP-11 computer systems, PDP-11/34 engineering manager, and PDP-11/05 marketing manager. He is credited with having directed the development and introduction of the PDP 11/34, which achieved $2 billion in revenue, and is considered one of the most successful minicomputers ever designed. He holds an M.B.A. from Harvard School of Business.

David R. Earl, vice president of manufacturing, was formerly v.p. of manufacturing at Data Terminal Systems, where he was responsible for bringing start-up manufacturing operations to high volume capacities. He was also operations manager and a key member of the start-up team of Hewlett-Packard's Andover Division.

William F. Ganong III, director of research, is an authority on speech perception, English phonology, and the digital representation and processing of speech. Prior to joining Kurzweil AI, Ganong was a faculty member at the University of Pennsylvania, and during 1980-82 was a visiting scientist at M.I.T.'s Cognitive Science Center. He holds a PhD. from M.I.T..

Robin Kinkead, director of product development, served from 1973-1982 as the manager of industrial design and human factors for Xerox Corporation's office products division. He headed the design team responsible for the user interface of the highly successful Xerox Memorywriter, among other projects.

Richard S. Goldhor, assistant director of research, holds a B.S.E.E. and M.S.E.E. from M.I.T., where he is a doctoral candidate in Speech Communications. He has worked on a number of speech projects and designed the architecture for the MITALK text-to-speech system.

Robert S. Joseph, director of marketing, was formerly v.p. of marketing at VIA Systems, a manufacturer of CAD/CAM workstations, and v.p. of marketing and sales at Computer Devices, Inc. Prior to that he was at Digital Equipment Corporation, where he managed marketing for the $1 billion Technical Products

Group and was responsible for building Digital's CAD/CAM group to over $100 million in sales.

Susumu Kuno, consultant on syntactic analysis, served as chairman of the Harvard University Department of Linguistics from 1972-1981. He developed the first successful computerized English language parser in 1963, and is a leading figure in the field of computational linguistics, having published several books and over 80 papers in the field.

Dennis Klatt, consultant on speech analysis, is a leading researcher in the field of speech synthesis and recognition. He has designed many of the computer speech synthesizers on the market today, including DEC talk, and has published over 75 articles in speech and computer science journals. He is a senior research scientist at M.I.T.'s Research Laboratory of Electronics.

Steve Rothman, director of systems engineering, is a proven performer in bringing complex engineering projects to the marketplace. In his sixteen years at DEC, he managed design and development of the VAX 11/75 and supervised engineering of the PDP 11/70 project. Mr. Rothman holds four patents for the VAX system architecture.

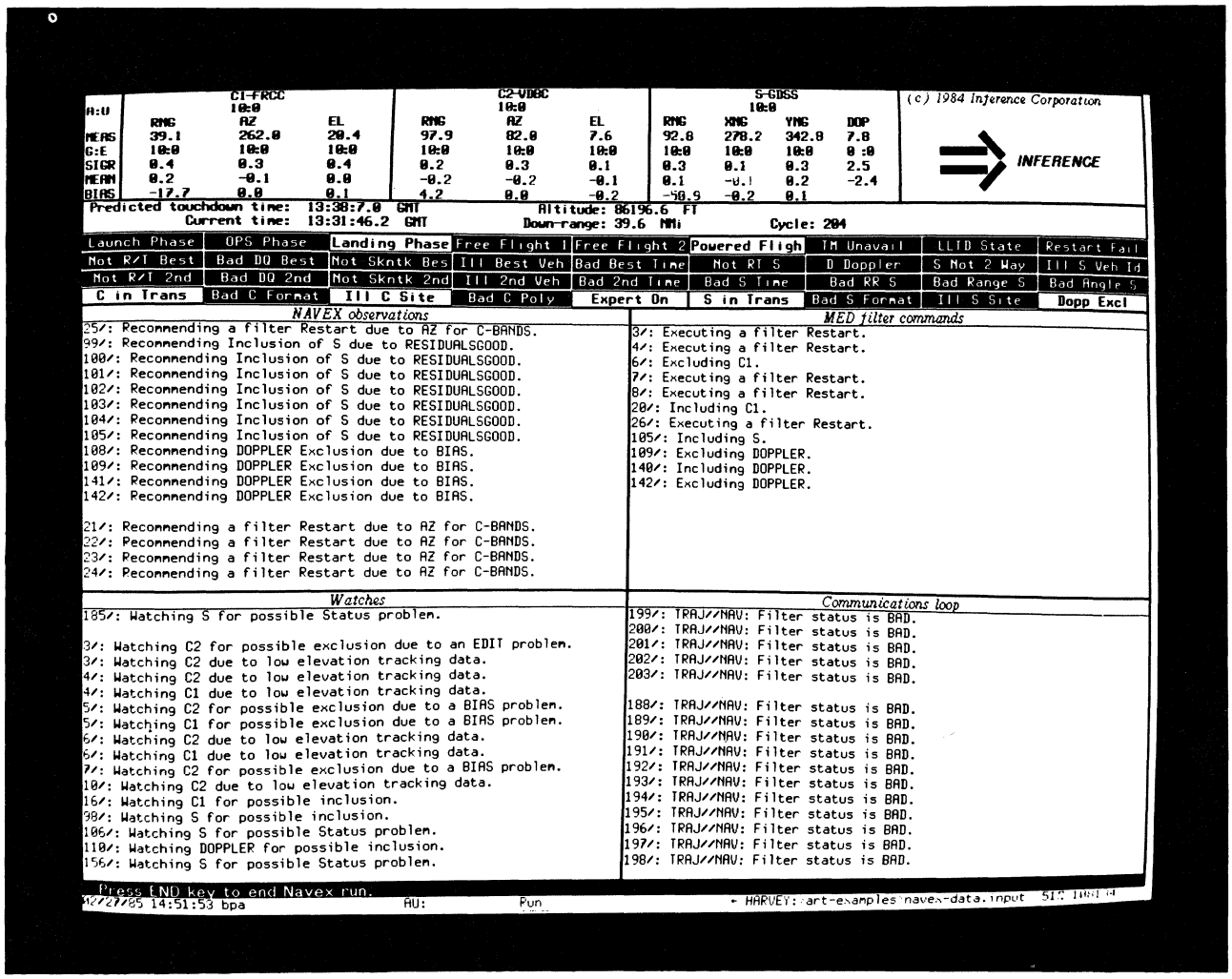
Richard W. Pascal, vice-president, sales and service, is a sixteen year veteran of DEC's sales force. Most recently, he served as manager for the NY/NJ region, where he managed several hundred million dollars of revenue annually. He is also a former DEC sales manager for the mid-Atlantic region, covering fourteen states.

# # # # # # #

NAVEX:

NASA'S FIRST EXPERT SYSTEM

FOR THE SPACE SHUTTLE



LOS ANGELES, CA -- March 5, 1985 -- Inference Corporation today announced its commercial shipment of the Automated Reasoning Tool™ (ART™). ART is a development tool that allows users to rapidly develop commercial expert systems for many applications including resource scheduling, manufacturing planning, aerospace programs, financial planning and military command and control.

The attached photograph is a simulation of NAVEX (Navigation Expert System), that was developed by Inference for NASA's Johnson Space Center. NAVEX will monitor the high speed navigation control console much like human console operators for the reentry phase of the Space Shuttle.

NAVEX makes recommendations based on incoming data from three radar stations. The human console operator may make decisions based on the NAVEX observations or may choose to override them.

Introduction

Although artificial intelligence (AI) technology has been under development for over 35 years, its has remained relatively well hidden in university and corporate laboratories. A few early applications in the areas of medical diagnosis, military command and control, and oil and mineral exploration proved the technical feasibility of AI. But the cost and development time of these early systems led observers to question the commercial viability of AI in more general applications. A recent project at NASA's Johnson Space Center demonstrates that expert systems can solve real-world problems when the new generation of AI-based development tools is employed.

Aerospace leads the way

The aerospace industry, led by NASA, is initiating AI applications that will demonstrate the evolution of AI technology. The state of AI has changed due to the recent combination of several technology trends: a critical shortage in highly-skilled manpower, an exponential increase in affordable computing power, and the emergence of powerful new AI development tools.

At NASA, planning, coordination, and mission control are labor-intensive processes vital to the success of the space program and beyond that, the space station project. NASA is looking to AI technology, in the form of expert systems, to provide part of the productivity and technological advancements.

An expert system is an advanced type of computer program that uses AI technology to reason and make decisions based on a body of human knowledge. The facts that make up the knowledge base are derived from human experts in the field and are unique for each application. The methods of reasoning about knowledge are contained in an "inference engine," which is the permanent part of the expert system.

Currently, expert systems are used on specialized hardware referred to as "LISP machines" after the AI language for which they are optimized.

Pilot project for space shuttle navigation

After a year of investigation by the Technology Development and Applications Branch at the Johnson Space Center, JSC initiated its first expert system development project in May of 1984. The goal was to develop an expert system program that would monitor the high-speed navigation control console, much like human console operators. The console position is a crucial function during space shuttle reentry which begins after the shuttle leaves its orbit at about 180,000 feet. Operators are responsible for monitoring the reliability of a computer solution of the shuttle state vector (position and velocity), selecting data for processing, and reinitializing the console process if inaccurate data mistakenly gets into the system. The job, performed by three flight controllers, requires the operators to continuously observe over 100 radar related parameters on a display screen and 30-50 status lights. To be able to quickly recognize whether data is valid, each operator requires 18 months of highly specialized training and an excellent attention span and split second judgement, should an emergency arise. The task is tedious, but is a requirement at NASA where it is an essential safety measure to guarantee that navigational data is reliable at all times.

A test for AI

The NAVEX project was considered pivotal at NASA because it would help determine the ability of AI to meet NASA's future demands for programmed expertise. The NASA AI group evaluated expert system development tools from several vendors for the navigational expert system,

named NAVEX. They chose the Automated Reasoning Tool™, or ART™, from Inference Corporation because ART offered the greatest amount of flexibility in using AI techniques for complex problems. ART packages AI technology in a form that can be readily used by non-AI specialists to develop their own expert systems. It has a versatile syntax for presentation of human knowledge, employs multiple pattern matching and search strategies, and gives fast real-time response due to its efficient compiler. ART is also a complete development environment with an editor, debugger, and execution monitor implemented through a graphical interface.

An Inference "knowledge engineer" developed the first phase (for shuttle reentry navigation) of NAVEX using about 100 decision rules derived from interviews with experts and from NASA training documentation. In five weeks the first phase was up and running. Once NAVEX was delivered, the console operators were given a week-long ART programming course by Inference, and thereafter took over the continuing development of NAVEX by defining additional rules governing NAVEX's behavior.

AI proves itself viable

NAVEX has now passed its first critical milestone at NASA. Not only is the system able to perform the console operation with decision accuracy, it is able to review eight times more data (operating on a Symbolics 3670 workstation) than its human predecessors. NAVEX also helps eliminate "tunnel vision" (the tendency of human operators to focus on a single problem at a time) by responding to all input parameters continuously. Now the navigation console could be manned by only one operator, instead of three, freeing the other two for more creative challenges.

Perhaps as important as the successful operation of NAVEX itself, NASA personnel demonstrated that expert systems can be developed by

non-AI specialists. Using advanced tools like ART, NASA expects that recent college graduates without computer science backgrounds will be able to program expert systems after approximately two months and with some initial application support by Inference consultants.

The future of AI at NASA

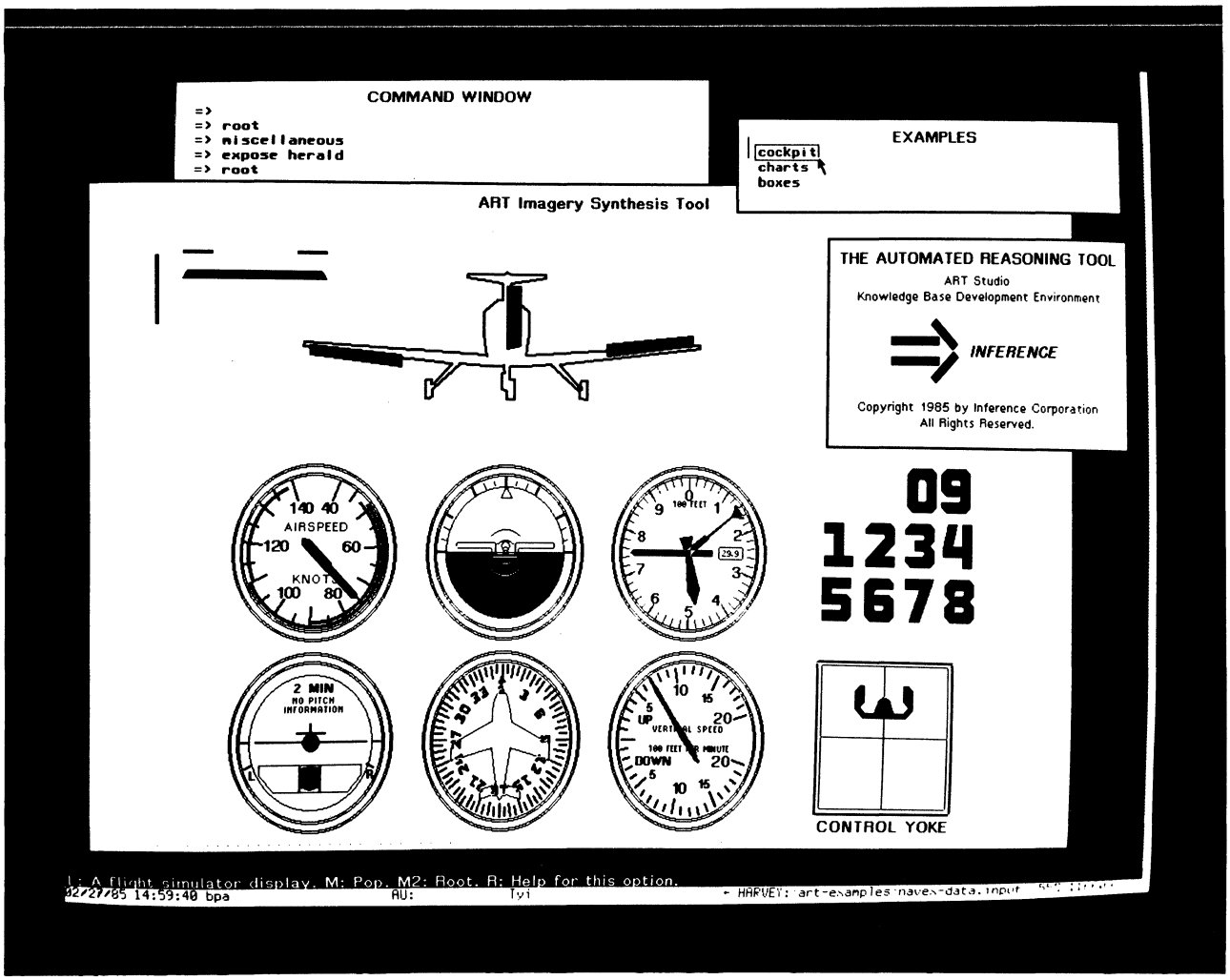
Following the success of NAVEX, NASA is now working on several new expert systems including:

- a flight design system that will help new controllers design the trajectory of a shuttle flight;
- an automated software development and verification system to manage millions of lines of existing computer code at the Center;
- an expert system to manage consumables such as oxygen and electricity aboard the shuttle, and later the space station.

