Canadian Artificial Intelligence

Intelligence Artificielle au Canada

October/octobre 1988 **No. 17**

An official publication of CSCSI, the Canadian Society for Computational Studies of Intelligence
Une publication officielle de la SCEIO, la Société canadienne pour l'étude de l'intelligence par ordinateur

AI and Canada's Participation in Space Station
Connie Bryson
L'IA et la participation canadienne à la station orbitale

Neural Networks: An Engineer's Perspective
Casimir Klimasauskas
Les réseaux neuronaux: le point de vux d'un ingénieur

Research in the Knowledge Sciences at the University of Calgary
Ian Witten and Brian Gaines
Recherche en sciences de la connaissance à l'Université de Calgary

AI Research and Development at CompEngServ, of the CEMTECH Group Ltd.
Archie Bowen
Recherche et développement en IA à CompEngServ, du Groupe CEMTECH Ltée.

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Canadian Society for Computational Studies of Intelligence

Founded 1973

CSCSI is the Canadian society for the promotion of interest and activity in artificial intelligence. It conducts workshops and fully refereed national conferences, publishes this magazine, sponsors the journal *Computational Intelligence*, and coordinates activities with related societies, government, and industry. To join CSCSI, use the membership form in this issue. Non-Canadian members are welcomed. CSCSI is affiliated with the Canadian Information Processing Society and International Joint Conferences on Artificial Intelligence, Inc.

Memberships in CSCSI:
Membership form is on the last page. Please send subscriptions, memberships, and changes of address to:

CSCSI, c/o CIPS, 243 College Street, 5th floor
Toronto, Ontario, CANADA M5T 2Y1

Société canadienne pour l'étude de l'intelligence par ordinateur

Fondée 1973

SCEIO est la Société canadienne encourageant l'intérêt et la recherche en Intelligence Artificielle. Elle organise des ateliers ainsi que des conférences nationales avec évaluation des articles soumis. Elle publie ce magazine, subventionne le journal *Intelligence Informatique*, et coordonne toute interaction avec des sociétés parallèles, le gouvernement, et l'industrie. Pour devenir membre de la SCEIO, veuillez utiliser le formulaire d'inscription de ce numéro. Les non-canadiens sont bienvenus. La SCEIO est affiliée à l'Association canadienne informatique, et aux International Joint Conferences on Artificial Intelligence, Inc.

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Canadian Artificial Intelligence

Intelligence Artificielle au Canada

Founded in 1974 as / Fondée en 1974 en tant que *CSCSI/SCEIO Newsletter*

Submissions:
Canadian Artificial Intelligence is published quarterly by CSCSI/SCEIO and is a benefit of membership in the society. *Canadian AI* solicits contributions in English or French on any matter related to artificial intelligence, including: articles of general interest; descriptions of current research and courses; reports of recent conferences and workshops; announcements of forthcoming activities; calls for papers; book reviews and books for review; announcements of new AI companies and products; opinions, counterpoints, polemic, controversy; abstracts of recent publications, theses, and technical reports; humour, cartoons, artwork; advertisements (rates upon request); anything else concerned with AI. Paper or electronic submissions are welcome. Electronic submissions are preferred and should be unformatted. *Canadian AI* is published in January, April, July, and October. Material for publication is due six weeks before the start of the month of publication.

Advertising:
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Please send submissions to / Prière d'envoyer contributions à:
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ou à / or to: Marlene Jones
Canadian Artificial Intelligence
Alberta Research Council
6815 8th Street NE, 3rd floor
Calgary, Alberta, CANADA T2E 7H7

Contributions:
L'*Intelligence artificielle au Canada* est publiée trimestriellement par la CSCSI/SCEIO, et est offerte gratuitement aux membres. L'*IA au Canada* encourage les contributions, en français ou en anglais, portant sur l'intelligence artificielle. Ceci comprend: des articles d'intérêt général; des descriptions de recherche courante et de cours; des rapports de conférences récentes et d'ateliers; l'annonce d'activités à venir, et des requêtes d'articles; des critiques de livres ainsi que des livres à critiquer; l'annonce de nouvelles compagnies en IA et de leurs produits; des opinions, des répliques, tout ce qui est polémique; des résumés de publication récentes, de thèses et de rapports; des trucs humoristiques ou artistiques, de bandes dessinées; des annonces (s'enquérir des frais); tout autre matériel touchant à l'IA. Contributions, sur papier ou par courrier électronique, sont bienvenues. Nous préférons le courrier électronique mais les submissions ne devraient pas avoir un format. L'*IA au Canada* apparait en janvier, en avril, en juillet, et en octobre. Toute communication à publier doit nous parvenir au moins six semaines avant le début du mois de parution.

Réclame:
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CDNnet: gh@ai.toronto.cdn
CSNET: gh@ai.toronto.edu
UUCP: gh@utai.uucp
ou à / or to: Graeme Hirst, *Canadian Artificial Intelligence*
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Executive Notes

Talking About AI

In the July issue of *Canadian AI,* Bill Havens wrote an editorial urging collaboration between researchers and would-be users of AI "technology". He emphasized the importance of including work on industrial applications where possible; a view which I strongly support. He also referred to the current downturn in the financial position of most AI suppliers, and noted that we are at a transition point for our discipline and perhaps for CSCSI as well.

Industry, at least the Fortune 100, jumped onto the AI bandwagon in the early 1980's and there has been a change in CSCSI membership since then. Thanks particularly to Nick Cercone and Gord McCalla's initiative in investigating and reporting what was happening in AI across the country, and thanks also to the metamorphosis through which Graeme Hirst turned this magazine into a really useful publication, CSCSI membership has diversified enormously. We have grown from being a small group of university members, mainly professors and graduate students, to the broader-based composition shown here:

CSCSI membership, June 1988

	Regular	Student
University or College	127	91
Industry	219	5
Government	21	—
Unknown	195	55

The field has always been full of optimism and huge expectations, often that is what drives the research, but when industry got involved some of these hopes and dreams were converted into deliverable items and milestones in project schedules. In many cases these milestones should not have been set and they have not been achieved. This produces an atmosphere of disillusionment, and there is now a strong danger that areas of contact being established between universities and industries will shrink instead of grow.

If we don't want that to happen then we must all do a better job of communication. Most people haven't a clue what AI is all about, including many computer professionals. We need to describe much more clearly what the programs that we build can and cannot do. McCarthy's comments on standards for AI research (*AI Magazine,* Fall 1984) are well worth reading. The research problems that we work on do not need ambiguity and grandiose jargon for justification. They are difficult computational problems, and describing them better would help other people understand what is being achieved and what is being attempted.

On the applications side, much clearer problem statements are necessary to differentiate between what is essential in a problem solution and what is merely desirable. Just wanting some of the magic elixir of "intelligence" to overcome apparent difficulties in conventional computing isn't enough. Nobody expects an inventory program to be adaptive and plan its own evolution. Yet everyone seems to expect an expert system for diagnosis or configuration to update itself, explain how it is doing this, and generally behave in other startling ways! Just being able to build the system in the first place is a major step forward, and we should strive to make people understand why.

Sometimes problems and solutions are described at levels of abstraction which are too high to allow a good understanding. Why is recognizing objects by computer so difficult? Isn't it just a matter of transforming to a standard view and picking the best match? Yes, just like playing the clarinet is easy because all you have to do is blow in one end and run your fingers up and down the holes at the right time!

We must make every effort to get to grips with explanations of real requirements, real difficulties, real achievements, and then perhaps we can make progress on real problems when they are attempted. This will help CSCSI members with different backgrounds understand each other better, will help industrial strength AI flourish, and ensure that our research programs are better understood and supported.

Dick Peacocke
President

Changes in Staff

Effective September 1, 1988, I will no longer be co-editor of *Canadian Artificial Intelligence.* I am leaving the magazine to pursue a Ph.D. at the University of Toronto, a task which will no doubt be equally challenging. Roy Masrani, also of the Alberta Research Council, will be assuming the job of co-editor. Despite the hard work, I have truly enjoyed my year working on the magazine. Thanks again to all the members of the ARC staff, and to our translators, who could always be counted on when deadlines were tight.

On a similar note, Randy Goebel, who has been the treasurer since 1986, is stepping down from this position. In his place, we welcome Jan Mulder of Dalhousie University. I think I can speak on behalf of the society in thanking Randy for the long hours he spent deciphering records and straightening the books. Good luck, Jan, in continuing this process.

Sheila McIlraith
Co-editor

1988 General Meeting of CSCSI

The seventh biennial conference of the CSCSI is now history. The 1988 general meeting of CSCSI was, of course, the highlight of the conference.

The meeting was held in the afternoon of June 6. There were 29 people present when our president, Dick Peacocke, called the meeting to order. Dick reported that overall there were about 300 persons attending Conference'88 while 158 registered for CSCSI'88. We were the biggest draw of the three combined conferences. The president thanked Wayne Davis, the organizer of Conference '88, first and foremost for his considerable efforts. Everything went smoothly and professionally Even the weather was delightful. Randy Goebel handled the conference registration duties superbly. Jonathan Schaeffer was in charge of publicity. Bob Woodham and Nick Cercone were the program committee co-chairs and, with the help of their program committee and referees, produced an excellent technical program. The CSCSI executive thanks all of you for a job well done! Dick reported on CSCSI's support of three future workshops:

- the First International Conference on Principles of Knowledge Representation and Reasoning
- the Second International Workshop on AI & Statistics
- the International Workshop on Cognitive Informatics Applied to Organizations.

Thanks was offered to our outgoing editor Graeme Hirst for an outstanding effort to expand the quality and circulation of this magazine. Graeme's success has profited us all. The concurrent success of the journal *Computational Intelligence (CI)* under the editorial guidance of Nick Cercone and Gord McCalla was also noted.

Dick then reported on the NRC Associate Committee responsible for giving the federal government advice on intelligent systems and future cooperative efforts among industry, university and government. The committee has asked for public submissions regarding these issues. Our committee members to contact are Gord McCalla, Dick Peacocke, Alan Mackworth and Renato De Mori. In a related request, Dick asked for volunteers to compile a current inventory of AI research in Canada.

Outgoing treasurer, Randy Goebel, made his report. In summary, magazine advertising has risen (thanks given to the new editors, Marlene Jones and Sheila McIlraith). There was a good profit of about $18,000 from the previous conference (CSCSI'86 in Montreal) with only a break even expectation for CSCSI'88. The financial balance of the society as of March 31, 1988 was $19,923.59 which was almost $4,000 more than expected. The treasurer called for hiring a professional accountant for assistance. Ted Elcock suggested an annual formal audit to protect the treasurer given the rising financial sums being administered for the society. Dick Peacocke offered thanks to Randy for his considerable work as treasurer and welcomed the new treasurer, Jan Mulder, into the executive.

At the suggestion of the president, the CSCSI executive will investigate adding the editor and the past-president formally to the executive. Their experience offers a needed continuity for the functioning of the society. The membership present voted to implement a de facto addition in the meantime.

The major items of business arising at the meeting were the society's CIPS affiliation, possible corporate memberships, a membership drive, the spawning of special interest groups (SIGS), and a host site for the 1990 CSCSI conference. The CIPS issue dominated and evoked the strongest responses from the membership. Nick Cercone said that CIPS has been losing *CI* journal subscriptions. Randy Goebel has been displeased with continuing administrative problems at CIPS. However, there have been some recent administrative changes within CIPS. The larger issue of CSCSI being a SIG of CIPS was discussed at length. There was general dissatisfaction about CIPS. A large majority of members indicated problems with renewing both CSCSI and *CI* subscriptions through CIPS. Dick asked for specific information from the membership regarding this problem and will confront CIPS with the statistics. Please send him your particulars.

The current membership of CSCSI was reported to be about 700. Of this total, about 150 are university faculty, 150 are students, and the larger remainder are individuals from industry and government. It was agreed that CSCSI could distribute our membership list (as printed mailing labels) for worthy causes. No commercial sales of labels will be allowed. Dick outlined the need for a membership drive. He indicated that his own efforts were insufficient and asked for volunteer help. Please advertise our society to your colleagues and acquaintances. There is a membership application in the back of each copy of this magazine.

The issue of corporate memberships in CSCSI was discussed and informally approved. Involving corporations in the Canadian AI community was deemed a good idea and their financial assistance would be welcome. The executive will investigate and formulate a proposal for corporate memberships to be presented to the society.

Gord McCalla requested that CSCSI consider SIGs within the society. In particular, there is a proposal by Philippe Duchastel appearing in the last issue of this magazine for a Special Interest Group on Education and Training (SIGET). The request was passed in principle without dissent.