Inference's ART product is the leading candidate for the development of future expert systems at NASA.

NASA is also looking at expert systems to preserve and distribute the valuable experience of engineers already employed at the center. Many of the engineers and scientists at the Johnson Space Center have 20 or more years of experience. NASA can't afford to lose that wealth of knowledge and judgment when these people retire, so they intend to preserve it in expert systems. In this way the experience of these human experts will be made available to new NASA employees both as operational systems and as training aids.

The success of NAVEX at the Johnson Space Center has gone a long way toward convincing others that AI technology is now a commercially viable tool for emulating the reasoning abilities of humans.



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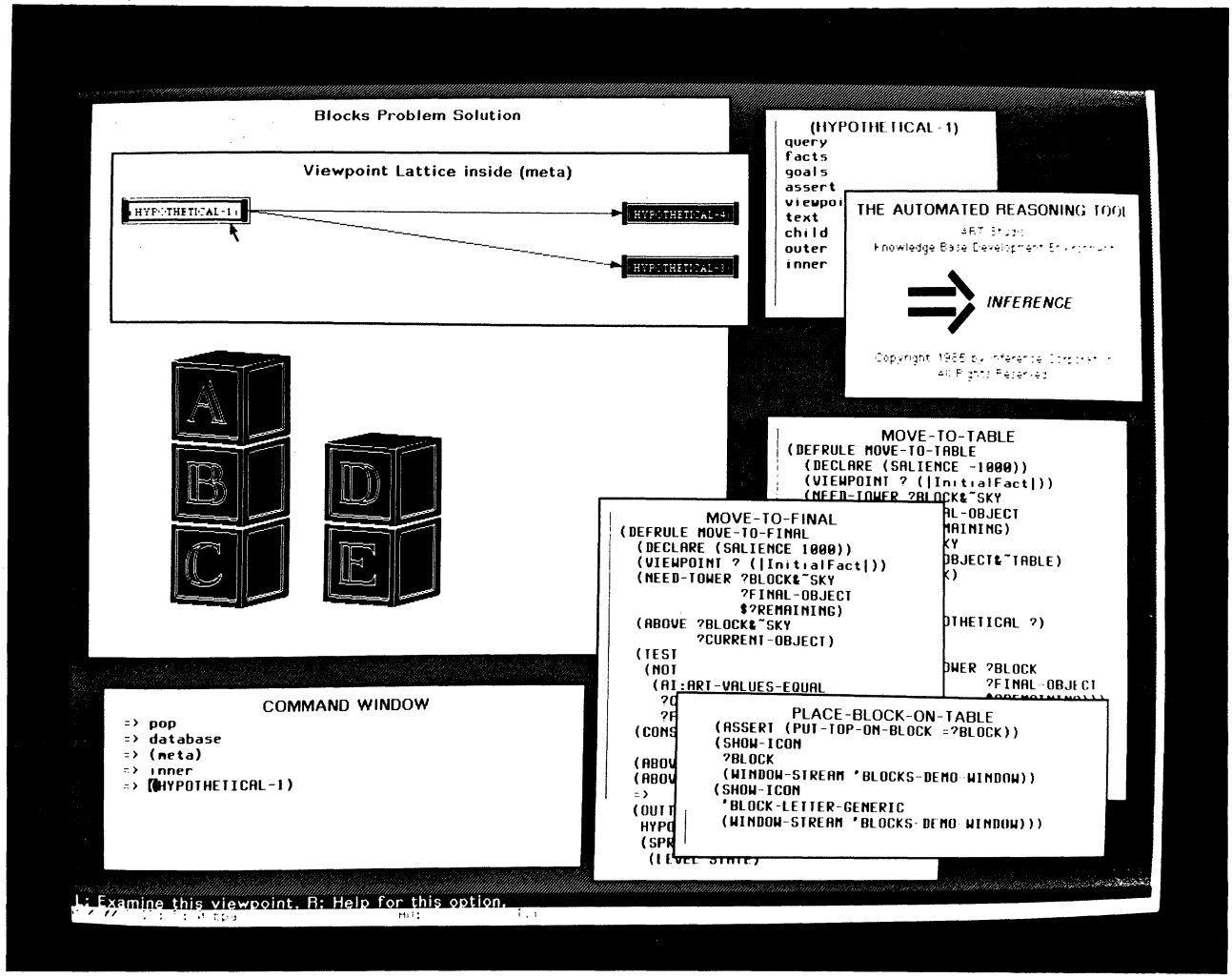
The attached photograph demonstrates the ARTIST™ feature of ART. ARTIST™ is a tool for building end-user interfaces which represent information using graphics. The particular display shown above is that of a flight simulator representing the use of icon graphics integrated with rules and schemata.



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The attached photograph demonstrates ART's Viewpoint (or hypothetical situation considered for problem solving) structure generated by the program. The program is considering one of two possible alternatives to assembling and disassembling blocks into a configuration to satisfy a user's requests. This is an example of the use of Viewpoint in a situation which requires both hypothetical and temporal reasoning.

REPRESENTATIVE AI PROJECTS

SOFTWARE A&E IS CURRENTLY PERFORMING ON A DIVERSE SET OF CUSTOM EXPERT SYSTEM PROJECTS. A BRIEF SUMMARY OF SOME OF THESE PROJECTS FOLLOWS.

Tactical Mission Planning

Software A&E has developed a prototype system for the U.S. Army Engineering Topographic Laboratory that applies spatial reasoning to the problem of tactical mission planning. The prototype uses a symbolically-encoded terrain data base, drawn from aerial photographs and other intelligence sources, to deduce the likely locations of enemy emplacements. This information is used to allocate reconnaissance resources.

The prototype architecture utilizes KES and other existing software; however, the spatial reasoning subsystem was developed by Software A&E specifically for this application. KES was used for the top level problem-solving control. It invokes the spatial reasoning subsystem that uses the terrain data base for the basic information elements feeding the spatial reasoning process. Software provided by Carnegie-Mellon University was used to drive graphic output.

A first release has been completed and delivered to the Army. The prototype successfully demonstrated the feasibility of reasoning about terrain data. The Engineering Topographic Laboratory has funded the follow-on effort to extend the capabilities of the prototype.

Acquisition Manager's Assistant (AMA)

Software A&E is combining the technologies of microcomputer-based personal workstations and expert systems to support all facets of Navy acquisition management. The project is jointly sponsored by the Office of Naval Research (ONR) and the Software Technology for Adaptable and Reliable Systems (STARS) program. The objective of the AMA is to complement the skills and experience of the program management staff, reducing costly errors and increasing the quality of the acquisition process.

The AMA will integrate expert system technology with standard management tools. The purpose of the expert systems are: (1) to aid in the preparation of the procurement package documents, (2) to provide consultation on acquisition strategy and related technical issues, and (3) to support administrative activities associated with the acquisition life cycle.

The first release of the AMA is currently under development. It includes many innovative technological advances. For example, the huge domain knowledge associated with acquisition will be developed and managed incrementally. Techniques will be employed to maintain consistency among common attributes in multiple knowledge modules.

Mainframe Crash Diagnosis

Software A&E has developed an expert system for a major computer mainframe manufacturer. The expert system determines the cause of a mainframe failure by analyzing the resulting memory dump. The expert system operates directly on the dump file without operator interaction. It incorporates the ability to traverse the file and retrieve selected records.

The first demonstration system was created in five days with KES. The customer had originally planned one year for this effort using traditional approaches. A production prototype was then developed in less than three months using KES. Its knowledge base included over 800 production rules. The system is currently under evaluation in an operational setting.

Permit Writer's Assistant

Software A&E has just completed a prototype expert system for the Environmental Protection Agency to aid permit writers in reducing the 6,000 permit application backlog. The workstation-based system leads the permit writer through the process, scheduling water quality and other tests as warranted by the permit request at hand. At the completion of the process, the system prints out a complete permit.

Initial evaluation by permitting experts at EPA has resulted in high marks for the system. Based on the evaluation, the EPA has given Software A&E approval for a phase two effort to build a production prototype.

Data Base Analysis

The major objective of this system is to automatically read and analyze data in a large data base in order to identify critical situations which require human action. Software A&E teamed with CTEC to implement the demonstration expert system for the Department of the Treasury. Currently, human analysts perform the tasks but, due to the volume of information, critical situations are discovered as much as two years after they have occurred. The expert system analysis will make it feasible to identify critical situations as they occur.

The customer response to the demonstration was very enthusiastic. A proposal was submitted and award of contract has just been given. The proposed system would provide five microcomputer-based analyst workstations in a network including the mainframe which controls the data base.

SOFTWARE TOOL KIT FOR BUILDING EXPERT SYSTEMS NOW AVAILABLE ON IBM PC-AT, PC-XT, AND UNIX-BASED COMPUTERS

Rulemaster™ package speeds creation of expert systems without extensive knowledge engineering or AI programming

AUSTIN, Texas, Mar. 25, 1985 -- A software tool kit for rapidly building and operating industrial scale expert systems on the IBM PC-AT and PC-XT is now available from Radian Corporation.

Called RuleMaster™, the new software package--also available for UNIX-based computers--permits the creation of expert systems for complex advisory, diagnosis, prediction, or control applications, yet requires only the ability to logically organize the application in a modular or structured fashion. RuleMaster does not require LISP or Prolog language skills or machines.

RuleMaster applications cover a broad range of engineering, technical, and industrial areas, including fault diagnosis, on-line operations advice, interactive maintenance manuals, weather prediction, and chemical analysis advice.

8501 Mo-Pac Blvd. / P.O. Box 9948 / Austin, TX 78766 / (512)454-4797

RADIAN CORPORATION

Rulemaster is the latest in a series of specialized, PC-based application packages from Radian, a 900-person high-technology firm founded in 1969, with 1984 sales of approximately $50 million.

According to Radian vice president F. Scott Lagrone, the availability of RuleMaster on the PC-AT and PC-XT signals the arrival of cost-effective expert systems in the mainstream of business, engineering, and scientific computer applications.

"With RuleMaster, expert systems addressing a wide range of problems in technical and business decision-making can be developed and run on the PC-AT, while smaller applications and tutorials can be run on the PC-XT," said Lagrone. "As a result, small companies can now use expert systems in their day-to-day operations, and large corporations will employ multiple systems throughout their organization."

RuleMaster differs radically from conventional LISP-based tools

RuleMaster offers a simple yet powerful approach to expert systems development which differs radically from that of systems based on conventional AI languages such as LISP. Unlike LISP, whose complexities require a highly trained analyst, RuleMaster provides to knowledge engineers a pair of easy-to-use application development tools:

- RuleMaker™, a facility for inducing rules from examples;
- Radial™, a high-level language for expressing rules;

Radial is similar to structured algorithmic programming languages such as Ada and Pascal.

RuleMaker facility speeds application development

The RuleMaker facility speeds application development by automatically generating rules and Radial code from a set of declarative examples supplied by an expert. Minimal programming

is required on the part of the knowledge engineer, who gathers examples from the expert, and enters them into an "example table" in any order. RuleMaker induces procedural rules from the examples, and generates modules that express those rules in the Radial language. Conflicts in the resulting logic that stem from improperly constructed example tables are discovered and reported by RuleMaster to the user for correction. Additionally, omission of required logical entries in an example table are reported to the user for modification.

"RuleMaker greatly simplifies the knowledge engineer's task, both in terms of gathering information and incorporating that information into an application," said Lagrone. "Most experts can discuss real-world examples far more easily than they can formulate abstract, procedural rules. And the engineer is spared the need to laboriously translate the expert's knowledge into the complex syntax of an AI programming language."

RuleMaker also optimizes an application by automatically prioritizing each module's "if-then-else" statements according to the amount of information they provide. A RuleMaster-based application program queries the user in a manner that statistically provides the most information in the shortest time. This reduces the number of questions asked by the expert system, thereby minimizing processing time and overhead.

High-level Radial language easy to learn and use

Knowledge engineers working with RuleMaster can write code directly in the Radial language if they prefer, or if that approach is more appropriate for the application. Manually written Radial code, moreover, can be inserted into code generated by RuleMaker from an example table.

With only 14 key words, Radial is easy to learn and use. Knowledge engineers can quickly develop applications because

Radial is a structured language which makes it easy to implement structured solutions.

System uses both backward and forward chaining

The Radial language implements two fundamental reasoning mechanisms: backward and forward chaining. Most practical applications require a combination of backward and forward chaining for different parts of the solution. With RuleMaster, a knowledge engineer can combine both chaining methods in a single expert system.

Backward chaining is commonly employed for diagnostic applications. This reasoning mechanism is useful for selecting the best solution to a problem from a number of possibilities, such as the most probable cause of equipment failure from many possible causes.

Forward chaining, a capability found in very few microcomputer-based expert systems, is a reasoning mechanism useful in planning and monitoring expert systems. Applications include process control, robotic control, and simulation.