The selection of a site for the biennial conference of 1990 was discussed. Two hosts, Ottawa and Halifax, were proposed. Ottawa would encourage higher participation of industry and government. The attendance figures from CSCSI '86 in Montreal (about 400) were compared to those of CSCSI '88 indicating some advantage in a central Canadian venue. Halifax was advocated by Bob Woodham in order to coordinate with the Vision Interface conference again. Dick reiterated that local

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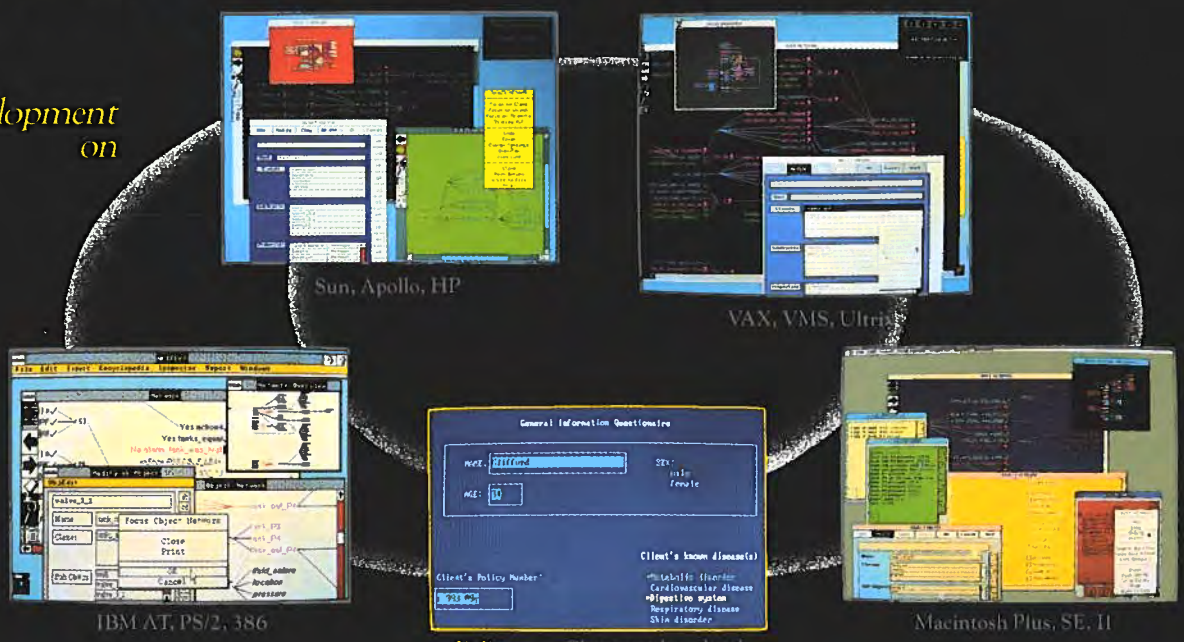

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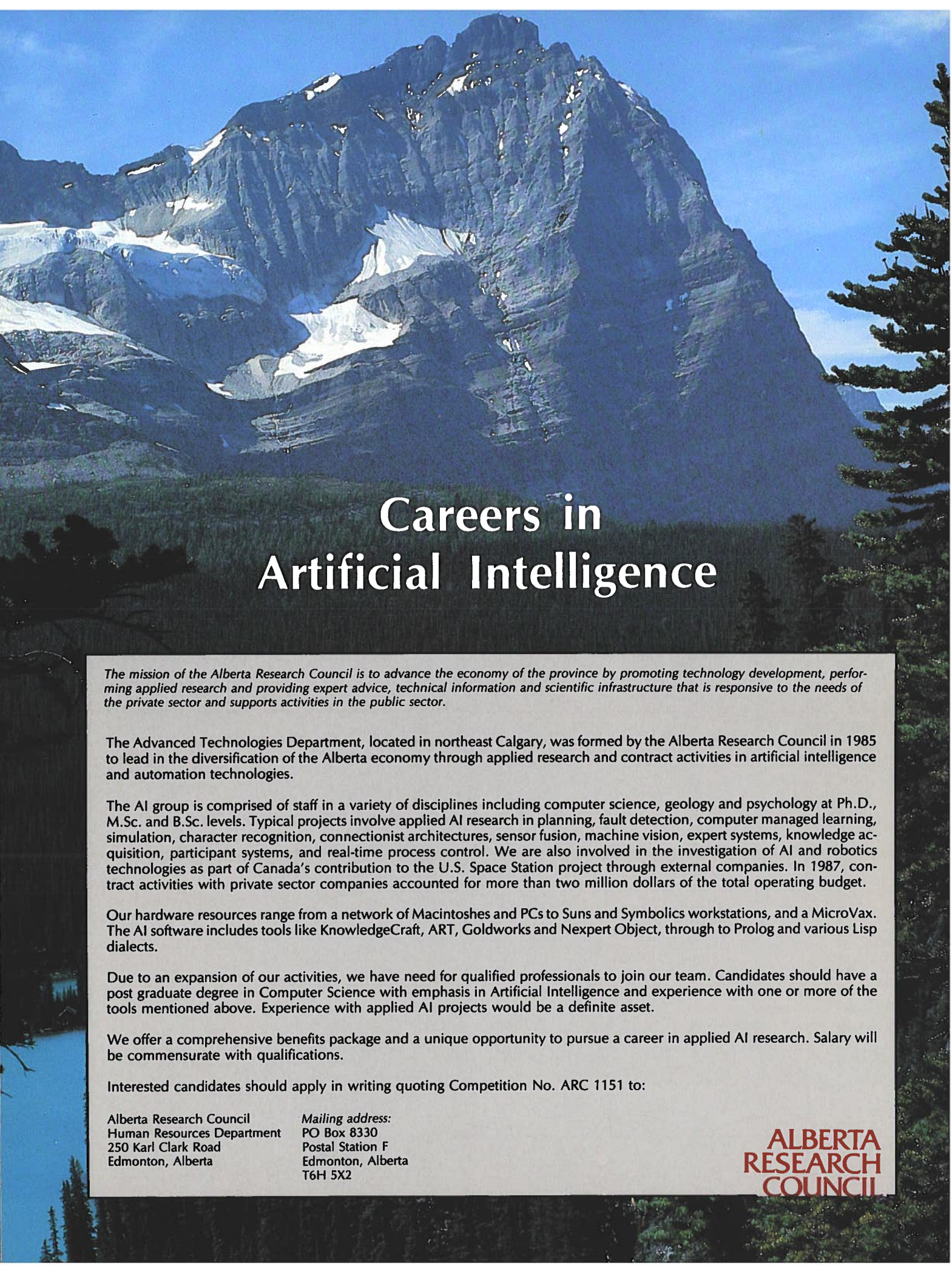

Careers in Artificial Intelligence

The mission of the Alberta Research Council is to advance the economy of the province by promoting technology development, performing applied research and providing expert advice, technical information and scientific infrastructure that is responsive to the needs of the private sector and supports activities in the public sector.

The Advanced Technologies Department, located in northeast Calgary, was formed by the Alberta Research Council in 1985 to lead in the diversification of the Alberta economy through applied research and contract activities in artificial intelligence and automation technologies.

The AI group is comprised of staff in a variety of disciplines including computer science, geology and psychology at Ph.D., M.Sc. and B.Sc. levels. Typical projects involve applied AI research in planning, fault detection, computer managed learning, simulation, character recognition, connectionist architectures, sensor fusion, machine vision, expert systems, knowledge acquisition, participant systems, and real-time process control. We are also involved in the investigation of AI and robotics technologies as part of Canada's contribution to the U.S. Space Station project through external companies. In 1987, contract activities with private sector companies accounted for more than two million dollars of the total operating budget.

Our hardware resources range from a network of Macintoshes and PCs to Suns and Symbolics workstations, and a MicroVax. The AI software includes tools like KnowledgeCraft, ART, Goldworks and Nexpert Object, through to Prolog and various Lisp dialects.

Due to an expansion of our activities, we have need for qualified professionals to join our team. Candidates should have a post graduate degree in Computer Science with emphasis in Artificial Intelligence and experience with one or more of the tools mentioned above. Experience with applied AI projects would be a definite asset.

We offer a comprehensive benefits package and a unique opportunity to pursue a career in applied AI research. Salary will be commensurate with qualifications.

Interested candidates should apply in writing quoting Competition No. ARC 1151 to:

Alberta Research Council
Human Resources Department
250 Karl Clark Road
Edmonton, Alberta

Mailing address:
PO Box 8330
Postal Station F
Edmonton, Alberta
T6H 5X2

ALBERTA RESEARCH COUNCIL

support for the conference is a prime concern. Jan Mulder expressed some interest in hosting the conference in Halifax. Toronto was also suggested as a site. The executive is seeking proposals as soon as possible.

Finally, under new business, Nick Cercone gave a report on the Canadian Fifth Generation Society. He reported that the society had been dormant. The meeting arrived at a concensus on disbanding the society. There were no objections. Bill Havens noted that the conference banquet (an Alberta barbecue) was to start in one minute and moved adjournment. Randy Goebel seconded and President Peacocke adjourned the meeting as the membership voted with their feet.

Bill Havens
Secretary

Treasurer's Report, 1988

It seems that whenever it is time for a treasurer's report it is also time to announce an increase in dues. This report is no different, although most of you will have already noticed that the most recent increase took effect as of January 1, 1988. Our dues are still modest however, and we continue to produce a fine magazine and support a well-respected biennial conference.

Before reviewing the details here are the actual figures:

CSCSI/SCEIO Financial Statement Summary
1 April 1986 to 31 March 1988

Balance forward	**5,786.46**
Savings account	1,389.00
Chequing account	2,057.42
CIPS account	2,340.04
86-87 Revenue	**56,794.06**
Dues	13,973.00
CI subscriptions	2,561.00
Publications (CIPS)	2,706.22
Publications (Morgan Kaufmann)	1,888.61
CAI Magazine paid invoices	11,479.14
TANLU revenue	5,416.00
CSCSI '86 revenue	18,331.91
Bank interest	438.18
86-87 Expenses	**46,099.33**
CIPS administration	5,680.00
Customs brokers	102.00
Couriers	167.00
Postage	2,358.00
Refunds	212.00
CI subscriptions	4,606.00
Printing	5,323.00
CSCSI '88 advance	4,000.00
CSCSI '86 printing	3,368.20
CAI Magazine cover	565.43
Misc. printing	263.22
Misc.	182.00
CAI Magazine production	19,272.48
86-87 Net	**10,694.73**
87-88 Revenue	**36,368.49**
Dues	12,070.00
CI subscriptions	3,698.00
Publications (CIPS)	1,069.00
Publications (Morgan Kaufmann)	2,873.78
CAI Magazine paid invoices	16,336.88
Bank interest	320.83
87-88 Expenses	**37,018.73**
CIPS administration	5,190.00
Customs brokers	67.00
Couriers	99.00
Postage	134.00
Refunds	69.00
CI subscriptions	3,600.00
Printing	5,131.00
Misc. printing	539.40
CAI Magazine production	22,189.33
87-88 Net	**-650.24**
86-88 Net	**10,044.49**
Expected balance, 31 March 1988	**15,830.95**
Actual balance, 31 March 1988	**19,923.59**
Savings account	8,200.45
Chequing account	6,167.14
CIPS account	5,556.00

The March 31, 1988 balance was higher than expected because of some misalignment of revenue and expenses over the last two fiscal periods. It is likely that a magazine printing invoice was doubly counted (once by CIPS and once by me), but the information that would resolve the problem is buried in CIPS records that are beyond my control. The discrepancy results from primitive book-keeping practices, not from some anonymous donation, and is a symptom of our society's growing need for something more than a volunteer accountant.

As of March 31, 1988, we have 853 members (285 regular CIPS members, 49 student CIPS members, 381 regular non-CIPS members, and 138 student non-CIPS members). Just to give you some history, the membership figures have been 283 (March 1984), 650 (September 1985), 799 (March 1986), and now 853 (March 1988). With the enormous AI hype of the last five years, I'm surprised that our membership has not grown faster. The executive has discussed some kind of membership campaign, but the volunteer cycles can accomplish only so much. For now, we are relying on the stability of our current membership, and their enthusiasm in attracting new members.

Our dues structure has been modified so that the non-CIPS members pay $10 more than CIPS members in order to cover the $10 surcharge that CIPS charges the CSCSI for administering each non-CIPS member of our society. Our old rates suggested a reduction in fees for CIPS members; now our policy is to keep the same base membership ($15 student, $25 regular) and add the $10 CIPS charge for non-CIPS members. *Computational Intelligence* is still at $16, so no more than $51 gets you eight great publications a year, plus discounts for conference registration and CSCSI'88 proceedings.

Speaking of proceedings, our arrangement with Morgan Kaufmann for non-Canadian distribution of CSCSI proceedings has been working out fairly well. After our initial agreement signed in July of 1986, we delivered 60 proceedings of CSCSI '86 for sale outside of Canada, 54 of which were sold by December 1986. We produced 200 more copies of CSCSI '86, and as of December 1987, only 62 copies remain. Not only does Morgan Kaufmann increase the profile of our biennial conferences, but it gives us income for a vastly expanded market as the figures above show. This year Morgan Kaufmann has requested that we produce between 500-700 extra proceedings for distribution outside of Canada.