RuleMaster interfaces to external routines

RuleMaster can access external routines written in various languages such as FORTRAN and Pascal. A RuleMaster-based expert system can thus access data bases and numerical processing and handling input and output devices. Radian Corporation meteorologists employed this capability in building STORM, an expert system for severe storm forecasting; the system accesses weather data on several remote government data bases, and also uses FORTRAN routines for numerical analysis to extract meteorological features from the data.

Explanation and logic flow continuously available to user

RuleMaster provides an extensive explanation facility. The end-user needs only to type in the word "WHY" at any point during a session to get an explanation of the system's response or a justification for its line or questioning.

Availability and pricing

Rulemaster is available immediately for use on the IBM PC-AT and PC-XT running under the Xenix or DOS 3.0 operating system. The price for the PC-AT version is $15,000; for the PC-XT version, $5,000. Quantity discounts are available. The purchase price covers a four-day training session held at Radian each month.

UNIX version also available

Written in C, RuleMaster can potentially be run on any computer with a C compiler. The UNIX version of RuleMaster, released in December 1984, currently runs on DEC VAX systems, and has been implemented on several other UNIX-based systems from Gould, Perkin-Elmer, and Sun Microsystems. The UNIX version of RuleMaster is priced at $25,000.

RuleMaster is the result of the collaboration since 1982 between Radian Corporation's knowledge engineers and Professor Donald Michie, an internationally recognized pioneer in artificial intelligence and expert systems research. Professor Michie is currently at the University of Strathclyde in Glasgow, Scotland, and is also affiliated with the Turing Institute.

Radian Corporation is an advanced technology firm that specializes in developing cost-effective solutions for technical problems. A large percentage of Radian's 900 employees, including its top-level managers, are technical professionals. From its 300,000 square feet of offices, laboratories,

manufacturing facilities, and computer center--all located on a 20-acre tract in Austin, Texas--Radian is continually expanding its broad range of product lines and service areas, including state-of-the-art hardware and software systems.

Radian Corporation is a subsidiary of Hartford Steam Boiler Inspection and Insurance Company, which is traded OTC, NASDAQ symbol HBOL.

For further information, contact Ben Finkel, Marketing Manager, Radian Corporation, 8501 Mo-Pac Blvd., P.O. Box 9948, Austin, TX 78766, (512) 454-4797.

RuleMaster™ Severe Storm Forecasting Expert System

```
How is low-level moisture at 1000mb changing?
    [increasing, not_changing, decreasing] increasing
Is the 850 millibar dew point depression < 8 Deg C ? [yes,no] yes
Is the value of the Lifted Index at 00Z June 3, 1984 strong, marginal, or weak?
    [strong,marginal,weak] marginal
Is solar insolation strong? [yes,no] yes
Is there a low level wind maximum upstream of the location?
    [present,absent] present
Is a 500 millibar short wave trough approaching? [yes,no] yes
Is upper level cold air advection present or absent? [present,absent] absent
What is the vertical change of Equiv. Pot. Temp?
    [convectively_stable,convectively_neutral,convectively_unstable]
    convectively_unstable
Is upper level diffluence present? [yes,no] yes
Is strong 700 millibar subsidence present or absent? [present,absent] present

Advice: Thunderstorms occurring near Austin, Texas at 1200 March 13, 1985 MAY
    APPROACH severe limits.
```

```
Since subsidence is present it follows that preventative factors is present
Since upper level diffluence as a possible venting mechanism for increasing
    upward vertical velocities is present when the lapse rate of equivalent
    potential temperature is convectively_unstable and upper level cold air
    advection causing enchanced destabilization is absent it follows that the
    upper-level destabilization potential is favorable
Since an approaching 500 millibar short wave trough is present it follows that
    the vertical velocity field is favorable
Since the Lifted Index is marginal it follows that the condition indicated by
    the stability indices is marginal
Since a low-level wind maximum is present when daytime heating acting as a
    possible trigger mechanism for potential instability release is strong and
    the condition indicated by the stability indices is marginal it follows that
    low-level destabilization potential is favorable
Since a small 850 mb dew point depression, indicating the depth of the low-level
    moisture field, is present when the rate of change of low-level moisture at
    1000 mbs is increasing it follows that the low-level moisture field is
    abundant
Since preventative factors is present when the upper-level destabilization
    potential is favorable and the vertical velocity field is favorable and low-
    level destabilization potential is favorable and the low-level moisture
    field is abundant it is necessary to advise 'Thunderstorms occurring near
    Austin, Texas at 1200 March 13, 1985 MAY APPROACH severe limits' in order to
    actually forecast the chance of severe thunderstorms

Advice: Thunderstorms occurring near Austin, Texas at 1200 March 13, 1985 MAY
    APPROACH severe limits.
```

An example of an expert system for storm prediction based on the RuleMaster™ expert systems software tool kit from Radian Corporation

The upper box shows the type of questions that the system poses to the end-user. The lower box illustrates the system's explanation facility. Available for use on the IBM PC-AT, PC-XT, and UNIX-based systems, RuleMaster permits the creation of industrial-scale expert systems for advisory, diagnosis, prediction, and control applications.

MARTIN MARIETTA, ERLI SIGN AGREEMENT TO OFFER FRENCH NATURAL LANGUAGE COMPREHENSION

PRINCETON, NJ--Mathematica, a unit of Martin Marietta Data Systems Information Technology division, here, and ERLI (Societe d'Eturdes et de Recherche Linguistique et Informatique), a leading artificial intelligence research and development company in Paris, France, have signed an agreement to offer a French natural language comprehension component for the RAMIS II fourth-generation language and DBMS. The agreement includes plans for continued development of RAMIS II natural language comprehension for additional romance languages as well as other cooperative efforts in artificial intelligence research and development by Mathematica and ERLI.

The new RAMIS II Francais component processes requests expressed in everyday French. It responds to questions with direct yes/no answers, to questions concerning "how many," and to requests requiring tabular reports. If the request is unclear, RAMIS II Francais resolves the uncertainty through dialogue with the user. In some cases, RAMIS II Francais will paraphrase the request and ask the user to confirm its interpretation of the question or directive. Users will also have the ability to display the equivalent RAMIS II nonprocedural language request. RAMIS II Francais is a knowledge-

based system that includes facilities to develop and enrich the system's vocabulary, allowing the use of specialized terminology in requesting information.

With the offering of RAMIS II Francais, French speaking users will have three ways to produce reports through RAMIS II:

- o RAMIS II Reporter--The French national language version of RAMIS II uses nonprocedural French-like syntax.

- o MARVEL--uses an intelligent series of prompts to guide the user in preparing a report

- o RAMIS II Francais--uses natural French language requests and infers what the user desires by understanding the meaning of French statements.

RAMIS II Francais will be offered as a fully-integrated component of RAMIS II. Data will not have to be copied or restructured for French processing because RAMIS II Francais provides direct access to data stored in RAMIS II data bases; IMS, DL/1, ADABAS, TOTAL, and IDMS data bases; RAMIS II relations; and sequential, VSAM, and ISAM files. Regardless of the data source, requests lead to an efficient retrieval process.

Commenting on the announcement, Bernard Finzi, senior vice president and director of technical services for Mathematica and a native French speaker, noted, "RAMIS II Francais will be the first commercial offering of a French

natural language comprehension interface to RAMIS II and other major data bases. It represents a basic change in working with computers for French speaking users, allowing novices access to information without training in a computer language. With the addition of RAMIS II Francais, RAMIS II now meets the needs of an even broader range of information consumers. It is another step Mathematica has taken towards offering the power of computers to everyone, regardless of their DP knowledge or language."

The offering of RAMIS II Francais is part of a company strategy to be the leader in natural language comprehension. In making the announcement, Frank Fish, Mathematica's vice president of customer support and marketing, noted, "We believe that within a few short years, most international users will demand access to computerized information through natural language. As the current leader in end user information processing, it behooves Mathematica to lead in natural processing as well."

Also commenting on the announcement, Bernard Normier, president director general of ERLI, said, "This cooperation with Mathematica, the leader in developing fourth-generation language systems, is most exciting since it continues our development in accord with our strategy and refocuses the leadership position of ERLI with respect to native language processing in France."

RAMIS II Francais will be marketed through MFSA, Mathematica's affiliate in France, and Mathematica Products Group, Canada, Ltd. in Canada. RAMIS II Francais will be the second natural language comprehension component for RAMIS II. The first, RAMIS II English, was released April 1, 1984 and is already

installed at more than one hundred sites. By providing both RAMIS II Francais and RAMIS II English, Mathematica becomes the first vendor to offer natural language comprehension in two languages.

RAMIS II Francais is scheduled for initial release in September 1985. Price for the new component will range from $18,000 to $36,000, based on CPU performance rating levels.

Founded in 1977, ERLI is a French artificial intelligence firm which, in addition to its research and product development activities, provides data base application development consulting. It has a staff of twenty-seven and is headquartered in Paris, France. ERLI's major software products are SAPHIR, a French natural language system, and ALEXIS, a linguistic data base system.

Mathematica is a developer and marketer of data base management systems and application development tools. In addition to RAMIS II, Mathematica produces RAMIS II English, a natural language knowledge-based component for RAMIS II based on artificial intelligence technologies, as well as ATLAS^{TM}, a data communications monitor. Mathematica, headquartered in Princeton, New Jersey, is a Martin Marietta Data Systems company, a supplier of computer software, services, and integrated systems.

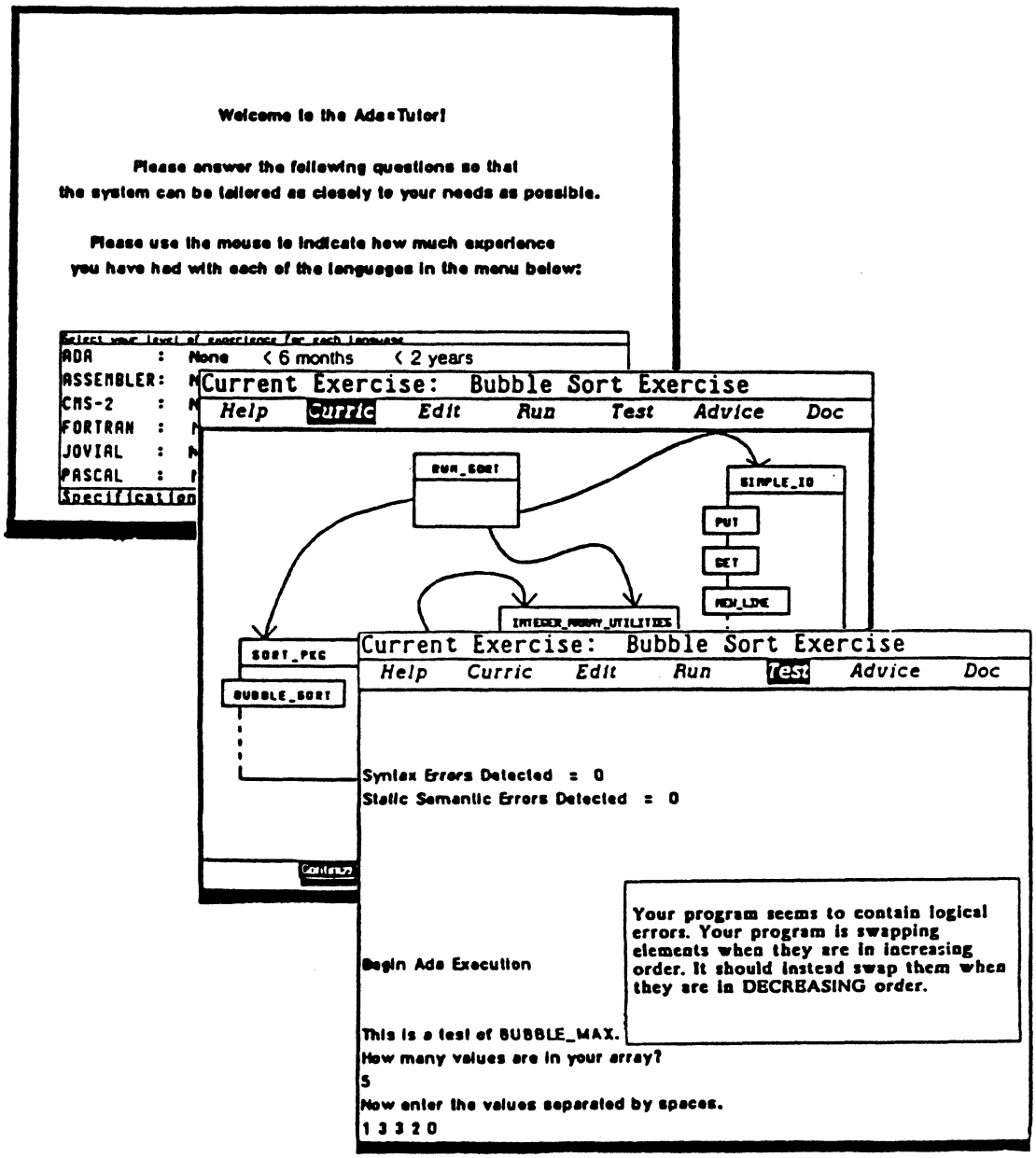
For more information on RAMIS II Francais, contact Glenn Frantz, Mathematica Inc., P.O. Box 2392, Princeton, NJ 08540 or telephone toll-free 800-257-5171, in New Jersey, 609-799-2600.

The

COMPUTER*THOUGHT CORPORATION

Ada*Tutor Research Project

The Ada*Tutor, a research project of Computer * Thought Research Laboratories, Inc., will integrate the current Ada® Interpreter/Debugger with a set of Ada practice exercises, individual student experience profiles, and a solution analysis expert system to form a knowledge-based tutorial environment. This system is being prototyped on **Symbolics™ 3600 Series** workstations for ultimate delivery on these and similar high-performance workstations.



Overview

The Computer * Thought Ada*Tutor is one of several research and development projects presently underway at Computer*Thought Research Laboratories, Inc., C*T's wholly-owned R&D subsidiary. Currently at the working prototype stage, the Ada*Tutor is intended to supplement the existing Ada product line with a powerful training capability.

Individualized Training

The Ada*Tutor creates a student model that customizes each programmer's learning experience to conform to that person's background, skills and familiarity with other programming languages. Whereas traditional computer-aided instruction (CAI) systems tend to be unfriendly and inflexible, C*T's knowledge-based CAI technology strives to provide insightful, individualized training comparable in effectiveness to one-on-one interaction with an expert human tutor.

Exercises and Solution Analysis System

The exercises and solution analysis modules of the tutor, which require the student to write and modify Ada programs, are coordinated with the case study used in C*T's seminar package. A student's solution to an exercise can be evaluated by automatically applying test functions that observe and analyze the program's dynamic behavior. By examining both I/O behavior and intermediate program states, as well as the student model, the Ada*Tutor can then generate an individualized summary of the logical errors in the student's program.

Future Research

Although the Ada*Tutor's sophistication in diagnosing logical errors is already impressive, the AI technology and curriculum could be enhanced by further research and development.

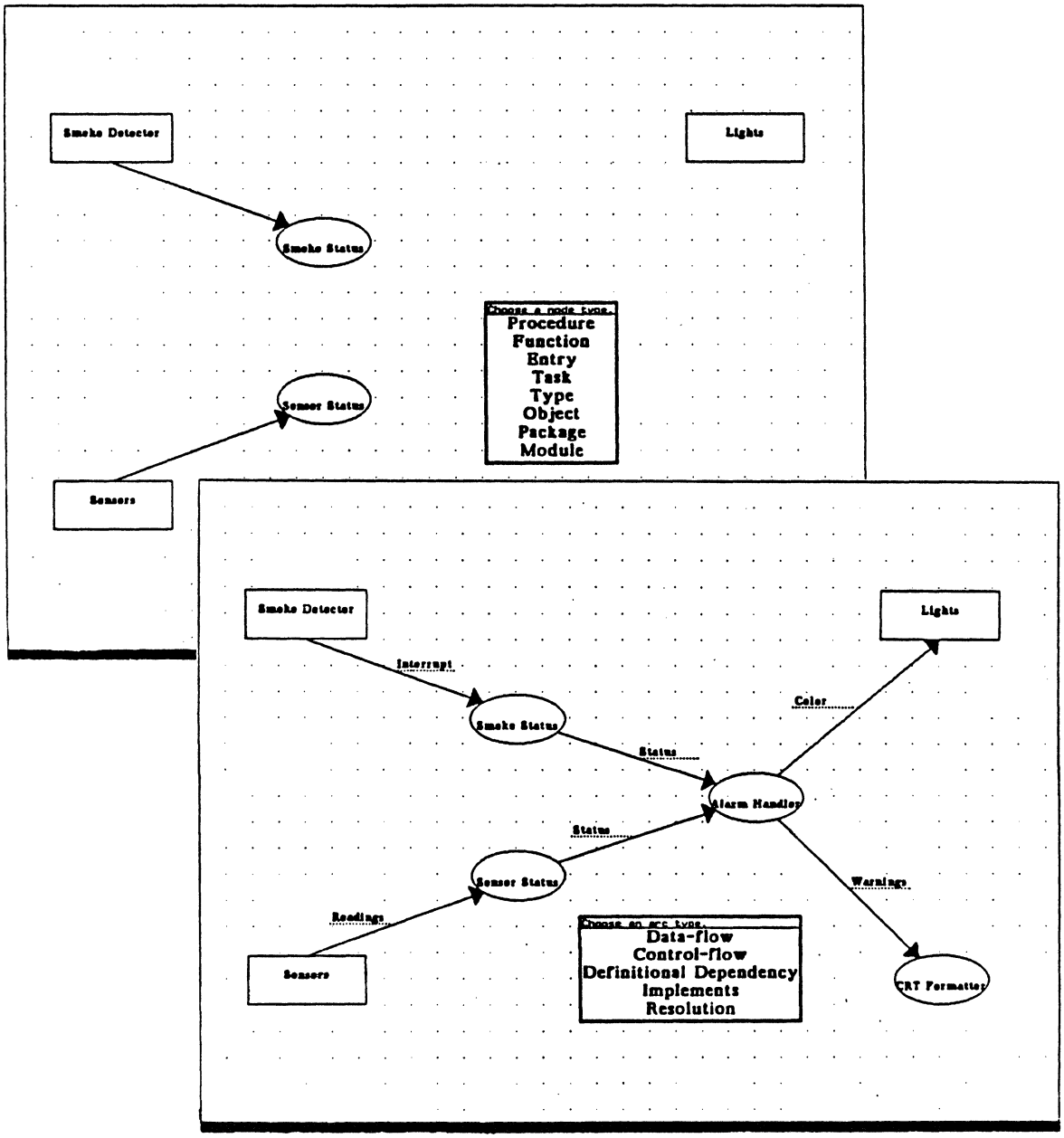
C*T seeks joint ventures, partnerships and contract funding opportunities to accelerate this and related efforts.

The

COMPUTER*THOUGHT CORPORATION

Design Assistant Research Project

The Design Assistant, a research project of Computer * Thought Research Laboratories, Inc., provides graphics tools and knowledge-based assistance to software designers. This is the first member of a proposed family of Life Cycle Assistant products that are being prototyped on **Symbolics[tm] 3600 Series** workstations for ultimate delivery on these and similar high-performance workstations.



Overview

The first version of the Design Assistant will be customized for the Ada® programming language. Key requirements for the overall product family include support for traceability and generation of MIL-STD documentation. Current work focuses on the development of the three major components described below.

The **Graph Editor** will allow a user to input, modify, and display a program design graphically. Using this tool, a program designer can build and manipulate graphic elements representing various design aspects, such as modules and data flow (represented as nodes and arcs). A user can interactively add and delete nodes and arcs, or change the scale and perspective with which the graph under construction is being viewed. The graph editor automatically prevents parts of the graph from overlapping with each other, and can generate layouts automatically from limited structural information.

The **Program Design Knowledge Base and Inference Engine** will use artificial intelligence techniques to handle low-level details, enabling the user to concentrate on key decisions. For example, as the designer uses the Graph Editor to construct a diagram representing a program design, a knowledge-based system will examine the structure, check dependencies and consistency, and make inferences about various types of relationships, such as data flow and control flow between modules. An early prototype supported dialogues such as the following:

```
Question: What is the evidence that ALARM HANDLER should be the top node?
Answer: ALARM HANDLER should be the top node because:
    It is a processor that gets input and sends output to other processors.
    It is a processor with many inputs and many outputs.
    Note: There is also negative evidence on this question.
```

From a design graph built using the Graph Editor, the first version of the **Program Design Language (PDL) Generator** will produce skeletal Ada code in the form of Ada package and task specifications. As such, this code can be compiled for consistency checking.

Future Research

Future research and development work will address productivity aids for other phases of the software development life cycle such as semi-automated testing, knowledge-based tools for analysts and software project managers, and language-independent versions of the Design Assistant.

C*T seeks joint ventures, partnerships and contract funding opportunities to accelerate this and related efforts.

The COMPUTER*THOUGHT CORPORATION

High-Level-Language Translator Research Project

The High-Level-Language (HLL) Translator, a research project of Computer * Thought Research Laboratories, Inc., will translate programs written in certain other high-level languages into Ada.® This system is being prototyped on the Symbolics™ 3600 Series workstation for ultimate delivery on a variety of target machines.

```
Line#  J73 Source program

1.
2.
3.              START
4.                PROGRAM recfact ;
5.
6.                      BEGIN
7.                              ITEM ans U ;
8.                              ITEM i U ;
9.
10.                       FOR i : 1 BY 1 WHILE i <= 8 ;
11.                             ans = factorial(i);
12.                     END
13.
14.             PROC factorial REC (arg) U ;
15.                     BEGIN
16.                             ITEM arg U ;
17.
18.                       IF arg < 2 ;
19.                             factorial = 1 ;
20.                       ELSE
21.                             factorial = fact
22.                     END
23.             TERM
```

```
procedure RECFACT is

   ANS:INTEGER;
   I:INTEGER;
   function FACTORIAL(ARG:in INTEGER)  return INTEGER is
      FACTORIALI6898:INTEGER;
   begin
      if ARG < 2 then
         FACTORIALI6898:=1;
      else
         FACTORIALI6898:=FACTORIAL(ARG - 1) * ARG;
      end if;
      return FACTORIALI6898;
   end;
begin
   I:=1;
   while I <= 8 loop
      ANS:=FACTORIAL(I);
      I:=I + 1;
   end loop;
end;
```

Overview

Many systems written in earlier programming languages such as JOVIAL and FORTRAN will soon have to be rewritten in Ada -- recently adopted as a standard by the U.S. Department of Defense for mission-critical tasks. It is common for embedded systems written in these older languages to be hundreds of thousands of lines long. Consequently, there is a need for automatic or semi-automatic translation tools. The Computer * Thought High-Level-Language Translator addresses this need. This translation tool is one of several research and development projects currently underway at Computer * Thought Research Laboratories, Inc., C*T's wholly-owned R&D subsidiary.

JOVIAL and FORTRAN Translators

Prototype systems for translating JOVIAL J73 (the dialect primarily used among Air Force contractors) and ANSI FORTRAN 77 programs into Ada now exist. The prototypes were constructed from existing modules in the Computer * Thought Ada Interpreter, supplemented by a high-level language plan representation and a rule-based translation architecture.

Translation Phases

The translation process includes four phases. In the case of a J73-to-Ada translation, the first phase transforms the source program into a J73-specific internal representation. This representation in turn is changed into a language-independent plan representation. A rule-based translation system converts this into an Ada-specific internal form, which is then converted into Ada source code by an existing module of the Computer * Thought Ada Interpreter.

Other Language Translators

Comparable translators for Pascal, other dialects of JOVIAL, and possibly COBOL could be developed by adapting the first two phases of this system to the appropriate language. The last two phases of the translation process would be re-used in the translation of other languages into Ada.

Conclusion

C*T's involvement with Ada enables us to generate HLL-to-Ada translators with relatively short development schedules. The tools and expertise we have built up in developing our Ada product family, and our well-tuned understanding of the relationships between similar constructs of different languages make HLL-to-Ada translation an obvious project for C*T.

C*T seeks joint ventures, partnerships and contract funding opportunities to accelerate this and related efforts.

COMPUTER * THOUGHT
CORPORATION

COMPUTER * THOUGHT AND TEKNOWLEDGE PLAN JOINT DEVELOPMENT OF AI TOOLS IN ADA

LOS ANGELES, CA, August 19, 1985 -- Computer * Thought Corporation, of Plano, Texas, and Teknowledge Inc. of Palo Alto, California, today announced at the International Joint Conference on Artificial Intelligence, that negotiations are underway between the two companies for Computer * Thought to convert Teknowledge's S.1, Version 2 knowledge system development tool to the Ada programming language.

"This would enable our aerospace and defense customers to comply with the DoD requirement for Ada implementation of mission-critical systems incorporating expert systems technology," said Dr. Bruce Bullock, Vice President and General Manager of Teknowledge Federal Systems. He added that users of the current versions of S.1 would be able to transition to versions meeting the Ada requirement with minimal difficulty as they become available.

1721 West Plano Parkway • Suite 125 • Plano, Texas 75075 • 214/424-3511

DESCRIPTION

Using fifth generation technology, TRANSFORM/IMS automates the development and management of computer applications, freeing your technical staff to concentrate on solving business problems rather than the mechanics of design and programming.

TRANSFORM/IMS can accept the requirements of any business application directly from analysts' specifications. Using those requirements, it fully automates the internal design and programming.

Programs are produced in ANS COBOL 74, and operate in an IMS DB/DC environment. Also generated are all MFS macros, DBD's and PSB's. Each online transaction includes a HELP function.

Generated programs are well-structured, and are of the quality of professionally handwritten code. Moreover, no debugging is required. TRANSFORM/IMS automatically generates the JCL to update source libraries, compile, and link all generated elements.

No programming skills or specific knowledge of IMS, COBOL or JCL are required. All that is needed is familiarity with the database concept and knowledge of business practice. Storage and performance tuning may be done by the database administrator using TRANSFORM options after system functional requirements are realized. Generally, only five days of training are required to become fully proficient in using TRANSFORM/IMS.

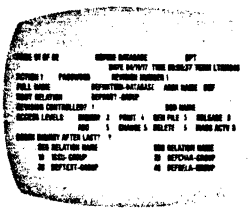
ADVANTAGES

Standard COBOL output: The generated applications are independent and can be maintained conventionally if desired. You are not "locked in" to a fourth generation interpreter for execution.

Automatic revision control: When migrating from a test to a production version, no retesting is required.

Data dictionary: TRANSFORM/IMS contains its own full-function, active dictionary.

Non-procedural input: Applications are specified by filling out simple online forms. No if-then-else logic is required. This is the source of most errors in programming.



SAMPLE INPUT SCREEN

Greatly simplified maintenance: Changes need be made only to the system definition (schema), which is saved from version to version. TRANSFORM/IMS automatically regenerates only the affected parts of the application. No re-testing is required after each change.

Quick prototype creation: Generating a trial system, refining the specifications, and regenerating a new system can be done with very little effort.

Efficiency: Generated systems are compiled and executed, not interpreted, so they perform efficiently and are not limited to small transaction volumes. Performance tests show them to be about equal in efficiency to handwritten code.

Flexibility: Generated systems can interact with existing systems: Data to and from external systems may be processed by the applications generated. Generated applications contain only standard IMS databases.

You can rely on TRANSFORM/IMS for complete automatic application system development directly from specifications, in substantially less time and at dramatically lower cost. Write or call for further information.

ICONICS INC.

Iconics, Inc.
8502 E. Via De Ventura
Scottsdale, AZ 85258
(602) 948-2600

FMC establishes artificial intelligence venture with Teknowledge

CHICAGO, ILLINOIS, March 1985 — FMC Corporation announced that it is investing $3.5 million to acquire approximately 11 percent of Teknowledge, Inc., a Palo Alto, California, firm specializing in artificial intelligence software products and services. FMC and Teknowledge will engage in a variety of mutually beneficial technical activities in the artificial intelligence area.