Of course our biennial conferences are continuing. The Montreal conference was our most financially successful yet, no doubt due to both the venue and the organization.

The production of *Canadian AI* Magazine continues to be our single largest expense, costing nearly $8,000.00 per issue. Marlene Jones, Sheila McIlraith and the rest of the crew at the Alberta Research Council in Calgary have done an amazing job taking over from Graeme Hirst but they have had to solicit more advertising to keep the quality high (a testament to the efforts of Graeme!). Continued production of the magazine still depends on the stable support of both our advertisers and our membership.

As of the CSCSI '88 general meeting, Jan Mulder of Dalhousie University is the new treasurer. Jan is the third treasurer of our society; I know that you will join me in wishing him the best of luck, and will provide him with enthusiastic encouragement whenever you have the opportunity. I hope that things continue to run relatively smoothly and that his spreadsheets always behave.

Finally, I want to thank all the members of the CSCSI for giving me the opportunity to learn about things that my formal education never provided. I am now convinced that I was never meant to be an accountant.

Randy Goebel
Treasurer 1986-1988

Notes from Members

New Bindings

Fahiem Bacchus has joined the Computer Science Department at the University of Waterloo as an Assistant Professor. He is a recent Ph.D. graduate from the University of Alberta.

Lewis Baxter, formerly MProlog product manager, Logicware Inc., Toronto to Intelligent Systems Research, Bell-Northern Research, Toronto.

Sheila McIlraith from the Alberta Research Council to the University of Toronto to pursue a Ph.D. in computer science.

Lynn Sutherland from the Alberta Research Council to the University of Saskatchewan to pursue a master's degree in computer science.

L'échéance pour le numéro de janvier est le 15 novembre

Deadline for the January issue is 15 November

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At BNR (Bell-Northern Research), our people are prepared for the challenge and have the creativity and uncompromising dedication to lead our industry.

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The candidate will be involved in expanding the development of Artificial Intelligence technology at BNR. Current applications include real-time monitoring systems and developing software knowledge bases. Other activities include producing an in-house AI training course, and reviewing various applications in progress. A significant amount of external interaction will be required, including management of research and development programs with partners from a consortium of other industries and universities.

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Send your resume to Bell-Northern Research, Staffing Dept., Stop No. 84148, P.O. Box 3511, Stn. C, Ottawa, Ontario, K1Y 4H7.

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BNR

WHERE FINE MINDS MANAGE INNOVATION

Short Takes

PRECARN Approves Seven Research Applications

PRECARN Associates Inc., the consortium of 35 Canadian companies formed to support precompetitive research in robotics and artificial intelligence, has announced its first funding decisions. Out of 28 proposals, seven have been selected for feasibility studies over the next six months. The total cost of funding these studies is Cdn$688,000. The projects are briefly described below.

Ontario Hydro, CAE Electronics Ltd., University of Toronto: Develop an advanced, computer-based control and diagnostic system for continuous processes such as chemical plants, oil refineries, and electric power plants. Contact: Dr. J.Q.B. Chou, Ontario Hydro. Phone: (416) 592-5125.

MPB Technologies Inc., Hydro-Québec, CAE Electronics Ltd., Centre de recherche informatique de Montréal, Canadian Institute for Advanced Research, McGill University: A telerobotic system for operation in hazardous environments such as space, underground mining, undersea, and maintenance of high voltage lines. Contact: Dr. M. P. Bachynski, MPB Technologies Inc. Phone: (514) 683-1490.

MacDonald Dettwiler & Associates, Advanced Systems Institute of British Columbia, Robotic Systems International, University of British Columbia, MacMillan Bloedel Ltd.: The application of advanced automation technology to heavy machinery, such as the use of mobile robotic vehicles in rugged terrain. Contact: Dr. G. Immega, MacDonald Dettwiler & Associates. Phone: (604) 278-3411.

Ontario Hydro, Atomic Energy of Canada Limited, York University, University of Toronto: Computer vision as an aid to navigation of mobile robots. Contact: Dr. S.B. Nickerson, Ontario Hydro. Phone: (416) 231-4111.

Hydro-Québec, Alcan International Inc., Centre de recherche informatique de Montréal, McGill University: Develop a family of expert systems to diagnose power outages and monitor power production and transmission equipment. Contact: Dr. M. Marin, Hydro-Quebec. Phone: (514) 652-8312.

MPB Technologies Inc., Noranda Inc., National Research Council of Canada, University of New Brunswick, Simon Fraser University: Develop, install, and evaluate an advanced real-time expert system for process control and other applications. Contact: Dr. M.P. Bachynski, MPB Technologies Inc. Phone: (514) 683-1490.

Spar Aerospace Ltd., Bell Northern Research, universities to be named: Develop knowledge acquisition and representation techniques which will achieve significant gains in the effectiveness and productivity of system analysis monitoring and fault diagnosis. Contact: G. Norgate, Spar Aerospace Limited. Phone: (416) 745-9680.

Prise de vue

PRECARN approuve sept propositions de recherche

PRECARN Associates Inc., le consortium de 35 compagnies canadiennes formé pour supporter la recherche précompétitive en robotique et en intelligence artificielle, a annoncé ses premières décisions de subventions. De 28 propositions, sept ont été sélectionnées pour des études préliminaires durant les six prochains mois. Le cout total des subventions à ces études s'élève à 688 000$Cdn. Les projets sélectionnés sont décrits brièvement ci-dessous.

A l'Hydro-Ontario, CAE Electronics Ltd. et l'Université de Toronto: pour développer un système avancé de contrôle par ordinateur et de diagnostic pour les processus continus, tels que les industries chimiques, les raffineries de pétrole et les centrales électriques. Contacter: Dr. J.Q.B. Chou, Hydro-Ontario. Phone: (416) 592-5125.

A MPB Technologies Inc., Hydro-Québec, CAE Electronics Ltd., le Centre de recherche informatique de Montréal, l'Institut canadien de recherche avancée et l'Université McGill: pour un système de télérobotique qui puisse opérer dans les environnements dangereux, tels que l'espace, les mines, le fond des mers, et l'entretien des lignes à haute tension. Contacter: Dr. M. P. Bachynski, MPB Technologies Inc. Phone: (514) 683-1490.

A MacDonald Dettwiler et associés, Advanced Systems Institute of British Columbia, Robotic Systems International, l'Université de Columbie Britanique et MacMillan Bloedel Ltée.: pour l'application de technologie d'automation avancée à la machinerie lourde, tels que l'utilisation de véhicules robotiques mobiles en terrain rude. Contacter: Dr. G. Immega, MacDonald Dettwiler et associés. Phone: (604) 278-3411.

A l'Hydro-Ontario, Energie atomique du Canada Ltée., l'Université York et l'Université de Toronto: pour la vision par ordinateur comme aide à la navigation de robots mobiles. Contacter: Dr. S.B. Nickerson, Hydro-Ontario. Phone: (416) 231-4111.

A l'Hydro-Québec, Alcan international inc., le Centre de recherche informatique de Montréal et l'Université McGill: pour une famille de systèmes experts pour le diagnostic des pannes d'électricité et la surveillance de l'équipement de production et de transmission d'électricité. Contacter: Dr. M. Marin, Hydro-Québec. Phone: (514) 652-8312.

A MPB Technologies Inc., Noranda inc., le Conseil national de recherche du Canada, l'Université du Nouveau Brunswick et l'Université Simon Fraser: pour le développement, l'installation et l'évaluation d'un système expert temps-réel avancé pour le contrôle de processus et autres applications. Contacter: Dr. M.P. Bachynski, MPB Technologies Inc. Phone: (514) 683-1490.

A Spar Aerospace Ltd., Bell-Northern Research et des universités à être nommées plus tard: pour le développement de techniques de représentation et d'acquisition des connaissances qui mèneront à des gains importants dans la execution et la productivité de la surveillance de l'analyse de systèmes et le diagnostic des défauts. Contacter: G. Norgate, Spar Aerospace Limited. Phone: (416) 745-9680.

Government Increases Research Funding

The Honourable Robert de Cotret, Minister of Regional Industrial Expansion and Minister of State for Science and Technology, and the Honourable Frank Oberle, Minister of State (Science and Technology) have announced a $240 million program for the establishment of national Networks of Centres of Excellence, and a $200 million increase in the base budgets of the university research granting councils.

The Networks of Centres of Excellence will promote university-industry partnerships to enhance world-class research and support Canada's long-term international competitiveness. Researchers in a variety of different institutions including universities, industry, and government laboratories, will be eligible to participate in the program. All disciplines are eligible to participate. The networks will be chosen by a peer review process of international calibre to be administered by the granting councils.

The government also recognizes the need to further strengthen support for the broad base of research and training in Canadian universities. It will provide an additional $200 million over five years to the base budgets of the National Sciences and Engineering Research Council (NSERC), the Medical Research Council (MRC), and the Social Sciences and Humanities Research Council (SSHRC). NSERC will have its budget increased by $103 million, MRC $61 million, and SSHRC $36 million, over five years. The federal government currently provides more than half a billion dollars annually to the university research granting councils.

Apple Sues Microsoft and HP

Apple Computer Inc. filed a lawsuit last March to protect the visual interface on its Macintosh computers. Although the suit's wording is vague, the complaint is that Microsoft Windows 2.03 and Hewlett-Packard's New Wave software, itself built with Windows 2.03, infringe on the "unique and distinctive" Macintosh display.

XEROX AI Spinoff

Xerox Corporation has announced that its Xerox Artificial Intelligence Systems Business Unit has become an independent, employee-owned company. The new company is called Envos Corporation. Envos will market advanced applications for industrial and business environments and will act as a consultant to software engineering departments. Envos will be responsible for support and maintenance of current Xerox AI software and the Xerox 1186 workstations. The company has a two-year renewable agreement with Xerox Palo Alto Research Center. The agreement allows Envos to encorporate PARC's advanced programming technologies into Envos products.

AI and Engineering Journal

Academic Press is publishing a new journal devoted to the application of artificial intelligence technologies in the areas of engineering and design. AI EDAM, Artificial Intelligence for Engineering Design, Analysis and

Le gouvernement augmente les subventions à la recherche

L'Honorable Robert de Cotret, Ministre de l'expansion économique régionale et Ministre d'état à la science et la technologie, et l'Honorable Frank Oberle, Ministre d'état (science et technologie), ont annoncé un programme de 248$ millions pour l'établissement de réseaux nationaux de centres d'excellence et une augmentation de 200$ millions des budgets de base des conseils subventionant la recherche universitaire.

Les réseaux de centres d'excellence encourageront la coopération entre les universités et l'industrie dans le but d'augmenter la recherche de qualité mondiale et de supporter la compétitivité internationnale à long terme du Canada. Les chercheurs appartenant à toute une gamme d'institutions incluant les universités, l'industrie et les laboratoires gouvernementaux, seront éligibles à participer au programme. Toutes les disciplines seront éligibles. Les participants aux réseaux seront sélectionnés par un processus d'évaluation par des pairs administré par le conseil responsable.

Le gouvernement reconnaît aussi le besoin de renforcer encore plus son appui à la structure de recherche et de formation des universités canadiennes. Il ajoutera 200$ millions répartis sur cinq ans aux budgets de base du Conseil de recherche en sciences naturelles et en génie (CRSNG), du Conseil de recherche médicale (CRM) et du Conseil de recherche en sciences humaines (CRSH). Le CRSNG vera son budget augmenté de 103$ millions, le CRM de 61$ millions et le CRSH de 36$ millions (sur cinq ans). Le gouvernement fédéral verse présentement plus d'un demi milliard de dollars par an aux conseils subventionnant la recherche universitaire.

Apple poursuit Microsoft et HP

Apple Computer Inc. a intenté une poursuite en mars dernier pour protéger l'interface visuel de ses ordinateurs Macintosh. Même si le libellé de la poursuite est vague, celle-ci avance que le logiciel Windows 2.03 de Microsoft et le New Wave de Hewlett-Packard, lui-même construit avec le Windows 2.03, empiètent sur le format d'affichage "unique et distinctif" du Macintosh.

Nouvelle compagnie de produits d'IA issue de XEROX

La Corporation Xerox a annoncé que son Xerox Artificial Intelligence Systems Business Unit est devenue une compagnie indépendante appartenant à ses employés. La nouvelle compagnie se nomme Envos Corporation. Elle mettra sur le marché des applications avancées pour les environnements industriels et d'affaires et agira comme consultant pour les départements de génie logiciel. Envos sera responsable du support et de l'entretien des logiciels d'IA courrants de Xerox et des postes de travail Xerox 1186. La compagnie a une entente renouvelable de deux ans avec le Xerox Palo Alto Research Center (PARC). L'entente permet à Envos d'incorporer les technologies de programmation avancées de PARC aux produits Envos.

Revue sur l'IA et le génie

Academic Press a commencé à publier une nouvelle revue sur les applications des technologies de

Manufacturing will encourage publication of articles that develop new and interesting applications which are firmly grounded in state-of-the-art AI research. The Journal costs US$98 for 3 issues. Contact: Journals Promotion Department, Academic Press Inc., 1250 Sixth Avenue, San Diego, CA 92101.

Computing and Society Journal

The Journal of Computing and Society will begin publishing in the spring of 1989. This quarterly journal will be devoted to material on the social implications of computer technology and computerization. The emphasis in the journal will be on high quality writing and provocative ideas. The journal will try to avoid conventional academic writing in favor of well-crafted essays. The journal is intended to appeal to a general audience as well as the profession of computer science. The journal will be published by Ablex Publishing Corporation, Norwood, New Jersey. Subscription rates have not been determined. There will be a personal subscription rate for individuals.

New Products

New AI Compendium 1954-1987

Scientific DataLink, New York, has published a five-volume collection of indexed references to research in artificial intelligence. The Artificial Intelligence Compendium 1954-1987, contains a subject index, author index, title index, and abstracts, to papers from organizations such as MIT, Stanford, Carnegie-Mellon, SRI, Edinburgh, Bolt Beranek and Newman, Xerox PARC, IBM, and Schlumberger. For more information, contact: Scientific DataLink, 270 Lafayette Street, New York, NY 10012. Phone: (212) 334-1922.

Goldworks Training Expert System

Gold Hill has announced AXLE, a software package that illustrates basic and advanced techniques used in expert system development. AXLE walks a developer through the development cycle of an expert system, teaching practical development techniques at each step. It includes full source code for applications in diagnostics and planning. The software can be run stand-alone or with GoldWorks. It is priced at US$1995.

Fast Apollo Workstations

Apollo Computer has introduced two new personal workstation product lines. The Series 3500™ delivers 4 MIPS for less than Cdn$12,000, while the Series 4500™ delivers 7 MIPS for Cdn$29,000. Both machines are based on the Motorola MC68030, running at 25MHz and 33MHz respectively. Contact: Apollo Computer (Canada) Ltd. Phone: (416) 297-0700.

l'intelligence artificielle dans les domaines du génie et du design. AI EDAM, Artificial Intelligence for Engineering Design, Analysis and Manufacturing, encouragera la publication d'articles sur de nouvelles applications s'inspirant de la recherche de pointe en IA. La revue coute 98$US pour 3 éditions. Contacter: Journals Promotion Department, Academic Press Inc., 1250 Sixth Avenue, San Diego, CA 92101.

Revue sur les implication sociales de l'informatique

Le Journal of Computing and Society commencera à publier au printemps 1989. Cette revue trimestrielle a pour objectif de publier des articles sur les implications sociales de la technologie informatique et de l'informatisation. La revue mettra l'accent sur la qualité des textes et les opinions controversées. Elle tentera de remplacer les textes académiques conventionnels par des essais de haute qualité. La revue cherchera à toucher non seulement les informaticiens, mais aussi le grand public. Elle sera publiée par Ablex Publishing de Norwood, New Jersey. Le cout des souscriptions n'a pas encore été déterminé, mais il y aura un tarif de souscription pour les individus.

Nouveaux produits

Nouvel ouvrage de référence sur l'IA 1954-1987

Scientific DataLink de New York a publié une collection de références indexées de cinq volumes sur la recherche en intelligence artificielle. Le Artificial Intelligence Compendium 1954-1987, contient un index des sujets, un index des auteurs, un index des titres, et des résumés, de communications provenant d'organisations telles que le MIT, Stanford, Carnegie-Mellon, SRI, Edimbourg, Bolt Beranek and Newman, Xerox PARC, IBM et Schlumberger. Pour plus de renseignements, contacter: Scientific DataLink, 270 Lafayette Street, New York, NY 10012 USA. Phone: (212) 334-1922.

Système expert de formation de Goldworks

Gold Hill a annoncé AXLE, un nouveau logiciel qui illustre les techniques de base et avancées de développement de systèmes experts. AXLE accompagne un concepteur de logiciel à travers le cycle de développement d'un système expert, enseignant des techniques de développement pratiques à chaque étape. Le code d'origine complet est inclus pour les applications en diagnostic et en planification. Le logiciel peut être exécuté seul ou avec GoldWorks. Il se vend 1995$US.

Postes de travail rapides d'Apollo

Apollo Computers a annoncé deux nouvelles séries de postes de travail personnels. La Série 3500™ livre 4 MIPS pour moins de 12 000$Cdn, alors que la Série 4500™ livre 7 MIPS pour 29 000$Cdn. Les deux machines sont basées sur le Motorola MC68030, fonctionnant à 25MHz et 33Mhz respectivement. Contacter: Apollo Computer (Canada) Ltd. Phone: (416) 297-0700.

Neural Nets Updates

NeuralWare, Inc., Sewickley, Pennsylvania, has announced new products and enhancements to their NeuralWare PC-based neural network exploration software. A major update to their original product, NeuralWorks Professional I, NeuralWorks Professional II, and NeuralWorks Explorer, are now available. The Explorer and the Professional II software are also available on the SUN/3 workstations.

The NeuralWare software provides graphics-oriented tools for prototyping neural networks. Prices for the software range from US$199 to US$995. Contact: Jane Klimasauskas. Phone: (412) 741-5959.

Gold Hill Lisp Student Version

Gold Hill is offering GCLisp SE (Student Edition), a subset of Gold Hill's full Common Lisp for PCs. Included with the software are the San Marco Lisp Explorer® (a Lisp tutorial package), the GCLisp interpreter, a GMACS editor, and on-line help. The software is priced at US$49.95. The package is offered in conjunction with the latest edition of the Winston and Horn Lisp textbook. Each book will contain a mail-in coupon for a copy of GCLisp SE. Gold Hill also announced attractive University prices for its GoldWorks and Developer products. Contact: Linda Bessette. Phone: (617) 621-3300.

New Expert System Shell

Comdale Technologies, Toronto, have released a new expert system development tool. COMDALE/X is easy to use and includes debugging and explanation capabilities. The knowledge base features include fuzzy logic and fuzzy sets, rule partitioning, meta-rules, and logical, mathematical, and string expressions. The software is compatible with COMDALE/C, a real-time process control expert system shell. The software runs on PCs under DOS and XENIX and costs Cdn$1,500. Contact: Tony Harris. Phone: (416) 252-2424.

Knowledge Acquisition for NEXPERT

A knowledge acquisition tool, NEXTRA, is now available for the NEXPERT OBJECT expert system shell. The acquisition tool allows multiple expert perspectives and generates a knowledge base that may run on all platforms. Cost: US$4,000.

Interlisp Environment Ported to Sun

Envos Corporation has announced that the Xerox Artificial Intelligence Environment (XAIE), now called Medley, and LOOPS, an object oriented extension for Medley, are now available on Sun Microsystems' Sun-3™ and Sun-4™ families of workstations. The environment supports both Interlisp-D and Common Lisp.

Annonces de NeuralWare

NeuralWare Inc. de Sewickley, PA, a annoncé de nouveaux produits et des versions améliorées de ses logiciels d'exploration de réseaux neuronaux sur PC NeuralWare. Des versions substantiellement revisées de son produit original NeuralWorks Professional I, et de NeuralWorks Professional II et NeuralWorks Explorer, sont maintenant disponibles. L'Explorer et le Professional II sont aussi disponibles sur les postes de travail SUN/3.

Les logiciels de NeuralWare sont des outils à interface graphique pour le développement de prototypes de reseaux neuronaux. Les prix des logiciels vont de 199$US à 995$US. Pour plus d'informations, contacter: Jane Klimasauskas. Phone: (412) 741-5959.

Version pour étudiant de Gold Hill Lisp

Gold Hill offre maintenant GCLISP SE, un sous-ensemble pour étudiant de leur Common Lisp complet pour les PCs. L'ensemble inclus le San Marco LISP Explorer® (un logiciel d'instruction sur le Lisp), l'interprète GCLISP, un éditeur GMACS et un système d'aide en direct. Le logiciel se vend 49,95$US. L'ensemble est offert conjointement avec la dernière éditio n du manuel de Lisp de Winston et Horn. Chaque manuel contiendra un coupon-réponse pour une copie de GCLISP SE. Gold Hill a aussi annoncé des prix universitaires spéciaux pour ses produits GoldWorks et Developer. Contacter: Linda Bessette. Phone: (617) 621-3300.

Nouvelle coquille de système expert

Comdale Technologies de Toronto a mis en vente un nouvel outil de développement de systèmes experts. COMDALE/X est facile à utiliser et comprends des outils de mise au point et d'explication. Le système de représentation des connaissances supporte la logique floue et les ensembles flous, le partitionnement des règles, les méta-règles et les expressions logiques, mathématiques et de chaînes. Ce logiciel est compatible avec COMDALE/C, une coquille de système expert temps-réel. Le logiciel fonctionne sur les PCs sous DOS et XENIX et coute 1 500$Cdn. Contacter: Tony Harris. Phone: (416) 252-2424.

Outil d'acquisition de connaissances pour NEXPERT

Un outil d'acquisition de connaissances, NEXTRA, est maintenant disponible pour utilisation avec la coquille de système expert NEXPERT OBJECT. L'outil permet des perspectives multiples et génère une base de connaissances qui exécute sur toutes les plate-formes. Cout: 4000$US.

L'environnement Interlisp est transporté sur les Sun

Envos Corporation a annoncé que l'Environnement d'IA Xerox, maintenant nommé Medley, et LOOPS, une extension à base d'objets de Medley, sont maintenant disponibles sur les séries Sun-3™ et Sun-4™ de postes de travail de Sun Microsystems. L'environnement supporte à la fois Interlisp-D et Common Lisp.

Humour

Iconic Interfaces for Office Systems Based on Video Games

Saul Greenberg
Human-Machine Systems Laboratory
University of Calgary

Roy Masrani
Alberta Research Council
Calgary

Executive Summary: Although users are enthusiastic about modern icon-based interfaces using direct-manipulation principles [3], we argue that their full potential has yet to be realized. Specifically, certain aspects of video games can be fruitfully incorporated into conventional icon systems [1], providing "players" with an exciting way of getting their work done.

We have developed the concept of WAP (Work And Play) at our lab as a testbed for these complex ideas. Icons are used as in standard systems; however, icon manipulation has an exciting video game flavour providing an action-packed session at the terminals. For example, the passive trąsh can is discarded and replaced with a sophisticated laser weapon icon. The "player" may aim the weapon at a file and attempt to destroy it. Of course, the file will take evasive action, using other files as camouflage if necessary. To add an element of risk, shooting the wrong file destroys it too. We will add a notion of inter-icon communications to allow icons to negotiate with each other to establish "friendships" and "teams" to avoid rampant destruction by the laser. Goal-directed behaviour modelled after Schank's notion of goals, is an interesting possibility (especially the **s-survival** [2] goal for those well versed in Schanks' theories).

We are also concerned about the lack of the appropriate motor coordination to deal with such a complex interface. After considerable experimentation, we found that a statistically significant ($p < .0001$) number of subjects had poor aiming skills, resulting in the loss of many years' work and corporate displeasure. To compensate, a "Zeus" icon can reincarnate dead files or to create new ones. In keeping with the gaming spirit, a robust natural language interface (complete with intentionality and speech acts) uses "praying" scripts [2] to give users an opportunity to convince Zeus to restore their files. Proper user interface techniques, of course, dictate that this icon has a complete representation of the user and may decide to shoot a lightning bolt at him/her (which reinitializes the disk).

We have been experimenting with the system for the past eleven months. We found that productivity has improved dramatically, as measured by login hours. Unfortunately, funding is running low and we are searching for sponsors.

[Authors' note: Unfortunately, at the time of writing, the laser icon destroyed the prototype and most of the valuable research ideas. We have determined the cause to be the attribution of **e-entertainment** to the trash can laser. Judicious use of these powerful goals is imperative in furthering research in this exciting field.]

References

[1] Malone, T., "Heuristics for designing enjoyable user interfaces: lessons from computer games" *Proceedings of Human Factors in Computer Systems (SIGCHI)*, Gaithersburg, Maryland, 1983.

[2] Schank, R., Abelson, R., *Scripts, Plans, Goals and Understanding,* Lawrence Erlbaum Associates, Inc., Hillsdale, New Jersey, 1977.

[3] Shneiderman, B., "Direct manipulation: A step beyond programming languages" *IEEE Computer,* 16 (8), 1983.

"Text only" electronic submissions preferred

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Very special thanks to

Sheila McIlraith

Co-editor (1987/88)
Canadian Artificial Intelligence

whose enthusiasm and perseverance
saw us through
our first year with
the magazine.

We wish you all the best
with your PhD studies!