President and Chief Operating Officer Ray Tower said the investment is an important element in FMC's plan to build a premier capability in artificial intelligence. "We anticipate numerous applications of artificial intelligence technology in our defense, chemical, and machinery businesses, as well as in our internal design and manufacturing processes," Tower said. "This association will accelerate the achievement of our technology objectives."

As part of the investment agreement, FMC will hold a position on the Board of Directors of Teknowledge. Pete Weber, director, Research and Development, Machinery and Defense Operations, has been selected to fill this position and will be managing the strategic relationship between FMC and Teknowledge.

Collaborating with FMC's Artificial Intelligence Center, Central Engineering Laboratories (CEL), in Santa Clara, California, Teknowledge will develop generic artificial intelligence software tools with broad applicability to FMC's products and internal processes. The Center's Director, Perry Thorndyke, will be the technical liaison between CEL and Teknowledge.

In addition to joint R&D, Teknowledge personnel will conduct courses in selected artificial intelligence topics to assist FMC in developing a staff of 90 technical professionals.

Backround information on Teknowledge, Inc., Palo Alto, California

Teknowledge was incorporated in 1981 by 20 experienced AI research and applications scientists to commercialize that portion of artificial intelligence known as knowledge engineering. Since then they have become the premier company in the development of knowledge engineering software tools, which facilitate the process of building expert systems.

In June 1984, Teknowledge introduced two knowledge engineering software products into the commercial marketplace, S.1 and M.1. These products are among the first in a new generation of knowledge engineering tools which provide complete facilities for building, debugging, and maintaining a knowledge system.

General Motors became a strategic affiliate of Teknowledge in 1984 and acquired an interest in the company roughly equivalent to that being acquired by FMC. Two French companies, Elf Acquitaine (oil production) and Framatome (nuclearpower), also have major investments and commercial relationships with Teknowledge. ■

Artificial Intelligence emerges from the laboratory into industry and government

A Navy ship is in trouble in the mid-Atlantic. One of its Mk45 gun systems is down and FMC engineers are thousands of miles away. After a quick consultation with an expert, the malfunction is diagnosed and instructions given to repair the system. There is no reason to fly government or FMC test engineers to the ship.

An order is placed with a FMC field office. A quotation for a special petroleum wellhead design is required by a customer. With help from an engineering consultant, a casing design is generated to meet the specified drilling program and a quotation is ready immediately for a wellhead configuration satisfying the requirements and preferences of the customer.

A land vehicle is approaching a previously unknown hostile force. The vehicle commander considers soil conditions, available vegetation, and the topography of the terrain to plot a route which will avoid detection by circumventing obstacles and concealing the vehicle.

In all of these cases, the "advisor," "expert," and "commander" have one thing in common: they are not human. They are computer systems known as "expert systems," part of a broader science called Artificial Intelligence (AI).

Industry and military analysts alike have acclaimed AI as one of the technologies that will propel us into the 21st century. In June 1984, FMC Corporation announced plans to devote substantial commitment to artificial intelligence research and development in the next five years. The establishment of an Artificial Intelligence Center at Central Engineering Laboratories (CEL) in Santa Clara, California, was the first step. Now, almost a year later, the Center has a new facility, a director has been hired, and a staff of six has grown to 20.

"This new technology clearly will be one of great importance to major corporations in the late 80's," said Andy Chang, manager, Electronics Engineering and Computer Science Department, CEL. "And, it is a natural extension of CEL's electronics engineering and computer science capabilities."

According to Chang, within the next five to ten years AI will be incorporated into many FMC products and process controls. "FMC is already recognized as a major corporation taking active steps to be a technical leader," he said.

When asked to give a definition of AI for the layperson, CEL's Artificial Intelligence Center Director Perry Thorndyke is quick to respond that there are as many definitions of AI as there are practioners in the field. "It is the field of computer science that seeks to recreate in computer software the performance of humans on complex reasoning tasks," he says. "In other words, we are developing programs that perform intellectual functions using symbolic, rather than numeric, computations."

In AI, concepts and ideas rather than numbers are manipulated to reach conclusions. Thorndyke likes to use the example of deciding whether to carry an umbrella. "To decide whether to carry an umbrella, a person considers many imprecise indicators of the weather," he says. "What did the weather report predict? Is the air damp? Are there clouds in the sky? Are the birds nesting? Is my arthritis acting up? All this knowledge flows together and you make a decision to take an umbrella, or to leave it home."

"To represent this type of reasoning in algebraic or business programming languages like FORTRAN or COBOL would be very difficult," he continued. "So new 'English-like' programming languages have been developed which emulate human deductive and common-sense reasoning processes. The new languages allow conclusions to be drawn from huge stores of facts and beliefs relevant to a problem. There are no guaranteed answers, but as in the case of the umbrella, all the known information is pulled together in a logical way, the indicators are looked at, and a conclusion is provided with a certain confidence level."

Expert systems clone scarce human expertise

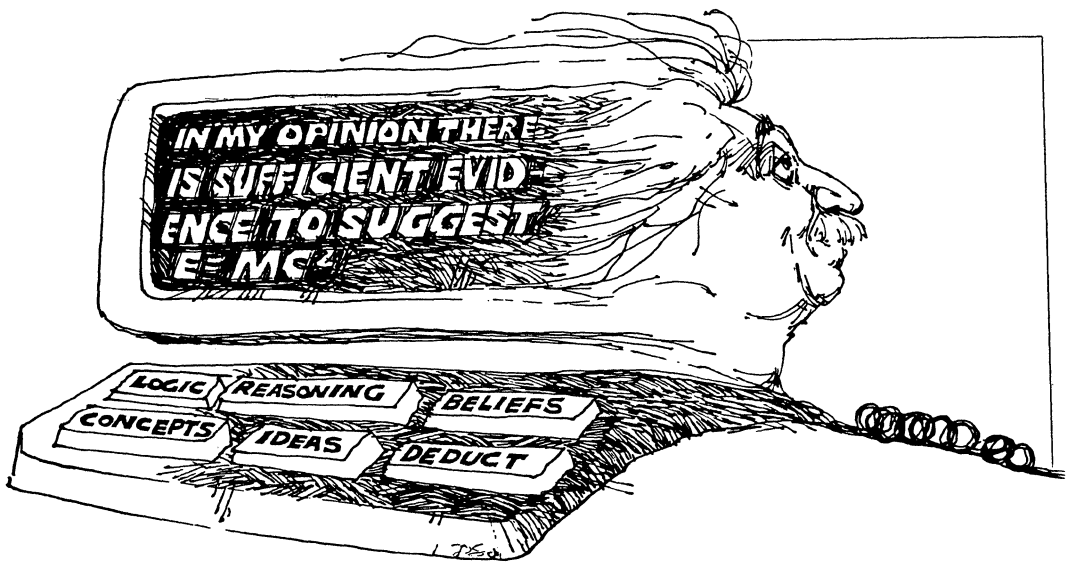
One of the most important branches of AI is knowledge systems, often referred to as expert systems. These systems incorporate expertise extracted from professionals such as chemists, physicians, and military commanders to enable problem-solving in specific areas such as chemical structure analysis, disease diagnosis, or planning of battlefield maneuvers.

Expert systems are best applied to problems that feature incomplete, uncertain, dynamic, or conflicting information. They are applicable to problems which have frequent and numerous occurrences, to problems where too few specialists or not enough time is available for a human solution, and to problems needing expert monitoring, diagnosis, prediction, and consultation.

These conditions exist

Perry W. Thorndyke

Perry W. Thorndyke, Ph.D., has been employed by FMC as Director of the Artificial Intelligence Center since August 1984. He



throughout industry and government, and they are on the rise. There are too few skilled specialists available. The increasing job complexity is overwhelming. Human processing capacity and labor and training costs are rising. The information glut is a bottleneck in decision making, and institutions need institutional memories to protect against brain drain. The solution is to shift information processing from people to machines.

"AI provides a unique opportunity to capture the knowledge of experts," Thorndyke went on. "An expert system like a human expert blends fundamental knowledge, practitioners' wisdom, and skill in application of that wisdom and knowledge, to solve difficult problems and explain its reasoning." The challenge for organizations is to harness the talent available and mine the valuable knowledge that gives the company its competitive advantage. "It is important to find the experts, extract their knowledge, and preserve perishable expertise for future use and distribution wherever it is needed in the company," he said.

Why is AI generating so much excitement?

AI is a 25-year-old science which is now in the process of becoming an industry. The technology emerged as a branch of computer science in the mid-1950's, and for the next twenty years remained in academia and research institutions. Carnegie-Mellon, Stanford, MIT, and SRI were the preeminent institutions in development of the technology, and they remain the principal sources of technical talent in the field.

Within the last 18 months, cover stories on artificial intelligence have appeared in *Fortune Magazine, Business Week, Industry Week,* and *High Technology,* and on the front pages of the *Wall Street Journal.* AI has grabbed the public's attention because of a growing recognition that there are problems needing to be solved which cannot be attacked with conventional computing methods. Recent media attention has focused on some of the early successful attempts to apply AI to problems in industry. "Expert systems work, and recent advances in hardware and software have made building them commercially feasible," Thorndyke said. "The current needs and future opportunities are plentiful, and they are strategically important to the government and to industry."

It is predicted that the market for AI computers and software services will explode from $150 million in 1984 to $5 billion in 1990, and up into the $50-100 billion range by the year 2000. The driving forces for AI applications are the time-critical military requirements for assessment and reaction in combat, the need for further productivity improvements to meet overseas competition, the availability of affordable hardware/powerful software, and the Japanese fifth-generation computer program.

Why is the technology of interest to FMC?

FMC's objective is to be an industry leader in cost-effective applications of artificial intelligence to its products as well as its internal design and manufacturing processes.

"In FMC's military businesses, a strong AI capability is a requirement for participation in major new procurement contracts to be awarded in the '90's, "Thorndyke said. "Although automated fault-diagnosis and maintenance systems and autonomous, all-terrain vehicles that can plot their own routes are a few years away, the technology is a commercial reality. AI products will become interactive assistants in all the knowledge-intensive professions."

"In FMC's chemical businesses, a competitive advantage can be gained by the application of AI to achieve more efficient process control and more rapid product design and development," Thorndyke continued. "In other FMC areas, opportunities exist for knowledge-based systems for design and design checking, production planning and management aids, real-time process control systems, training systems for equipment operation and maintenance, and expert consultation systems for support services."

The number of attractive application opportunities vastly exceeds the current resources available at FMC to exploit them. Because of the shortage of AI professionals, an internal training program has been initiated at CEL. Explaining the AI Center development program, Chang said, "We cannot reach our goals through recruiting alone. We need to train our own staff. So, in addition to a formal training program structured around courses offered by Stanford University's Instructional Television Network, we are using our own experts and outside consultants to teach courses designed to fit FMC's needs. Our new program offers an employee with a basic computer-science background the opportunity to receive formal training in AI and become an effective contributor to AI projects."

In addition, FMC plans to augment its internal resources through associations with other leading AI research institutions. "We have a significant consulting relationship with SRI International," Chang said, "and the recently announced agreement with Teknowledge, Inc., will help accelerate the achievement of our technology objectives.

"We are in the process of building a premier artificial intelligence organization," Chang went on. "Our AI staff has a very impressive list of credentials and considerable experience in AI research. The Corporation has made a very strong commitment to this field, and together with strategic affiliations with other AI companies, we are well on our way toward our goal — becoming an industry leader in applied artificial intelligence."■

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directs the research and development operations comprising leading edge basic research, exploratory and applied development, and technology transfer to FMC operating divisions. He also manages staff development activities, including an internal training program to develop AI professionals.

Prior to joining FMC, Dr. Thorndyke held positions as director of the Knowledge Systems Branch, Perceptronics, Inc.; computer scientist, Information Sciences Department, Rand Corporation; and a faculty appointment at UCLA.

The research and development efforts Dr. Thorndyke has managed include: the design of architectures for distributed-planning systems; the development of expert systems to aid planning and decision making; the design of interfaces and displays for optimizing managers' ability to assimilate and use information; the development of instructional technologies to improve individuals' reasoning and problem-solving skills, and computer-based tutoring systems. He has managed and collaborated with computer scientists, psychologists, policy analysts, educational researchers, mathematicians, and statisticians.

Dr. Thorndyke holds a B.A. degree in computer and information from Yale University and a Ph.D. degree in cognitive psychology from Stanford University. He has authored more than 30 journal publications, book chapters, and technical reports, and has presented more than 100 conference papers and management and technical briefings.■

INTRODUCTION

The field of artificial intelligence is beginning to bring direct benefits to the business community. Interest in the field is at an all-time high as the potential of AI technology captures the attention, hopes and imaginations of engineers, businessmen, and others who have realized the value in using information technology themselves.

Along with this surge of interest is a significant amount of confusion and the need for a clearer understanding of what AI is and is not, what it can and cannot do, what products are available now, and which ones are yet to be developed.

This guide provides a general introduction to the field of artificial intelligence, the natural language software product INTELLECT™ and Artificial Intelligence Corporation, Waltham, Massachusetts, producer of INTELLECT.

INTELLECT is an online information retrieval system designed for IBM mainframe computers. Using the technology of artificial intelligence to understand everyday conversational English, INTELLECT helps professionals get the information they need from the computer without having to learn a computer language or any key words or special codes.

INTELLECT "In the news..."

"...AIC is the first company to sell programs that enable computers to understand and answer questions in English."
Business Week

"The user can converse with INTELLECT as easily as with another person."
Infosystems

"...the only commercialized natural-language program worthy of the name is INTELLECT..."
Fortune Magazine

"The powerful endorsement of AIC's system by IBM is one of the few the industry giant has given to outside software vendors."
Business Week

"This remarkably rapid acceptance of INTELLECT is warranted by its remarkable capabilities. It represents a genuine breakthrough in the search for a means of communicating with a computer in natural, everyday English . . ."
Data Decisions

What is "artificial intelligence"?

AI is the field of computer science that attempts to simulate human cognitive behavior on computers. AI systems are computer programs that perform tasks usually associated with human intelligent behavior -- understanding language, learning, reasoning, and problem-solving.

What has AIC done with AI research?