From Chris, Doug, Farran, Julia, Ken, Kevin, Lynn, Marlene, Meg, Roy, Ruby, Tony

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National Research Council Canada

Conseil national de recherches Canada

AI RESEARCH AND DEVELOPMENT

Research Officer Position National Research Council Canada (Ottawa, Ontario)

The Laboratory for Intelligent Systems of the National Research Council's Division of Electrical Engineering has underway a program of research and development in the general area of applied artificial intelligence with a specific focus on knowledge-based systems. Current topics include intelligent advisor systems, engine health monitoring, natural language interface and machine learning applied to medical discovery, crime analysis and manufacturing. Work is undertaken in collaboration with other groups within NRC and with external partners in industry and university.

An opening exists for a research scientist to take the lead role in a new project in the area of real-time expert systems. The individual will lead a team of 3 professionals and will be responsible for planning and executing the project and for coordinating activities with the external project participants. Responsibilities will also include identifying research and development issues related to applied AI and contributing to the overall planning of the laboratory program.

The ideal candidate will have a PhD in artificial intelligence with evidence of outstanding research accomplishments or potential demonstrated by publications. If you have a strong background in Artificial Intelligence and project management and planning skills, we are interested in discussing your future in Canada's most respected Research and Development agency.

Salary: Will be commensurate with qualifications and experience.

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The Employment Office, National Research Council of Canada, Ottawa, Ontario K1A 0R6.

RECHERCHE ET DÉVELOPPEMENT EN MATIÉRE D'IA

Poste d'agent de recherches Conseil national de recherches Canada (Ottawa, Ontario)

Le Laboratoire des systèmes intelligents de la Division de génie électrique du Conseil national de recherches réalise un programme de recherche et de développement dans le domaine général de l'intelligence artificielle en accordant une attention particulière aux systems à base de connaissances. Parmi les secteurs actuellement couverts, mentionnons la mise au point d'un conseiller intelligent, la surveillance de l'état des moteurs, l'interface en langage naturel et l'apprentissage automatique appliqué aux découvertes médicales, à l'analyse des crimes et à la production industrielle. Les travaux sont réalisés en collaboration avec d'autres groupes au sein du CNRC et avec des partenaires externes provenant de l'industrie et du milieu universitaire.

Il y a un poste à pourvoir au sein du Laboratoire des systèmes intelligents. Il s'agit d'un poste de chercheur scientifique qui jouera un rôle prépondérant dans un nouveau projet portant sur les systèmes experts en temps réel. La personne choisie dirigera une équipe composée de 3 professionnels, sera responsable de la planification et de l'exécution du projet et devra coordonner les activités avec les participants externes. Le(la) titulaire devra en outre identifier les questions de recherche et de développement se rapportant à l'IA appliquée et contribuer à la planification globale du programme du laboratoire.

Le(la) candidat(e) idéal(e) possédera un doctorat en intelligence artificielle et ses publications devront témoigner de réalisations exceptionnelles en matière de recherche ou promettre beaucoup à cet égard. Si vous avez de l'acquis dans le domaine de l'intelligence artificielle et des capacités marquées en matière de planification et de gestion de projets, venez discuter de votre avenir au sein de l'organisme de recherche et de développement le plus respecté au Canada.

Traitement: selon la formation et l'expérience

Les personnes qualifiées sont invitées à envoyer leur curriculum vitae, **en citant le numéro de concours DEE-194** au:

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Canada

AI and Canada's Participation in Space Station

by Connie Bryson

L'IA et la participation canadienne à la station orbitale

RÉSUMÉ: Puisque les projets spatiaux utilisent des technologies établies plutôt que des technologies de pointe en raison étant limité par des contraintes de sécurité et de mise à l'épreuve, les technologies d'IA ne sont pas prêtes pour la station orbitale. Mais le projet de station orbitale doit s'étaler sur une période de 30 ans, ce qui est suffisant pour modifier et ajouter des composantes à mesure que les technologies évoluent. Lorsque des composantes d'IA et de systèmes experts auront fait leur preuves sur terre, elles pourront être envoyées dans l'espace. Le Canada aura la responsabilité du système de service mobile (SSM) de la station, un système qui assumera un rôle prépondérant dans l'assemblage et l'entretien de la station. Des sous-projets du SSM qui utilisent des composantes appréciables d'IA sont en oeuvre dans les domaines de l'automatisation, de l'interface homme-machine, de la vision et de la robotique.

With its sophisticated computers, complex electronics and advanced materials, one might think that space technology is about as "high" as any technology can get. Not really. Because of safety and testing requirements, space projects use proven rather than leading edge technology. As a result, much AI technology is simply not ready for Space Station. Although it won't be launched until the mid-1990's, some station components are already being designed and new technology must be incorporated or at least planned for at this stage.

But the situation isn't as bad for AI as it sounds. Space Station is not a short-term project but one with a 30-year life span, time enough to modify or add components as they become available. And Canada's role in Space Station also includes a large ground-based operation where there is ample opportunity for AI, especially expert systems. Once proven on the ground, these systems may be moved up to orbit.

Finally, one of the reasons for Canada's participation in Space Station was the technological spin-offs to other commercial space ventures and to industries at home. There's little doubt in the AI community that systems developed for space will have many, and perhaps even greater, terrestrial applications.

Canada's Involvement in Space Station

Although a space station concept was in NASA's plans in the 1960's, detailed planning did not take place until the early 1980's. The program received the go-ahead in 1984 and the U.S. sought partners to share the cost burden. Canada was interested and began a series of preliminary studies which concluded the country could benefit technologically and economically from participation in the station.

One such study, a report by the space station committee of the Canadian Institute for Advanced Research, said the right kind of Canadian participation would have a technological pull of great significance to Canadian industry. Among the benefits listed in the report are a substantial increase in Canada's exploitable R&D base in AI and robotics and a strong impact on the automation and robotics industries.

Connie Bryson is a free-lance technical writer based in Vegreville, Alberta.

In 1985, when Canada made a commitment in principle to participate in Space Station, it was still not clear exactly what Canada would do. At that time there were three main options: a free-flying remote sensing platform, solar power arrays, and an integrated service and test facility (ISTF).

ISTF, which included a hangar-like component often called a space garage, was the favoured concept because of its predicted technological spin-offs especially in robotics. ISTF was eventually repackaged as the Mobile Servicing System (MSS).

MSS contains all the advanced technologies from the ISTF without the garage component. Although Canadian-supplied robotic elements will serve key roles on Space Station, the U.S. and Japan will also contribute robotic and manipulator systems.

In March, 1986, Canada announced it would spend $800 million over 15 years to build and operate the MSS. In April 1988, this funding was increased to nearly $1.2 billion.

At the time of the second announcement, Frank Oberle, Minister of State (Science and Technology), said: "Participation in Space Station will enable Canada to build on its strong capabilities in robotics and artificial intelligence. We will reap substantial benefits from this project, while sharing costs with our international partners." Other partners now involved in the project with the U.S. and Canada are the European Space Agency, representing 13 European countries, and Japan.

The prime contractor for MSS is Spar Aerospace Ltd. which has assembled a team of Canadian firms to provide equipment and services. The prime contractor team consists of Spar, IMP Group Ltd., CAE Electronics Ltd., Canadian Astronautics Ltd., SED Systems Inc., and MacDonald Dettwiler and Associates Ltd.

The Canadian government estimates that revenues generated from Canadian investment in the MSS and the use of Space Station will be more than $5 billion along with 80,000 person-years of employment.

The Mobile Servicing System

The MSS will play the main role in Space Station assembly and maintenance — moving equipment and supplies around the station, releasing and capturing

satellites, supporting astronauts working in space, and servicing instruments and other payloads attached to the station. It will also be used for docking the Shuttle Orbiter to Space Station and then loading and unloading materials from its cargo bay. The key components of the MSS are outlined in Table 1.

In addition to these space systems, the MSS will include a ground-based operations centre and an operations management and logistics centre containing a major facility for simulation of manipulator systems.

The first of the MSS equipment is scheduled to be flown to Space Station orbit, 500 kilometres above Earth, in the mid-1990's on one of the first Space Shuttle missions dedicated to the station's assembly. The system will be launched in stages to provide an initial operating capability which will be used for assembly, maintenance and servicing of the station. The MSS will be upgraded by increments as progressive requirements and new available technologies evolve over the 30-year life span of Space Station.

MSS Technology

Because of the two robots on MSS — the very large single-armed SSRMS and the smaller, more dextrous two-armed SPDM — robotics and a computer vision system will play a key role in MSS technology.

One of the goals of the Space Station program is to keep the need for astronaut extravehicular activity to a minimum. Consequently there is a need for teleoperation from within pressurized modules and the automation of manipulator functions to the maximum extent possible.

"Using astronauts to do many of the tasks outside Space Station is very inefficient. Astronauts have to prebreathe oxygen so they don't get the bends and the space suits are cumbersome to work in. There's also the safety factor because of the presence of explosive propellents and hazardous chemicals," says Dr. Richard Hughes, Automation and Robotics Manager, Space Program, NRC.

"We're now at the stage where manipulators are operated in teleoperation mode — an astronaut with hand controls. We'll start automating the mundane things first, like having the robot pick up a tool itself instead of being guided by an astronaut. Then we'll move on to the less routine — commanding a robot to do an entire task."

A further goal of the program is to automate housekeeping and other operations on the station as far as possible, and to control these functions in orbit with a minimum of ground-based participation. This goal stimulates the need for comprehensive computer-based management systems that automate operational functions and raise the level of autonomy of certain components and subsystems.

Automation — including the use of knowledge-based systems — will also be needed in operations planning, failure diagnosis, planned maintenance and crew training.

Because of the multitude of MSS functions and tasks that can benefit from the application of advanced technology, it was necessary to choose specific areas of technology as the focal point of Canadian activity. The Advanced Technology Subcommittee, which has representatives from various government departments and Canadian aerospace companies, identified strategic technologies for MSS. These technologies, listed in Table 2, meet all of the following criteria:

- Be of potential use in the design and development of the MSS
- Be a new technology in Canada, or require a substantial upgrade of existing Canadian capability to achieve a technological advantage
- Be technically and economically feasible to develop in Canada, as opposed to purchase off-shore
- Have spin-off possibilities into other space or terrestrial applications.

The design of the MSS is derived from the Canadarm technology. For Space Station, extensions and improvements are required in the following general areas:

- increase in size and strength to cope with much larger payload masses
- increase in dexterity and operability of manipulators and the capability of the manipulator to be relocatable
- increase in controllability level for certain tasks from "teleoperation" to "man-supervised computer control" (telerobotics) and/or to "autonomous computer control" (robotics)
- on-orbit maintainability and longer continuous life in the space environment
- increase in autonomy of operational support functions.

Mobile Servicing Centre (MSC): a mobile base from which to operate space manipulators at remote sites and for transporting payloads about the station
Space Station Remote Manipulator System(SSRMS): a large robotic manipulator arm (the next generation of Canadarm) for general payload handling including capturing and berthing of the Shuttle Orbiter
Special Purpose Dexterous Manipulator (SPDM): a smaller two-armed robot capable of performing the dexterous tasks normally associated with astronauts
Support equipment such as control stations (both inside and outside the pressurized volume) and a maintenance depot.

Table 1. Mobile Servicing System Components

Teleoperation and Robotics
• vision systems
• sensors
• robot programming
• human-machine interfaces/telepresence
• manipulator analysis
• manipulator control
• simulators
• robot mechanisms.
Automation of Operations
• expert systems in operations
• automated data management
• automated power management.
Electrical and Electronics
• processor systems and interprocessor communications
• power systems.*
Structures and Materials
• materials
• lubrication in space.*
Verification
• automated test equipment
• qualification strategies*
• software development and verification.*
** denotes possible strategic importance*

Table 2. Technologies of Strategic Importance

For much of this technology, time is of the essence. The preliminary design review of the MSC must be completed by early 1989. The SPDM preliminary design is not required until 1991, leaving more room for the incorporation of new technology in this component.

"At the preliminary design stage we have to decide what technology to use," explains NRC's Hughes. "The technology must have reached the proof-of-principle stage; we must have reasonable confidence in the technology. There will be a very heavy emphasis on proving reliability and safety."

Because of the limited time available for technology R&D, the plan is to upgrade the initial operating capability during the 30-year life of Space Station.

For upgrading to be practical, it is necessary to anticipate future developments and build in software "hooks" and hardware "scars" to serve as interfaces for the enhancements. Typical hooks and scars would be excess computer memory and processor capability or extra cabling and space for additional sensors or processors. In the longer term, existing hardware and software may be replaced by more capable versions.

As Automation and Robotics Manager for Canada's space program, Hughes must identify new technology that has potential to be incorporated on Space Station at a later date. He calls himself "a customer of advanced technology. I have to identify the technology in order to leave room for it."

For some things, this process is fairly straightforward. If it's known that the manipulator arm will have to handle bigger payloads at a future date, it's fairly easy to put in this requirement for upgrading.

Predicting future requirements for many of the AI technologies is much more difficult because very often no one knows what they will actually "look" like.

"AI is very tough — the algorithms aren't clear, it's not clear what computer architecture will be needed and we're not sure where the technology is going," says Hughes.

However, it is clear that if AI is to be incorporated in Space Station, this type of forecasting will have to be done. Hughes says AI will likely first appear in ground support operations.

"Because Canada is doing its own operations planning and simulation, as opposed to Canadarm where NASA ran it, there's a great opportunity here for AI, particularly expert systems. These technologies will reduce the number of people needed on the ground. When you consider that the station will be operating for 30 years, this represents quite a saving. And once the systems are proven on the ground, they may move up to orbit and reduce Space Station's reliance on the ground."

Current MSS Technology Subprojects

The following list outlines some of the technology subprojects now underway (or envisaged) which contain an appreciable AI component. The prime contractor team is responsible for most of the work. Some of this work has been subcontracted to other industries or to universities.

Automation

Collision Detection / Avoidance

The motivation for this work stems from the need for the MSS to be capable of avoiding collisions while performing tasks. The work so far has concentrated on understanding and developing collision detection requirements and techniques.

AI-Based Fault Diagnosis, Health Monitoring, and Malfunction Procedure Handling for MSS

This project included an evaluation of AI techniques for health monitoring and fault diagnosis and a comparison of fault detection by built-in-test (BIT) equipment and AI. This initial study concluded that, for the initial operating capability of the MSS, AI-based diagnostics is limited to an advisory type of expert system which automates predefined procedures.

Work is continuing on the development of a procedural expert system to perform malfunction handling using the SSRMS as a prototype, as well as a prototype health monitoring/diagnostic system incorporating heuristic reasoning and reasoning based on a functional decomposition of the SSRMS.

Automatic Planning for MSS Operations

This initial study concluded that expert system technology can play a role in solving MSS planning and resource allocation problems. Further work is planned in developing the use of AI techniques for automatic procedure generation, as well as developing concepts for:

- imposing constraints in the form of rules (e.g. crew workload, availability of control stations, etc.)
- identifying break points, invoking simulation procedures for estimating task completion times, and interactive modification of plans.

Autonomous Power Management

This project will assess the requirements for the more complex functions of the Autonomous Power Manager of a power management system.

Expert System for an On-Orbit Integration, Test, and Maintenance Information System

Work on this project is aimed at developing "intelligent" database management techniques to allow the easy retrieval and display of procedural information for MSS operations such as integration, test, verification and maintenance.

Knowledge-based Health Monitoring and Planning System for MSS Power Management

Not yet underway, this project will evaluate expert systems for planning and health monitoring and develop them for application to the MSS power management and distribution system.

Command Language

This project will define requirements and evaluate concepts for a command language that will form the layer between MSS hardware elements and the operational level expert systems and/or crew members.

Human/Machine Interfaces

Speech Input / Output

A speech input system is being implemented using a VOTAN speech processor to transform a range of natural language inputs to command language. Another system to transform system response language to natural speech output is also being implemented. The entire system will be tested using simulated MSS tasks on a computer graphics workstation.

Touch Screen

A touch screen interface is being implemented to operate MSS manipulators simulated on a computer graphics workstation. Its use will be evaluated for applications such as MSS operational control, as an interface device for expert systems, and as an input device for command language programming.

Vision Systems

Vision systems on Space Station fall into two major categories: those that use the existing closed circuit television (CCTV) system as a front-end imager and those that provide their own optical and scanning/imaging system. There are four key vision technologies being investigated for roles in the MSS.

Real-time Photogrammetry

In this system, the output of a CCTV video camera is processed electronically in order to derive the relative object-to-camera position and orientation. The National Aeronautical Establishment's real-time photogrammetry system has been developed into the Space Vision System scheduled to fly as a Canadian experiment on an upcoming Shuttle flight.

Laser Range Scanning

By scanning the laser beam, a depth profile or 3-D view of the scene can be built up, offering a significant advantage over normal 2-D camera views. NRC's Division of Electrical Engineering has developed a laser scanner which uses a synchronized, double scanning approach for an enhanced depth of view.

Stereo Camera Processing

Recovering range information through the processing of two spatially separated camera views is an alternative to the use of a dedicated laser ranging sensor. The stereo camera approach is very flexible in that it can use the available CCTV system but will need a special image matching processor to derive depth from the two images.

2-D and 3-D Recognition Algorithms

A number of schemes for image segmentation (into points, lines or surface features), image classification (e.g. feature matching) and object recognition are under investigation.

Robotics

Software Technology for Manipulator Control

Work on this project entails developing and verifying a generic set of kinematic control algorithms and software that can be used to analyze the kinematics of a generic manipulator.

Automation of Teleoperation

While SPDM/SSRMS tasks can be performed in teleoperation mode — where manipulator operations are directly controlled at all times by an astronaut using hand controllers — it will be more efficient to automate teleoperation to a "supervised autonomy" mode. In this mode the SPDM/SSRMS would perform certain tasks under computer control after being briefly instructed by the astronauts.

Serpentine Manipulator

Because articulated manipulator arms such as Canadarm are limited in manoeuvrability, a study on a flexible "snake-like" multiple degree-of-freedom configuration was carried out. The result is the "truss arm" concept — a multi-bay truss configuration with variable length elements to control the shape of the truss and the position and orientation of the end point.

SPDM Ground Test Bed

This project entails the design and manufacture of a ground-based demonstration unit of a two-armed SPDM configuration.

Strategic Technologies Subprogram

The prime contractor team plays the main role in the technology items of the "basic" and "enhanced" type and some of the highly critical "advanced" type (Table 3). Other advanced technology items are being implemented by industries other than the prime contractor team through an innovative program called STEAR (Strategic Technology in Automation and Robotics). This program is designed to augment the development and spin-off potential of the strategic technologies.

STEAR's first Request for Proposals (RFP), on Automation of Operations, was issued in October, 1987, and has resulted in the awarding of six contracts each worth approximately $100,000. The second RFP, on Power Management, was issued in January, 1988; contracts were not awarded at the time of writing.

"The STEAR program is aimed at taking promising technology to the proof-of-principle stage," explains NRC's Hughes. "If it's done quickly, the technology could been be used in the SPDM because its preliminary design isn't required until 1991. If the technology takes more time to implement, we can upgrade the MSS at a later date."

The contracts awarded under the Automation of Operations RFP have a strong AI element through the use of advanced information system technology — integrated management of databases and knowledge bases — and knowledge-based or expert systems.

For the contractors and sub-contractors to this program, the contracts represent a unique opportunity. Victoria-based Acquired Intelligence Inc. and its subcontractor Atomic Energy of Canada Ltd. are working on two knowledge-based systems for operations planning and resource management and an intelligent tutoring system for crew training.

Project leader Dr. Brian Schaefer calls the RFP "an opportunity for concerted focus now. Otherwise we would have to wait for a client to come along."

Basic Technology
- technology essentially available in mature form
- one or more proven design options are available and in some cases choices need to be made
- available within the MSS team of contractors.

Enhanced Technology
- technology exists but is not mature, or selection from alternate processes, materials, or design configurations is required
- includes qualification of existing designs for long life, severe environmental conditions, etc.

Advanced Technology
- involves development of new concepts, proof of principle demonstrations, and MSS-specific design development and qualification.

Table 3. Categories of MSS technology

Victoria's Softwords company, along with the Alberta Research Council as sub-contractor, is working on a smart computer-based training system for astronauts. Softwords president Ellen Godfrey says the work builds on and expands the tools already developed by her company.

"Each project is a step in the tower, everything spins off of our previous work. But if we get the space project running, we'll have a big jump on the competition in this particular area of technology."

Dr. Touraj Nasseri, president of Det Norske Veritas Canada Ltd., Calgary, sees another benefit to the space work. His company, along with its sub-contractor the Alberta Research Council, is working on fault detection/diagnosis, health monitoring, and failure anticipation systems.

"I see the contract as a way to participate in the transfer of technology in AI. We want to know what we can gain from other industries and how the results from our work can help them. Rather than each of us re-inventing the wheel, we can have a kind of intellectual osmosis," says Nasseri.

Toronto's Dynacon Enterprises Ltd. is already involved in this sort of technology transfer. Although the company has been doing space work for years — in the area of dynamics and control — its contract on operations planning is its first foray into AI. (Dynacon's two sub-contractors are Humantech from Cookstown, Ontario, and Ottawa-based CAIP Corp.)

Dr. Mike Jenkins, from Queen's University, is working on an automated data management system. (Jenkins is a sub-contractor; the contractor is Spectrum Engineering Corporation Ltd., Peterborough, Ontario.)

"So far we've been building tools and testing them with abstract ideas. The beauty of this project is that it's an opportunity to use the tools on a real problem. We'll be able to see whether they're effective or if we need extra ones," says Jenkins.

"If we can devise an intelligent database of components it will have spin-offs on the ground. It could be used anywhere operational stability is needed."

Jean-Claude Gavrel, CAIP's Director of R&D, envisions many roles for AI in space. His company is working on an operations planning contract with sub-contractors Wardrop Engineering Inc., Winnipeg, and the Alberta Research Council.

"These contracts are a welcome initiative. It gives us and other companies opportunities to advance the state of knowledge in Canada. One only wishes there was funding to do more — we need more private sector involvement," says Gavrel.

"There is still some debate whether AI and expert systems are ready for space applications. You don't want technology in space to offer surprises, and a good testing methodology for expert systems has not yet been developed. This is a valid concern, but I believe these problems will be overcome."

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Neural Networks: An Engineer's Perspective

by Casimir Klimasauskas

Les réseaux neuronaux: le point de vux d'un ingénieur

RÉSUMÉ: Les réseaux neuronaux sont un paradigme computationnel très puissant inspiré par la structure physiologique du cerveau. Ils peuvent apprendre par leurs expériences, généraliser des concepts et utiliser efficacement les architectures de traitement parallel. Les applications présentes des réseaux neuronaux se groupent en deux catégories principales: la classification de formes et tions de synthèse fonctionnelle. Les applications de classification de formes se sont montrées utiles dans les systèmes experts, l'inspection industrielle et la reconnaissance de caractères. Les applications de synthèse fonctionnelle ont été utilisées dans les domaines du filtrage du bruit, de la prévision et du contrôle de processus.

Two and one-half years ago, I read an article in *Science* magazine about a new field called "Neural Networks". The article described the potential for this new technology and made claims that sounded too good to be true. After a year of investigating the technology, I became convinced that it is a better solution to a variety of problems than any other approach. In the future, it has the potential to solve some very difficult problems for which no good solution has been found. As an engineer, I am interested in what it can do *today*.

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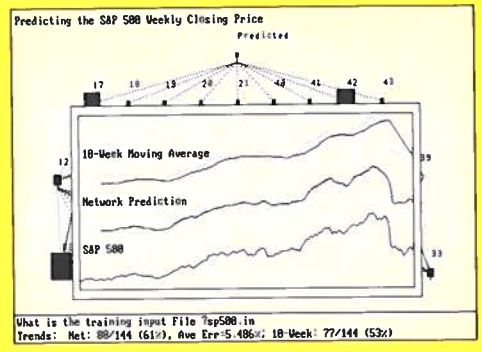
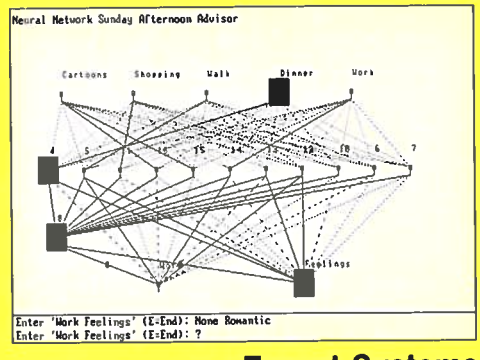
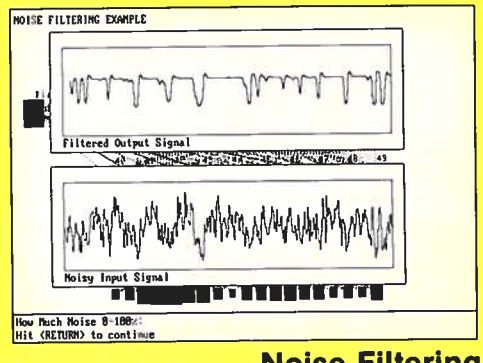


Stock Market Forecasting



Expert Systems



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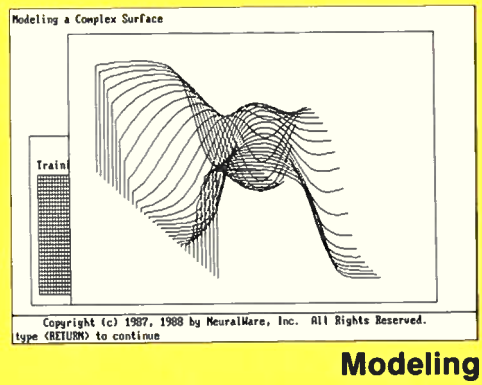

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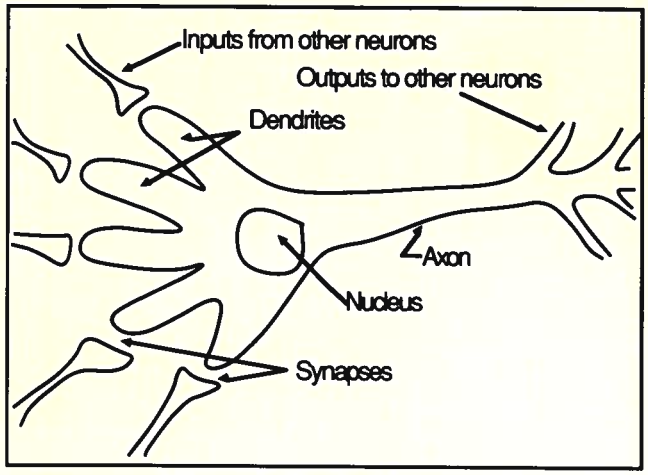

Figure 1. Typical Neuron

Today or Tomorrow?