AIC has moved well beyond theoretical laboratory research and turned a technical innovation into a powerful business tool. INTELLECT is the first (and, so far, only) practical, commercially successful natural language computer software product.

Although INTELLECT is continually being improved, it is not an experimental system. INTELLECT is a proven product with over 260 copies installed in the mainframe arena over the past three years.

How is using INTELLECT different from the way other software works?

Tasks performed with AI technology are distinct from the pre-programmed, rigid decision rules that we commonly associate with computers. With the technology of artificial intelligence, computers can simulate a less rigid deductive reasoning process. They have the ability to make inferences similar to the way humans do when presented with a group of related and/or unrelated facts.

Types of artificial intelligence

Within the broad category of AI are robotics, speech and image recognition, knowledge-based or expert systems, and natural language processing systems. INTELLECT is a natural language system.

What are the characteristics of a natural language system?

A true natural language system must:

- Understand English the way ordinary people use it, as if they were speaking to another person;
- Understand questions worded in a variety of ways;
- Look for, recognize, and clarify ambiguities and multiple meanings;
- *Not* require the user, the person making the informational request, to know how or where the data is stored in the computer.

INTELLECT contains a dictionary of basic common words in the English language, plus a lexicon of words and phrases identified with a particular application (words and phrases that are important to a specific company or industry), plus grammatical rules of the English language. These features allow the user to "converse" with the computer as though it were another "intelligent" being -- like a person.

What's different about INTELLECT? Aren't many computer programs "user-friendly" or "English-like"?

Yes, but these terms are relative. "English-like" can still mean that complicated key words and other technical knowledge is required to retrieve information. "User-friendly" means simply "easier to learn to use than writing a program from scratch". *Natural language* is what you already know. It's what we speak and write "naturally", without any special computer instructional training. Because INTELLECT "understands" ordinary English requests for information stored by the computer, it lets users converse with the computer in *their* own language -- everyday, non-technical English. Other programs require users to understand the *computer's* language.

How does INTELLECT fit into the information center concept?

The information center has become a place for users at all levels of experience to get information from their computer on their own, on an ad hoc basis. The benefits of this concept are many: the often backlogged data processing department is freed from programming many one-time requests, giving them more time to develop more sophisticated programs and applications; users get the answers they need when they need them; more people can become *efficient* "knowledge workers," transforming isolated bits of data into information that will help them make better decisions and work more productively.

Because a natural language system acts as a translator between the user and the computer, INTELLECT measurably enhances the effectiveness of an information center. If someone has a question, he simply turns to his personal terminal or walks over to a terminal in his company's information center, types in his question as though he were asking a colleague, retrieves the answer in a matter of seconds, and returns to his work supplied with the information he needs.

INTELLECT can be used as a "supervisor" of the information center, driving the database system and functioning as the front-end interface of a decision support system, graphics, and other end-user oriented tools. In this way INTELLECT enables a vastly larger group of people who need information to meet their responsibilities with the most up-to-date computer technology.

How and where is INTELLECT being used?

Applications

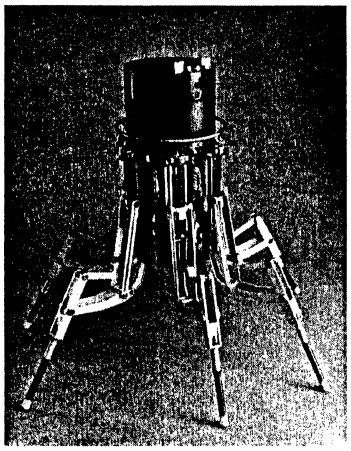
- Financial
- Marketing
- Manufacturing
- Personnel
- Computer utilization

. . . and any other personal information retrieval application

Industries

- Aerospace
- Banking
- Chemical
- Consumer Products
- Financial Services
- Government
- Insurance
- Package Delivery
- Retail
- Utilities

The functionoids in our future.



The word "functionoid" was coined by Odetics. It's the Company's way of differentiating mobile robots like ODEX I — the world's first functionoid — from the single-function, fixed-platform robots used to automate assembly lines. Future functionoids will serve in mobile, multi-tasking applications in a wide variety of industries, performing duties that up until now have either been extremely hazardous or impossible for humans to execute.

Introduced in March 1983, ODEX I is a capabilities model designed to demonstrate a number of significant advancements in electronic and mechanical engineering and computer science.

These advancements are most evidenced by ODEX I's unprecedented strength and agility. That it is the first robot of any kind capable of lifting loads many times its own weight is a revolutionary step forward. In addition, this six-legged walking machine can climb taking steps as high as 33 inches—allowing it to go where conventional wheeled or tracked vehicles can not.

The first functionoid serves as Odetics' base technology in mobile robotics, upon which the Company will add further attributes tailored for particular market requirements.

During FY '84, Odetics pursued marketing leads in several different industries, seeking joint venture licensing agreements where feasible. During the fourth quarter, Odetics signed an agreement with the RCA Government Systems Division to share technology in developing a mobile robotic system that can be applied to such military assignments as sentry duty.

The agreement includes RCA funding for Odetics to further develop its technology in mobile robotic transport capabilities. These capabilities will include system mobility and guidance to allow for the incorporation of RCA payload modules.

RCA will develop sensory packages as appropriate that will enable the robotic system to perform multi-task functions. RCA will also provide expertise in artificial intelligence.

To be marketed to the Department of Defense, RCA has an option to purchase significant numbers of this model, called ODEX II, over the next 10 years.

In addition to this effort, Odetics is continuing to market its mobile robotic technology to several promising commercial industries targeted for the Company by a leading national research firm. Some of these industries include nuclear power, mining, cargo handling and storage, agriculture, forestry, medicine, construction and commercial surveillance.

Odetics' associates continue their "work hard, play hard" ethic.

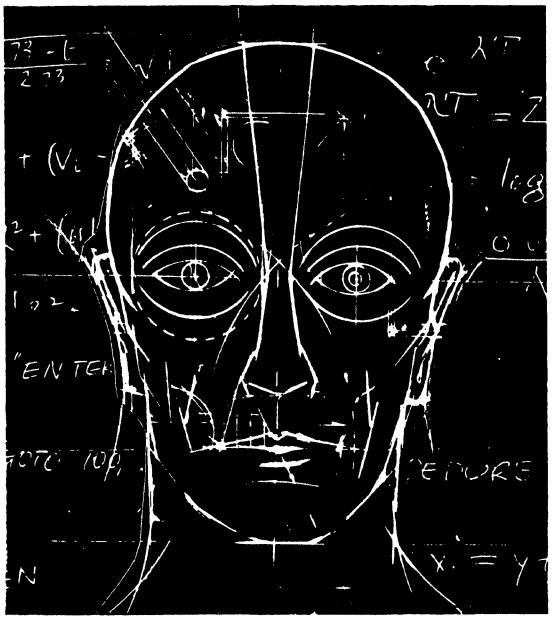
There is a very special environment at Odetics. It was recognized in a book published by Addison-Wesley in May 1984 entitled "The 100 Best Companies to Work for in America."

The authors devoted three pages to us, noting "the company has an enviable record of keeping people. In an industry where job-hopping is a way of life, Odetics has the lowest employee turnover of any electronics firm in California's Orange County, according to The Executive of Orange County magazine. Employees talk of the company as 'the family,' and even recruitment brochures talk of becoming part of 'The Odetics Family'."

The Odetics environment starts with a philosophy that fosters innovation, creativity and dignity. We promote a healthy, "work hard, play hard" ethic and offer one of the finest benefit packages in the industry—a benefit package recognized as one of the most unique in the country. For instance, the "Best Companies" authors wrote "Odetics may be the only corporation in America with its own repertory theater company."

At Odetics, our co-workers are not known as employees. We use the term "associate," which we consider a far more accurate description.

Research has shown that most people spend more of their waking hours at work than they do at home. To make all those hours rewarding ones, we encourage our associates to actively participate in corporate life with ideas and suggestions. In this way, we perform even more productively as a Company and as an investment.



CAMBRIDGE LISP 68000

the symbolic language for 68000 based computers

METACOMCO

LISP
The language of artificial intelligence

LISP (LISt Processing) is a well established computer language, suitable for a wide range of applications in science and engineering. As a symbolic language, it is particularly appropriate for work in artificial intelligence, where it offers a flexibility in the design of data and control structures that is not available from more traditional languages. It is possible, for instance, to create, modify, and execute LISP programs from within another LISP program. LISP has been used with success in robotics, symbolic algebra, natural language interfaces, and for many expert systems. The worldwide commitment to LISP for A.I. research and development confirms LISP as the language of artificial intelligence.

CAMBRIDGE LISP 68000

CAMBRIDGE LISP 68000 is an implementation of LISP for computers based on the Motorola 68000 range of microprocessors. Its performance, low price, and full range of features make it ideal for use in both academic and commercial environments.

In education:

Use CAMBRIDGE LISP 68000 for teaching LISP, and for learning about computer languages in general. CAMBRIDGE LISP 68000 provides a cost effective way of teaching and experimenting with expert systems. CAMBRIDGE LISP 68000 is already being used in a number of computer aided learning systems.

In research and development:

LISP is an ideal language for solving many scientific and engineering problems: symbolic programming offers efficient solutions to many problems that other languages cannot handle. Nuclear physics, geology, and oil platform design are just three of the diverse fields where LISP is being applied. LISP can also be used to create powerful tools for research and development work. For instance, REDUCE 3, a program written in CAMBRIDGE LISP, provides the professional with a desk top algebra calculator, capable of complex evaluations.

For expert systems:

Expert systems no longer have to be developed on an expensive machine, and then rewritten in another language in order to run on a cheaper end user system. Using CAMBRIDGE LISP 68000, expert systems can be developed on the same low cost machines that the end user system will run on. CAMBRIDGE LISP 68000's compiler ensures that the final program is fast and compact.

FEATURES

- ☐ Integral compiler
- ☐ 16 Megabyte address space
- ☐ Rational arithmetic
- ☐ Clear and concise error messages
- ☐ Catch, throw, and errorset
- ☐ Trigonometrical functions
- ☐ Large number of built in functions
- ☐ Full garbage collection
- ☐ Integers of any size
- ☐ Vectors
- ☐ Floating point arithmetic
- ☐ Compiled and interpreted functions can be used interchangeably
- ☐ Full tracing available in interpreted and compiled code
- ☐ Core image may be dumped
- ☐ Structure editor
- ☐ Load on call facility
- ☐ Shallow binding
- ☐ Complete automatic space allocation with no hard boundaries

See 'CAMBRIDGE LISP 68000: TECHNICAL NOTES' for further information.

CAMBRIDGE LISP 68000 *offers a complete development environment*

CAMBRIDGE LISP 68000 provides a complete LISP development environment on a microcomputer. Source code can be entered using the full screen editor, EDIT-68K. Using LISP's interpretive mode, together with the trace package, the programmer can quickly and efficiently develop and debug programs. CAMBRIDGE LISP 68000 helps program development by checking for exceptional cases, and providing clear diagnostics. Once developed, the program can be compiled, for significant improvements in speed, and to reduce the storage required. The control structure of LISP, which includes recursion and function composition, allows the programmer to use a 'top down' approach to break complex functions into simpler units. This approach is quick, and produces code that is easy to read and enhance.

CAMBRIDGE LISP 68000 *offers unbeatable price/performance*

CAMBRIDGE LISP 68000 allows every LISP programmer to have their own LISP workstation for the price of a microcomputer. Yet CAMBRIDGE LISP 68000 has the power of a mainframe LISP, limited only by the available memory, and running at speeds comparable with other LISP dialects on much larger machines. Neither does the workstation need to be dedicated to LISP: the choice of operating systems leaves the user free to run other languages and applications.

CAMBRIDGE LISP 68000 *has an impeccable pedigree*

LISP exists in many dialects of which there are four major groups centred around INTERLISP, MACLISP, STANDARD LISP and COMMON LISP. CAMBRIDGE LISP 68000 is a member of the STANDARD LISP family, and is very similar to PSL (PORTABLE STANDARD LISP).

CAMBRIDGE LISP was originally developed at the University of Cambridge in England on IBM 370 mainframe computers and represents the outcome of many years of development. The 68000 implementation is a full implementation of this mainframe system by Professor John Fitch and Dr Arthur Norman. Metacomco's close ties with the academic world will ensure that future releases of CAMBRIDGE LISP 68000 will continue to reflect the latest developments in LISP, and the emerging standards for this important language.

SOFTWARE TOOLS FOR THE CAMBRIDGE LISP ENVIRONMENT

REDUCE 3 *algebraic processor*

REDUCE 3 is an extremely powerful mathematics programming system for processing algebraic expressions. It can handle expressions of high complexity, and includes a comprehensive range of algebraic functions. For instance, it can integrate, differentiate, factorise, and perform matrix calculations. REDUCE 3 can be used either interactively, or in batch mode. Interactively, the user can simplify expressions, and use the program as a sophisticated algebraic calculator; in batch mode, the program can be left to calculate a complex sequence of evaluations.

REDUCE 3 has numerous applications to scientific and engineering problems; its set of Dirac matrix calculations are of special interest to high energy physicists.

REDUCE 3 is implemented in CAMBRIDGE LISP 68000, which must be present in order for REDUCE 3 to run.

EDIT-68K *Full screen editor for CP/M-68K*

EDIT-68K is a versatile full screen editor for use on computers running the CP/M-68K operating system. Its comprehensive range of commands make it ideal for editing any ASCII file, including program sources and data files. Features include screen scrolling, block move, file merging, and a set of Find and Replace commands. Use EDIT-68K for all development work, whether editing text, assembler, or high level languages.

This popular editor is available to all users of CP/M-68K either on its own, or else bundled with CAMBRIDGE LISP 68000.

Systems Requirements

CAMBRIDGE LISP, REDUCE, and EDIT-68K are available on most computers running the CP/M-68K operating system. LISP requires at least 512K bytes of main memory. CAMBRIDGE LISP 68000 must be present in order for REDUCE 3 to run: a system with both LISP and REDUCE should have at least 1M byte of main memory. EDIT-68K can be used on any CP/M-68K system with a minimum of 128K of RAM.