Both research and engineering are involved with solving problems. Research, in general, attempts to develop solutions to problems which seem just beyond what is possible today. Engineering takes established techniques and applies them to specific problems. In a sense, engineers tackle problems which can be solved today. Researchers focus on breakthroughs to provide solutions for problems tomorrow.

Neural networks are a very potent technology. They hold the promise for a variety of solutions to very difficult problems: continuous multi-speaker speech understanding, handwritten character recognition, adaptive expert systems, smart surveillance systems, smart munitions, automatic collision avoidance systems, and eventually, robots which can clean house. At present these solutions are in the future. The technology in its present form solves a variety of smaller though still difficult problems. Before we look at those, let's look briefly at what the technology is.

What are Neural Networks?

Neural networks as a technology are rooted in neurophysiology and a branch of psychology known as connectionism. The basic technology is *inspired* by studies of the brain and nervous system. The processing element, the basic building block of neural networks is analogous to the neuron, the basic building block of the nervous system.

Figure 1 shows a diagram of a typical neuron. The inputs to the neuron shown are actually the outputs from the axon of other neurons. The signals on an input are communicated to the nucleus of the neuron through the synapses. Signals in the nervous system are primarily chemical, and the size and type of the synapse determines to what degree the ionic activity of the neuron is increased or decreased by an input from another neuron. The electrical signals we often associate with nervous activity are by-products of these chemical processes. The synapses modulate the magnitude and sign of the input signal. When the internal activity level of the neuron exceeds some threshold, it produces an output pulse. The rate at which output pulses are produced is related in some non-linear way to the internal activity level of the neuron. This is a very simplistic description of how a neuron works. Researchers have identified over 100 different types of neurons.

The analogy to the neuron used in neural network technology is the processing element. Figure 2 shows a typical processing element. Inputs from other processing elements are modulated (multiplied) by connecting weights and added together. The resulting internal activation (sum) is applied to a transfer function to produce an output. Just as with neurons, processing elements come in a wide variety of types. Interesting properties emerge when groups of processing elements are connected together. Different connection topologies include feed-forward, feedback, automatic gain control, and competition. Figure 3 shows a simple feed-forward network used in a prototype system for predicting stock prices. The size of the processing elements is proportional to their output level. Filled boxes or circles are positive. Unfilled boxes or circles are negative. The shape indicates the type of processing element.

Neural networks *learn* from experience. Typically, a network is shown an input, and told what the output should be. The network adjusts the connecting weights so that it is more likely to respond with the correct answer the next time it is shown the input. In this way networks can be *trained* to classify inputs into various categories, or to synthesize functional relationships between several inputs and one or more outputs. Depending on the particular type of network, it can continue to learn over time, adapting to new situation as time goes by.

A second unique feature of neural networks is their ability to *generalize* what they have been shown to situations which they have never seen before. This is an important trait required by systems which may encounter novel or unexpected situations.

Neural networks are the one information processing technology which can effectively utilize parallel processing architectures. They are also well suited to VLSI (Very Large Scale Integrated circuits) and optical implementations. Herein lies their promise. One industry analyst noted that by the year 2000, it may be possible to produce a single VLSI chip with 10,000 processing elements on it boasting a combined through-put of 100,000 MIPs (100,000,000,000 instructions per second)!

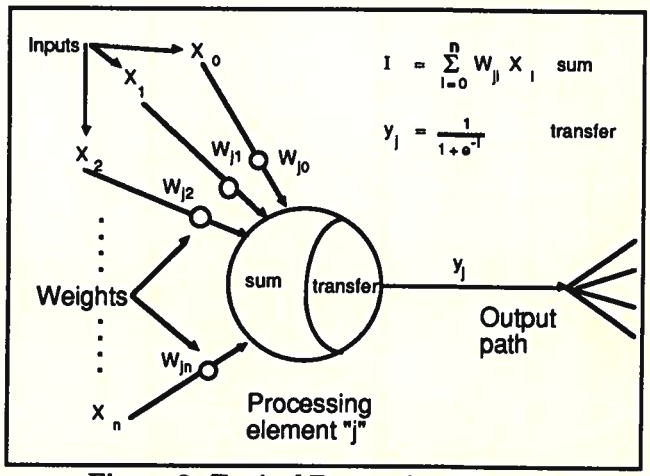

Figure 2. Typical Processing Element

Casimir C. "Casey" Klimasauskas is the president and founder of NeuralWare. He has spent 19 years in government and industry developing software and hardware products. He holds a vocational certificate in electronics and a bachelor's degree in mathematics from the California Institute of Technology.

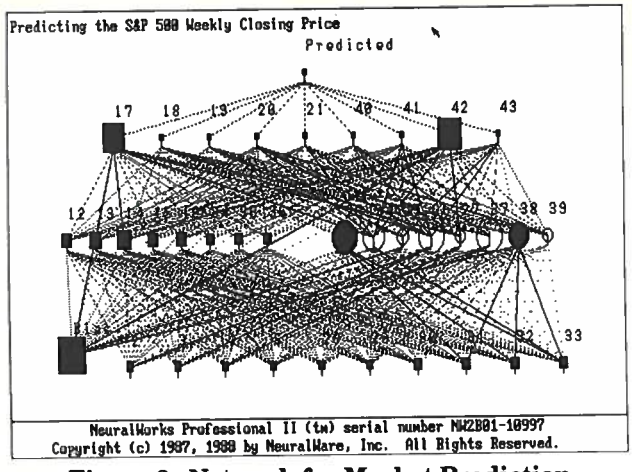

Figure 3. Network for Market Prediction

What can they do Today?

Neural network applications fall into two major categories: pattern classification and functional synthesis. The individual applications within each of these broad categories are limited only by your imagination.

Neural Network Pattern Classifiers

The basic pattern classification problem is to determine which of several classes a particular set of inputs belong to. Several researchers have confirmed that neural networks often do a better job of pattern classifying than any other technology. Three areas where they have or are being applied are: expert systems, industrial inspection, and character recognition.

One example of a *pattern classifying expert system* is a neural network used for loan approval. A typical loan application consists of several symbolic inputs such as occupation, checking accounts, and savings accounts as well as several numeric inputs such as income, and debt to income ratio. The symbolic inputs are coded into patterns of numeric inputs. The numeric values may be preprocessed or presented directly to the network as inputs. An approve/deny signal is provided as the training output. Using these pairs of loan application input and approve/deny output, the network learns which category a particular applicant belongs to. After training, it is integrated directly into the loan application processing system to provide an on-line approve/deny output. There are at least three companies which have implemented systems of this type. Their claims range from a 7% to 27% improvement in profitability over other techniques. A particularly attractive feature of neural network technology in this application is its ability to change with time to keep pace with changing economic conditions.

Variants on this approach might be used for insurance under-writing, fraud detection, credit rating, bond rating, and personnel evaluation.

A more industrial-oriented application of neural networks as pattern classifiers is in the area of inspection. In one instance, a company has developed a very high speed system designed to inspect packaged goods such as cereal boxes, chocolate chip cookies, and shampoo bottles. The system takes a picture of the product using a standard CCD video camera. Very fast hardware optically transforms the image to a series of numeric values, a "signature", which represent the image. The signature is classified by a neural network into an accept category or one of several reject categories. Comparing the neural network approach against several standard pattern classification techniques, they found that the neural network did a significantly better job of correctly classifying products.

Character recognition is another area ripe for neural network technology. Although no commercial systems have been deployed, this is an area with a lot of attention from both researchers and applied development groups. Work is proceeding both in improving recognition technology for printed characters, and for developing systems for recognizing handwritten characters in limited contexts. In particular, several companies are attempting to apply neural networks to reading the courtesy amounts on credit card slips.

These are a few examples of feasible engineering applications of neural networks. Beyond this, researchers have been applying them to a variety of pattern classification problems including speech recognition, speech synthesis, DNA analysis, board games (backgammon, checkers, tic-tac-toe), medical diagnosis, ship classification, sonar interpretation, and fuzzy expert systems.

Neural Networks for Functional Synthesis

One of the neural network types is called *backward error propagation* or *back-propagation* for short. It turns out that this is really an extremely powerful regression technique using linear combinations of arbitrarily complex bounded, continuous, differentiable functions. In essence, it is a near optimum method to develop a functional relationship between several continuous valued inputs and one or more continuous valued outputs. Quite a bit of research has been done which indicates that this is the best technique for modeling and forecasting. Some of the areas it has been applied include noise filtering, forecasting, and process control.

Traditional signal processing techniques can be used to develop adaptive filters when there is a good model of what the signal should look like, or when there is a good model of the noise. Neural networks can be used to learn about the shape of a particular signal when the only information is a combination of both the signal and noise. The network will adaptively develop a small number of filters which represent the most frequently recurring patterns of a certain duration. The process requires that the noise is of a higher frequency than the signal of interest and that the two are uncorrelated. This technique has been applied with excellent results to extracting the signal from very noisy EKG data. This same technique has been used for doing gray-scale image compression.

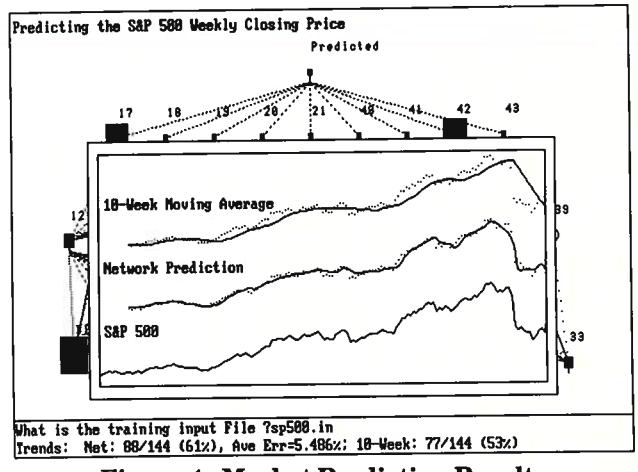

Figure 4. Market Prediction Results

Another customer asked us to apply neural networks to forecasting the Friday closing price of the Standard and Poors 500 and compare it to a ten week moving average. Actually, this work was inspired by the results of a group of researchers who found that neural networks do a better job of predicting chaotic time series than any other technique. We used ten weeks of closing prices as input and trained the network to predict the closing price the following week. The network for doing this is shown in figure 3. Figure 4 shows the results of the test. The dots to either side of the network prediction and the ten week moving average are the actual closing prices translated upward from the lower graph. Notice that the network did quite a bit better at predicting trends than a ten week moving average (61% versus 53%). This same technique has been used by others to forecast natural gas demand, gas industry profits, and policy objective analysis.

One of the problems which occurs in robotics and a number of other areas of process control is estimating residual error terms. In most real systems, a combination of mechanical dynamics, manufacturing variances, temperature, wear and computational constraints make it impossible to determine exactly how much to vary the system parameters to achieve a desired result. The most common technique is to make an initial approximation followed by a series of small corrections until the desired result is achieved. The better the guess, the faster the system is back on track. Neural networks have been applied quite effectively in robotic laboratories for adaptively developing mathematical models of what corrections to use. In independent tests, this has resulted in major improvements in performance with commensurate reductions in cycle times as well as improved positioning accuracy. Both of these are essential objectives for effective factory automation.

Where Do We Stand?

As I have described, there are several significant applications where neural network technology can provide a competitive edge. Some of them, particularly in the area of loan approval and industrial inspection, have already been fielded. Others are close to being deployed. The technology is just beginning to filter out of the research laboratories into the hands of engineers. On the positive side, neural networks are doing a better job of solving several difficult problems than conventional methods. There is a wealth of opportunities to develop major competitive advantages using the technology.