CAMBRIDGE LISP, REDUCE, and EDIT-68K are also available on certain 68000 based machines under the TRIPOS operating system. TRIPOS is a single user, multi-tasking operating system which provides a user friendly development environment with sophisticated features such as hierarchical file handling, concurrent working, and a full range of utilities. For more information about TRIPOS, please contact METACOMCO directly.

METACOMCO is a systems software house specialising in languages and utilities for computers based on the Motorola 68000 microprocessor. Its products include LISP, Fortran, Pascal, BCPL, editors and other utilities. These are offered for use in standard operating environments such as CP/M-68K or TRIPOS; alternatively, METACOMCO can adapt them to proprietary operating systems.

As well as providing these software products, METACOMCO offers its extensive expertise in the 68000 architecture to developers and manufacturers of 68000 based computers. It performs consultancy and implementation work for many leading manufacturers: recent customers have included Digital Research, CompuPro, Inmos, Siemens, ICL and Sinclair Research. Operating systems and utilities can be ported to new machines, development environments created, or entire languages implemented.

METACOMCO has offices in both the USA and the UK to support its customers worldwide. Its research and development work is carried out in Bristol, UK, where it has close links with several British universities. The quality of its software products is winning a growing reputation in both the academic and the commercial worlds; CAMBRIDGE LISP in particular is setting new standards for low cost artificial intelligence systems.

For further information contact your dealer, or:

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Tenchstar Inc
201 Hoffman Avenue
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TEXAS INSTRUMENTS

TEXAS INSTRUMENTS INTRODUCES ENHANCED VERSION
OF EXPERT SYSTEM DEVELOPMENT PACKAGE

LOS ANGELES (August 18, 1985) -- A second generation of TI's expert system development tools, Personal Consultant™ Plus software, will provide an array of new capabilities to application developers, Texas Instruments announced today. With its powerful extended knowledge representation features, increased rule capacity and an enhanced user interface, Personal Consultant Plus will enable developers to solve larger, more difficult problems without leaving the affordable environment of personal computers.

"Customer reaction to the original Personal Consultant has been very positive since we announced the product last summer. Working with our customer base throughout the year, we paid close attention to the market and its demands, incorporating new features into our expert system tool kit as industry feedback indicated," said Carroll Hall, manager for AI applications in TI's Data Systems Group.

Both Personal Consultant packages approach problem-solving with many of the same reasoning techniques used by human experts. Heuristics, or "rules of thumb" that work with ambiguous or uncertain information, set expert systems apart from conventional software packages that generally handle numeric processing. Designed to be knowledge-base compatible with TI's expert system development tools, Personal Consultant Plus improves on the rule-based, goal-driven problem solving techniques that made Personal Consultant popular. Both systems assist the end-user by explaining their reasoning in English sentences.

Personal Consultant Plus incorporates extended knowledge representation capabilities such as frames, procedural functions, access methods and meta rules in addition to the already powerful capabilities found in the existing Personal Consultant product.

Personal Consultant Plus provides a problem-structuring technique called "frames." The frames feature allows a complex problem to be divided into smaller, related sub-problems. Each frame has associated slots, or variables, called "parameters" which hold data about the frame. A frame also contains "rules" which can be used to determine the results for sub-problems.

"Procedures" are a way of accessing pre-defined calculations and incorporating them into the application. A full LISP programming environment is provided to the developer for the definition of customer procedures. These procedures are compiled for efficiency and become part of the application. An external program interface is also provided so that other programs, such as a data base manager, can be accessed during a consultation.

"Access methods" provide a way of attaching procedures to be performed when a particular frame parameter is accessed. An access method can provide a means of determining the value of a parameter such as reading from a disk file. An access method can also provide a way to specify actions that should be taken whenever a new value is determined for a parameter, such as updating a display.

"Meta-rules" (or rules about rules) allow the system to contain knowledge about how best to solve the problem. Meta-rules can help focus and control a consultation by specifying which rules are most important in a particular situation.

A graphics interface is provided to allow graphical information to be included in an expert system application. A "Snap Shot" capability can be used to capture graphics, such as a schematic diagram, created by any

separate graphics package. This picture image can then be displayed by Personal Consultant Plus at the appropriate time during a consultation.

A compiled version of the LISP language allows the new package to execute faster and work with more information. This increased capacity will allow Personal Consultant Plus to develop and deliver applications of up to 2,000 knowledge base elements. (Rules, variables and frames are all knowledge base elements.) The increased processing speed results in faster response times.

The development of applications using Personal Consultant Plus has been simplified and streamlined. Using an interactive dialogue, the developer is prompted only for essential information with many default values selected by the system. The rule specification language (which is very similar to Basic) has been expanded to provide direct access to more of the system's features. A full screen editor is available for making modifications to any information field.

The user interface to Personal Consultant Plus has been upgraded to make it even easier to use. Pop-up windows have been employed to display menu items and help information in a consistent manner. Certainty factors, which indicate a degree of confidence in a response, are entered using a natural graphic representation.

The Personal Consultant Plus package is both TI- and IBM- compatible, and has a TI suggested list price of $2,950. The original Personal Consultant expert system development tool package has been reduced in price to $950. Personal Consultant users can apply the $950 cost of the original package toward the purchase of the Plus version should they need the additional power and functionality. Upon purchasing the newer package, if the developer shows proof of purchase of the original Personal Consultant, the new version will be discounted by $950.

"This will encourage developers to purchase Personal Consultant now for quick prototyping of applications that later can be expanded with Personal

Consultant Plus -- with no loss of the initial investment," Hall said. This credit allowance is consistent with TI's strategy of improving its products while remaining committed to preserving the investments of its established user base.

Both packages require a minimum of 512K bytes of random access memory. Personal Consultant is available now and Personal Consultant Plus will be available in fourth quarter 1985 through TI's value added resellers, authorized distributors and national accounts. In addition, the packages can be purchased directly from TI by calling (512) 250-7357.

The Data Systems Group of Texas Instruments Incorporated today stands at the leading edge of commercializing applications for artificial intelligence. DSG's growth over the last 15 years has been fueled by the same technologies that contributed to the corporation's current position as the 63rd largest U.S. employer. Among the more than 4,000 Texas Instruments patents are the development of the silicon transistor and the invention of the integrated circuit, the microprocessor and the hand-held calculator.

TEXAS INSTRUMENTS

TI ANNOUNCES NEW CLASS OF "PERSONAL EFFECTIVENESS" SOFTWARE
WITH DECISION ANALYSIS PACKAGE FOR PERSONAL COMPUTERS

ANAHEIM, CALIFORNIA (March 24, 1985) -- A new concept in applying personal computers to decision making was displayed today by Texas Instruments in a new application software product entitled Arborist™. Arborist decision tree software, derived from a combination of operations research and artificial intelligence (AI) technologies, broadens the range of problems that personal computers can address.

"Arborist is on the leading-edge of a new class of 'personal effectiveness' software that concerns itself with helping managers and professionals face complex decision and analysis problems," said Carroll Hall, manager of the AI Applications Department in TI's Data Systems Group. Arborist can improve a managers effectiveness by allowing him to look closely at the elements of a decision, analyze different decision paths and make well thought-out and graphically documented decisions."

"In the past word processing or spreadsheet programs significantly improved the efficiency of writing and calculating tasks, however, further benefits from personal computers will have to comprehend the less structured aspects of a professionals job." said Hall. Problems addressed by "personal effectiveness software" could be in the areas of capital budgeting (capital acquisition), marketing (pricing policies), law (litigate versus settle), purchasing (lease vs purchase) and exploration (drill vs test) to name a few examples.

Applications such as Arborist have more impact on effectiveness or the quality of decisions in contrast to efficiency or the quantity of work performed. Since the selection of the proper tasks is more significant than how fast the task can be executed, many professionals will find personal effectiveness software to be even more important than the efficiency oriented software that justified their initial use of personal computers.

The symbolic processing technologies permitting the implementation of this more sophisticated problem solving software is only now becoming available with the convergence of artificial intelligence research and increased capacity personal computers.

The name, Arborist, is derived from the decision tree technique the software employs. It allows managers and professionals to build a model of complex decision processes. The graphical capabilities of the software facilitate the analysis and presentation of the decision model. Arborist software can add a quantitative element to decision making without requiring the user to do the calculations.

The decision tree technique is a way to represent a problem as a tree structure -- with decision branches leading to different chance outcomes, or to more branches representing subsequent alternatives. This technique allows a decision maker to structure the problem, represent it graphically, and identify the best set of alternatives.

The decision tree approach to problem analysis has been an important part of the curriculum in many colleges of business, industrial engineering, and public policy since the 1960's. However, use of this technique has been limited in the past due to the time-consuming and frustrating nature of performing it manually or setting it up to run on a mainframe. Arborist eliminates much of the labor and tedium previously associated with building and analyzing decision trees.

The Arborist software lets the user concentrate on the content of the

problem while it captures the information and represents it graphically. The user is free to change, refine and adapt the structure of the tree to changing conditions without having to go back to the beginning. Based on the values and probabilities assigned by the user, Arborist determines the expected value at each decision point and for each outcome.

Traditionally, decision trees have been used to help in areas as diverse as capital budgeting, marketing, oil exploration, legal, and medical decision making. They have been primarily used on very large problems which justify corresponding large computer and human resources or on very small problems which can be done with a pencil and paper. According to Hall, "Because Arborist runs on personal computers and employs an easy-to-use interface, it allows the decision tree technique to be used on the majority of problems which fall between the immensely complex and the very simple."

The high resolution display of today's personal computer is essential to the implementation of Arborist. A series of prompts, messages, and automatically constructed charts speed learning and running the problem. Graphical representations of the tree and of the results of various analyses provide easily understood and valuable information to the user.

The Arborist software uses windowing techniques to divide work areas on the screen. A Macro display gives the user an overview of the entire decision tree structure. A Micro display, or "focus window", shows a detailed look at one area of the tree. Both windows are synchronized so that the user always knows where he is in the tree. Navigation within the tree is accomplished with the cursor control keys.

A menu is always available which lists the possible functions such as displaying information, creating graphs, or editing data. Extensive help messages also appear on request in the macro window. Along the bottom of the screen, a one-line message window displays prompts, status, error explanations, and function descriptions.

Once the representation of the tree is finished, other types of information can be computed. For example, probability distribution decision outcomes permit the user to see the distribution of outcomes for a particular alternative. A distribution of outcomes provides the user with a way of measuring the risk involved in each alternative path. The user may also request a sensitivity analysis which can help locate the critical values that will significantly change the optimal decision path. Sensitivity analysis is a generalization of the "what if" capability found in many financial modeling packages.

Arborist will be available on the Texas Instruments Professional Computer family beginning in March, 1985, at a suggested retail price of $595. The minimum hardware configuration must include 512 kilobytes of internal memory, a single diskette drive, and three-plane graphics capability. Availability for the IBM™ Personal Computer and MS™-DOS compatible computers will follow in early May, 1985.

Arborist will be marketed directly by TI as a stand-alone product through direct mail, end-user seminars, and TI's education marketing organization. Distribution initially will be through TI-Express, TI's rapid response direct mail telemarketing system which sells software and accessories (1-800-TI-PARTS). The product will also be available through TI national account sales, value added resellers, and authorized distributors and dealers.

EDITOR'S NOTE:
PRICING AND AVAILABILITY OF PRODUCTS AND PROGRAMS VALID ONLY IN THE U.S.

Please refer all reader inquiries to:

Texas Instruments Incorporated
Data Systems Group
P.O. Box 809063
Dallas, TX 75380-9063
1-800-527-3500

TEXAS INSTRUMENTS

TEXAS INSTRUMENTS DEMONSTRATES "NATURAL LANGUAGE" INTERFACE ON TI PROFESSIONAL COMPUTER

NEW YORK, NEW YORK (January 31, 1983) -- Texas Instruments today demonstrated an advanced general purpose "natural language" interface on its TI Professional Computer. The natural language interface leads users to information by helping them ask the computer questions using common English words and phrases. This feature provides the TI Professional Computer with a level of "ease of use" previously available only on large mainframe computers in specialized artificial intelligence (AI) labs.

The natural language interface concept has been developed from extensive research in AI. "TI has long been recognized as a major contributor to AI research by the technical community. Natural language interfaces will be the first commercial products to result from this research," said Eric Jones, President of TI's Data Systems Group.

The TI natural language interface is designed to allow the user to easily construct a valid English language query or command that the computer understands. The video display screen is divided into several windows, each offering a set of words or phrases from which the user selects. The items that are selected from each window appear at the bottom of the screen composing a plain English sentence that describes the functions to be performed.

The interface actually leads the user through the sentence building process. By evaluating and giving a positive response to each of the user's choices, it eliminates the risk of asking questions that cannot be answered. Spelling errors are virtually eliminated because the user is not required to type selections using the keyboard.

If a user does not know exactly what question to ask, the interface can prompt the person through all of the available steps and determine what is permissable to ask, given the selections that have already been made. If it becomes evident that the selections made are not going to produce the desired result, the user can erase prior selections and backtrack.

A natural language interface to the Dow Jones News Retrieval™ data base, for example, would allow users to build an English-like sentence instructing the TI Professional Computer to display a particular company's closing stock prices for the past ten trading days.

While the interface was demonstrated using the English language, it is designed in such a way that this capability can be extended to foreign languages such as French and German.

Products using the natural language interface are scheduled to be introduced later this year. The interface will be supplied on disks as a general tool that can be customized to meet the specific needs of users.

LMI NAMES 18-YEAR DEC VETERAN
MACKENZIE TO CEO/CHAIRMAN POST

Los Angeles, CA.....LISP Machine Inc. (LMI) is pleased to announce the appointment of Ward D. MacKenzie, former Group Vice President of the OEM and Business Computer Groups at Digital Equipment Corporation, to the post of Chairman of the Board and Chief Executive Officer. F. Stephen Wyle, co-founder of LMI and former Chairman and CEO, has been named Vice-Chairman and Founder. Mr. Wyle will assume various entrepreneurial roles within the company, including the continuing oversight of the Process Systems and Aerospace divisions of LMI, the company's vertical market thrusts. Dr. Frank Spitznogle, President and Chief Operating Officer, will remain in that capacity. LISP Machine Inc. develops and manufactures LISP-based hardware and software for artificial intelligence research and applications of this technology in business, industry and government.

In a related development, several of the company's current investors have committed to an additional $8 million equity financing. This brings the

The LMI Lambda 3x3, from LISP Machine Inc., lowers the per-user cost of full-feature LISP Machines to $45,000 (list price — domestic); less than many less powerful entry-level LISP workstations. The Lambda 3x3 features three high-performance, tagged-architecture LISP processors, which operate in parallel on the Lambda's high-speed multi-processing bus.

total investment in the company to more than $25 million from major venture capital firms including Citicorp Venture Capital, Genesis Capital Corporation, Montgomery Securities, New Enterprise Associates and others.

"LISP-based computing is a proven technology that is already providing cost-effective solutions in a variety of real-world applications," says Mr. Wyle, "and as a result the LISP Machine market is rapidly evolving. Ward's 18 years of experience at DEC have equipped him with a thorough understanding of the needs of such a market, and as our new Chairman and CEO, he brings to LMI the sophisticated management know-how that will enable LMI to meet the challenges of this changing market." Adds Mr. Wyle, "Ward's appointment will allow me to concentrate on long-range business strategies as well as the entrepreneurial opportunities offered by the application of LMI's technology in specific industry areas."

"I'm very pleased to have been chosen for this position," says Mr. MacKenzie. "LISP Machine Inc., with its thoroughly real-world approach to artificial intelligence, represents the leading edge of a technology that will dramatically change the face of computing in the next decade, and this is an exciting opportunity to participate in that transformation." Ward MacKenzie joins LMI after 18 years at Digital Equipment Corporation, most recently as Group Vice-President of the OEM and Business Computer Groups, which account for a significant portion of DEC's sales. In this capacity, Ward was responsible for managing the company's OEM businesses and its thrust into the small business market, as well as the company's Microcomputer Group. Previous to his appointment as Vice-President in 1981, Mr. MacKenzie served in a variety of positions within DEC, including Group Manager for the U.S.

Technical OEM Group, European Manufacturing Manager, with responsibility for the company's plants in Ireland, Scotland, Germany, and others. Mr. MacKenzie holds an MBA from the Amos Tuck School of Business Administration at Dartmouth College.

LISP Machine Inc. (LMI) is a leading developer and manufacturer of LISP Machines and associated software -- the primary tools of artificial intelligence (AI) research and the commercial applications of this technology. LMI's LISP Machines are used worldwide to advance the science of AI and to bring its advantages to the commercial marketplace. In addition to the company's rapidly growing family of uniquely versatile LISP Machines, LMI is actively developing applications software to bring the power of AI techniques to specific, broadly-based industries. The company's customers are for the most part in the Fortune 500-plus, including Rockwell, Grumman, Gould, General Dynamics, Johnson Controls, M.C.C., Westinghouse, Mitsubishi, N.T.T., Toshiba, Texaco, Exxon and numerous others. The company has grown 25-fold over the past two years; it is privately held by a number of major U.S and European venture capital firms. LISP Machine Inc. takes its name from LISP (LIStProcessing language), a symbolic programming language that has become the language of choice in many AI laboratories.

Note to local editors: Ward MacKenzie lives in Bolton, Massachusetts with his wife and three sons. In addition to his MBS, he holds a BS in Physics from the Worcester Polytechnic Institute.

NEW USER-FRIENDLY PROGRAMMING
AID DOES WINDOWS AUTOMATICALLY

Los Angeles, CA.....WindowMaker™, a unique new programming tool from LISP Machine Inc. (LMI), automatically generates LISP code for on-screen windowing, simplifying the task of creating a user-friendly interface for LISP-based applications software and greatly enhancing programming productivity. "With WindowMaker, even a novice programmer can generate complex combinations of windows for an application," says Kenneth M. Johnson, LMI Vice President of Marketing and Sales. "This leaves more time for the really creative aspects of programming by eliminating the drudgery of writing complicated window system code." WindowMaker will be included in all future releases of LMI's System 2.0 ZETALISP-PLUS software as of May, 1985, and all present users of LMI Lambda LISP Machines will receive WindowMaker without charge.

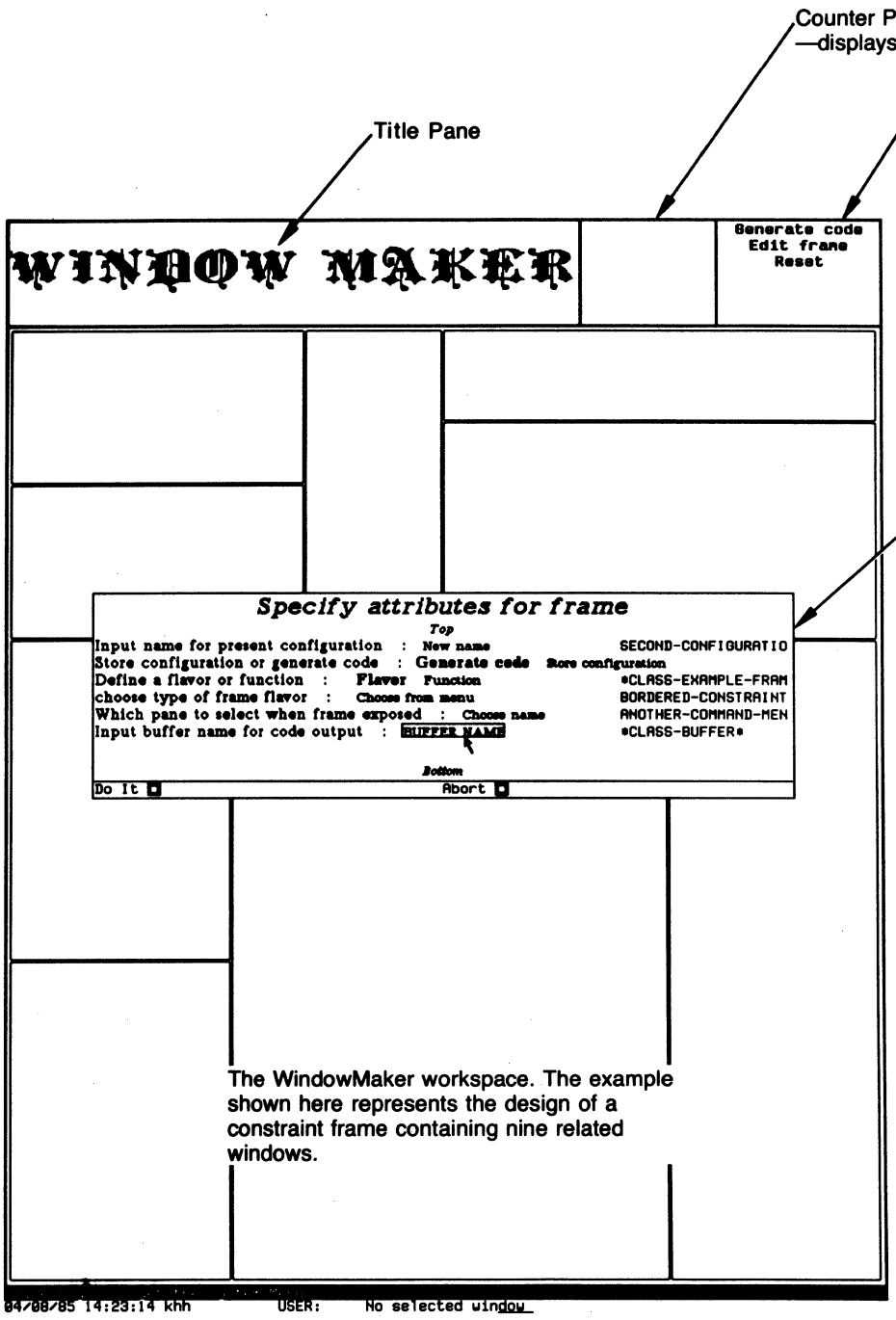
In the LISP environment, windows are an extremely powerful way of organizing system resources and making them available to the user in a simple, intuitive manner. In the LMI Lambda LISP Machines, the LMI Window System forms the

basis of much of the system's power and productivity. However, the code required to generate a related group of windows (called a constraint frame) is rather arcane and difficult to write, even for experienced LISP programmers.

With WindowMaker, even a novice programmer can create constraint-frame code in a matter of minutes. Prompted by a series of pop-up menus, the user designs as complex a set of windows as desired using only the mouse, and then WindowMaker automatically generates the related code for insertion into the program. WindowMaker is a robust, stand-alone tool. No additional overhead is added to the system at runtime, and efficiency is not compromised, since WindowMaker generates code just as a programmer might, legibly and in standard LISP format. The novice user can study the code to learn about constraint frames, while the sophisticated user might add advanced features by hand.

LISP Machine Inc. was formed in 1980 to develop and manufacture LISP-based computers and software for use in artificial intelligence research and applications. Its computers are used worldwide to advance the science of artificial intelligence and to bring the benefits of this advanced technology to the commercial marketplace. LISP Machine Inc. derives its name from LISP, a versatile and powerful symbolic programming language that has become the language of choice in many AI laboratories, as well as gaining recognition in the commercial marketplace as a highly productive programming environment.

For further information, contact Janice McGlashan at LISP Machine Inc., 6033 West Century Boulevard, Los Angeles, CA 90045. Phone: (213) 642-1116.



WindowMaker,™ a powerful new programming tool from LISP Machine Inc., automatically generates LISP code for complex window systems, greatly enhancing programmer productivity by simplifying the task of designing user-friendly interfaces for expert systems and other AI programs.

Where to Write for More Information

Where to Write for More Information

Advanced Information & Decision Systems — 201 San Antonio Circle, Suite 286, Mt. View, CA 94049. Military applications.

Applied Expert Systems — 5 Cambridge Center, Cambridge, MA 02142. Financial expert systems.

Artificial Intelligence Corporation — 200 Fifth Avenue, Waltham, MA 02254. Natural language interfaces.

Bolt, Beranek and Newman Inc. — 10 Moulton Street, Cambridge, MA 02238. AI systems development.

California Intelligence — 912 Powell Street, Suite 8, San Francisco, CA 94108. Microcomputer AI systems.

Carnegie Group — 4616 Henry Street, Pittsburgh, PA 15213. Knowledge-based financial applications.

Cognex Corporation — 72 River Park Street, Needham, MA 02194. Visual recognition systems.

Cognitive Systems Inc. — 234 Church Street, New Haven, CT 06510. Natural language interfaces and knowledge-based financial systems.

Digital Equipment Corporation — 200 Baker Avenue, Concord, MA 01742. AI workstations and AI software systems.

ExperTelligence — 559 San Ysidro Road, Santa Barbara, CA 93108. Expert systems.

Franz Inc. — 6321 Thornhill Drive, Oakland, CA 94611. Microcomputer-based LISP.

Frey Associates, Inc. — Chestnut Hill Road, Amherst, NH 03031. Natural language interfaces.

Gold Hill Computers, Inc. — 163 Harvard Street, Cambridge, MA 02139. AI LISP software for microcomputers.

Harmon Associates — 3752 Sixteenth Street, San Francisco, CA 94114. Microcomputer-based expert systems and consulting.

Human Edge Software — 2445 Faber Place, Palo Alto, CA 94303. Business strategy software and expert systems.

IBM — AI Group, Palo Alto Center, 1530 Page Mill Road, Palo Alto, CA. AI R&D.

Iconics — 8592 East Via de Ventura, Scottsdale, AZ 85258. Automatic AI programming and expert systems.

Inference Corporation — 5300 W. Century Boulevard, Los Angeles, CA 90045. Knowledge-based products.

IntelliCorp — 707 Laurel Street, Menlo Park, CA 94025. Knowledge-based application systems.

Jeffrey Perrone & Associates — 3685 17th Street, San Francisco, CA 94114. Expert system microcomputer products, seminars, and consultation.

Kestrel Institute — 1801 Page Mill Road, Palo Alto, CA. Natural language systems.

Kurzweil Applied Intelligence — 411 Waverly Oaks Road, Waltham, MA 02154. Voice recognition products, Talkwriter, musical synthesizers.

LISP Machine, Inc. — 6033 West Century Boulevard, Los Angeles, CA 90045. AI workstations.

Microelectronics and Computer Technology Corporation — 9430 Research Boulevard, Echelon Building #1, Suite 200, Austin, TX 78759. AI thinktank.

Mitchell Associates — P.O. Box 6189, San Rafael, CA 94903. LISP, PROLOG and expert system applications.

Odetics, Inc. — 1515 South Manchester Avenue, Anaheim, CA 92802. Functionoids (Robots).

PERQ Systems Corporation — 2600 Liberty Avenue, P.O. Box 2600, Pittsburgh, PA 15230. AI workstations.

Radian Corporation — P.O. Box 9948, Austin, TX 78766. Expert systems.

Software Architecture & Engineering, Inc. — 1500 Wilson Boulevard, Suite 800, Arlington, VA 22209. Expert system development applications.

Speech Systems — 18356 Oxnard Street, Tarzana, CA 91356. Typewriter that takes dictation.

Symantec — 10201 Torre Avenue, Cupertino, CA 95014. Microcomputer-based natural language interfaces.

Symbolics, Inc. — 11 Cambridge Center, Cambridge, MA 02142. AI workstations.

Syntelligence — 1000 Hamlin Court, P.O. Box 62259, Synnyvale, CA 94088. Knowledge-based financial applications for the banking and insurance communities.

Teknowledge, Inc. — 525 University Avenue, Palo Alto, CA 94301. Knowledge-based products for AI workstations and microcomputer applications.

Texas Instruments — P.O. Box 809603, Dallas, TX 75380. AI workstations, AI microcomputers, and AI software systems.

The Artificial Intelligence Report — 3600 West Bayshore Road, Palo Alto, CA 94303. Newsletter.

Verac Inc. — P.O. Box 26669, San Diego, CA 92126. AI expert systems development.

Vision Systems International — 3 Miltron Drive, Yardley, PA 19607.

Xerox Corp. — Palo Alto Research Center, 3333 Coyote Hill Road, Palo Alto, CA 94304. AI workstations and AI software systems.