On the other hand, there are a lot of rough edges in applying the technology. The success of a particular project is highly dependent on how skillfully inputs are selected and pre-processed. Adjusting network architectures, learning rules and other parameters is more of an art than a science. There are no cookbook solutions. However, when they work, the results are quite gratifying. With patience and practice, I have obtained consistently good results in developing applications. Good tools make a big difference in debugging networks.

I am sold on neural network technology. I am convinced that every company with an advanced technology group should be investigating neural networks. There are two payoffs. In the near term, there are enough problems which neural networks do a better job of solving than other technologies that it should be easy to find manageable problems with good returns. There are several very smart researchers tackling some very tough problems using neural networks. This work will ultimately lead to major breakthroughs. In the long term, the companies with experience in using neural networks will be better positioned to exploit these cutting edge breakthroughs as they occur.

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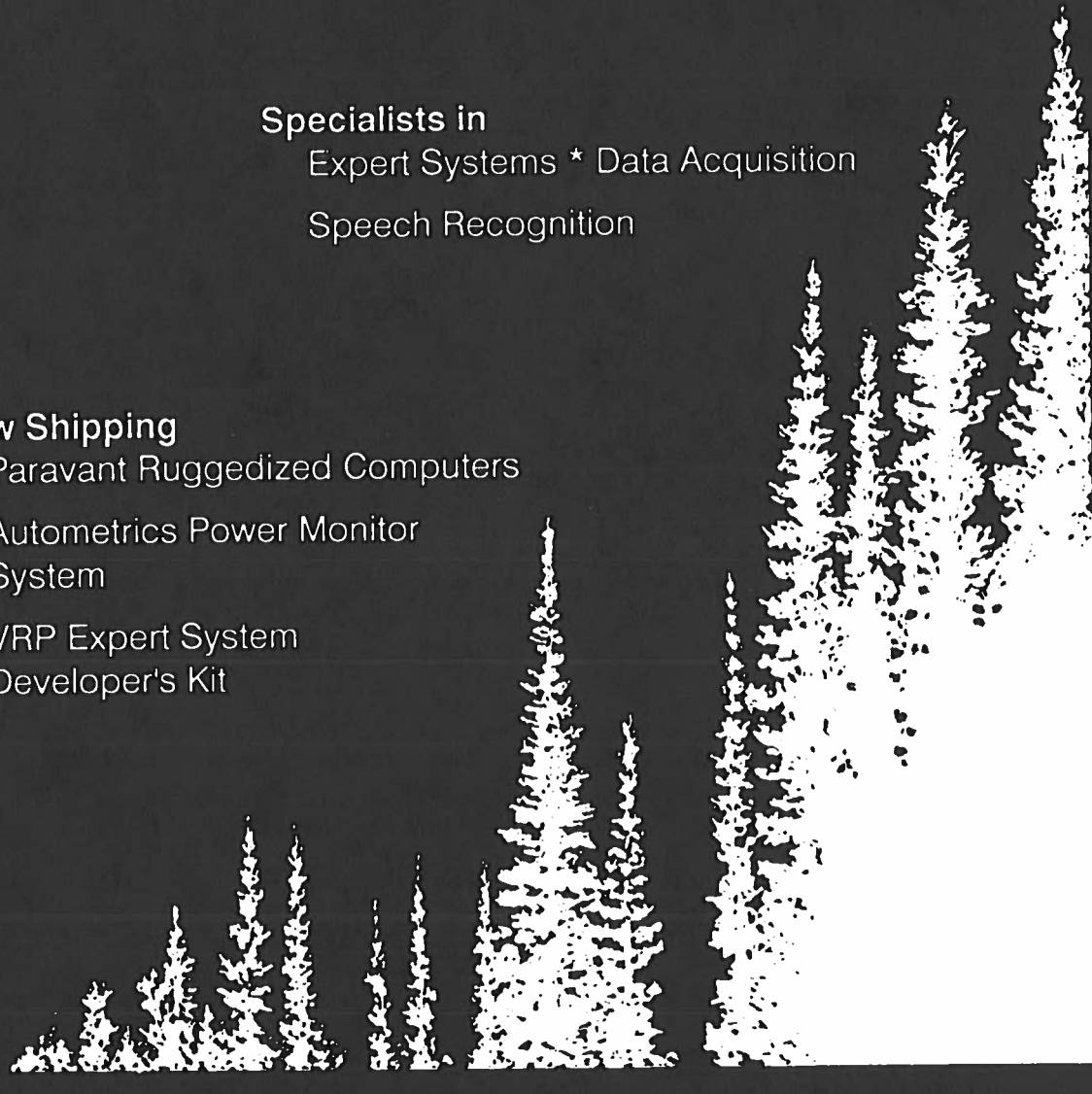

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Research in the Knowledge Sciences at the University of Calgary

by Ian Witten and Brian Gaines

Recherche en sciences de la connaissance à l'Université de Calgary

RÉSUMÉ: Le Knowledge Science Institute (KSI) de l'Université de Calgary a pour objectif d'effectuer des recherches en sciences de la connaissance, sur les technologies associées et sur leur impact économique et social. Ce survol se concentre sur la recherche en sciences de la connaissance effectuée par les professeurs d'informatique ou en collaboration étroite avec eux. Celle-ci se répartit parmi les domaines suivants: l'acquisition de connaissances pour les systèmes experts, l'apprentissage par ordinateur et la programmation par exemples, la théorie des systèmes et leur organisation (particulièrement la modélisation et la prédiction) et la programmation logique. La recherche dans les domaines associés à l'informatique, tels que l'interaction homme-ordinateur, les systèmes répartis, et les méthodes formelles pour la vérification de logiciel et de matériel, n'est pas couverte par cet article.

Since the late 1960's the Computer Science Department at the University of Calgary has enjoyed a major research presence in the field of human-computer interaction, and the last five to ten years have seen sharply increased emphasis on AI topics and methods. This trend was focused and strengthened by the establishment in 1985 of the Knowledge Science Institute (KSI), whose objectives are to study knowledge science, technology, economy and social impact, and to promote interdisciplinary research on knowledge-based systems. This has involved the provision of space, capital equipment, operating funds, the attachment of faculty, and the recruitment of research staff.

While the KSI operates as a network of multi-disciplinary research groups spanning several faculties and academic disciplines, this overview concentrates on knowledge science research undertaken by, or in close collaboration with, computer science faculty members. It is divided into the areas of knowledge acquisition for expert systems; machine learning and programming by example; system theory and organization (especially modeling and prediction); and logic programming. However, different projects mingle and overlap, and in practice no real distinction is made between those that involve artificial intelligence techniques and those that do not. Research in allied fields of computer science, such as human-computer interaction, distributed systems, and formal methods for software and hardware verification, is not covered here.

Research in Knowledge Engineering

A model of the development of the computing industry has been developed and used to account for past events and predict future trends, particularly fifth and sixth generation priorities. The industry came into being as a result of electronic device technology; thus enabling society to cope with an increasingly complex world. Underlying all developments in computing is a tiered succession of learning curves which make up the infrastructure of the computing industry. The model provides a framework for the industry based on this logical progression of developments. It links the framework empirically to key events in the development of computing. It links the framework theoretically to a model of economic, social, scientific and individual development as related learning processes with a simple phenomenological model. The fifth generation development program, with its emphasis on human-computer interaction and artificial intelligence, and the sixth generation program, with its emphasis on knowledge science, are natural developments in the foci of attention indicated by the model [9, 10].

Knowledge engineering represents a key technology within this model, and is a cornerstone of our activities.

Rapid Prototyping

Knowledge acquisition techniques are being developed for rapid prototyping of knowledge-based systems [14, 15, 16]. Problems of knowledge engineering have been recognized since the early days of expert systems and are impeding practical applications. It is difficult to elicit from experts the knowledge structures underlying their skills. This has heightened interest in the possibility of providing knowledge support systems to automate knowledge engineering as a process of direct interaction between domain experts and the computer [6, 8]. In 1980, we proposed that personal construct psychology could provide foundations for expert systems, particularly in systems that combined interactivity with database access and expert advice to provide decision support, and gave examples of algorithms and programs that extracted entailment rules from repertory grid data. In 1983, we reported further enhancements of these techniques and a preliminary experiment to validate them empirically as a knowledge engineering technique for priming expert systems. This work led to industrial studies of the methodology applied to the development of expert systems: Boeing Computer Services and Lockheed Software Technology Center have reported success in applications; and validation has been reported in a statistics domain.

Ian Witten and Brian Gaines are professors at the University of Calgary. Brian Gaines is founder and director of KSI.

The knowledge acquisition research focuses on the use of techniques based on personal construct psychology to automate knowledge engineering for expert systems. Knowledge support systems are being developed as interactive knowledge engineering tools, and the design criteria for such systems are being clearly defined. KITTEN is a knowledge support system developed for AI workstations which includes tools for interactive repertory grid elicitation and entailment analysis that have been widely used for rapid prototyping of industrial expert systems. It also includes tools for text analysis, behavioural analysis and schema analysis, that offer complementary and alternative approaches to knowledge acquisition. The KITTEN implementation integrates these tools around a common database with utilities designed to give multiple perspectives on the knowledge base [17, 18].

A wide range of tools developed elsewhere are also being investigated such as AutoIntelligence, ETS, KSSO, and NEXPERT; and validation studies are being undertaken of the performance of these tools in eliciting and structuring expert knowledge.

Hypermedia and Knowledge-based Sports Coaching

In the Knowledge Science and Neuro-Motor Laboratory in the Faculty of Physical Education, studies are being undertaken of knowledge-based sports coaching systems and the cognitive foundations of knowledge transfer [19]. The research focus is on eliciting, understanding, and applying the knowledge structures underlying the performance skills of athletes and the coaching skills of those involved in their selection and training. The abstract knowledge structures for sports coaching have been developed independently of specific sports. They have been shown to lead to significant analyses of a wide range of sports that guide the generation of coaching strategies and the individual acquisition of playing skills, and to be meaningful and comprehensible to both coaches and players. These knowledge structures are being applied through a variety of media, including books and computer-based hypermedia systems [20].

The new *Steps to Success* book series from Human Kinetics Publishers is based on the explicit use of the structures, and is available in handbooks for athletes and coaches. Initially ten sports are covered including archery, badminton, basketball, golf, gymnastics, tennis and swimming. In the research laboratory a range of hypermedia systems based on the knowledge structures are being developed, including an expert system for ice hockey coaching which was shown at the Winter Olympics in February 1988. This runs on a Macintosh using specialist knowledge acquisition, videodisc and CD-ROM control software. Film for the videodisc has been shot during a number of international games and associated training sessions.

Knowledge Processes in Society, Manufacturing and Human-Computer Interaction

A number of fundamental studies have been undertaken of the way in which knowledge develops in society through a variety of social and psychological processes [5, 7]. The results of these studies have direct implications for the design of expert systems to support the formation of expertise and to avoid problems of legal liability. The knowledge processes involved in manufacturing have been studied and modeled as part of the development of expert systems for computer-integrated manufacturing. The knowledge structures underlying human-computer interaction have also been studied in depth as part of the development of knowledge-based user interface management systems. We see major advances in a number of disciplines being possible through the development of overt knowledge structures available on shared knowledge bases to scientific and technological groups and communities. Our work in this area is now focusing on computer support of collaborative research, knowledge-based heterogeneous system integration, and the use of object-oriented knowledge bases to support creative thinking processes.

Knowledge Acquisition Workshops

The KSI has been heavily involved in organizing a series of workshops on knowledge acquisition for knowledge-based systems (KAW) attended by research workers worldwide. Three KAW's have been held in Banff, sponsored by the American Association for Artificial Intelligence and co-chaired by John Boose of Boeing Advanced Technology Center and Brian Gaines of the KSI. For the first KAW in November 1986, the intention was to hold a discussion-intensive meeting of some 35 highly involved researchers. In practice, over 120 papers were submitted and some 500 applications to attend were received from some 30 countries. This level of interest lead to a further AAAI KAW in Banff in October 1987 and another in November 1988, to an IEEE-sponsored KAW in England in September 1987, to an ACM-sponsored KAW in Germany in June 1988, and to a shorter KAW emphasizing integration issues at AAAI in St. Paul in August 1988. Further Knowledge Acquisition Workshops are already scheduled for Paris, Amsterdam, Tokyo and Banff in 1989 and 1990. These workshops have had a great impact on the literature on knowledge acquisition, resulting in some sixty journal papers and three books to date, and the discussion resulting from them has stimulated knowledge acquisition research worldwide.

Knowledge Engineering Training Program

An intensive one-year training program has been developed for knowledge engineers. Funded by a grant from Employment and Immigration Canada, the program was given to eleven professionals at graduate level from April 1987 through March 1988. The students, with degrees in a range of topics including computer science and psychology, were also employed as research assistants for a number of projects. Courses have been given in knowledge engineering, instructional design, computer hardware and telecommunications, software development and advanced software systems, videodisc development and human performance.

The training program has aroused much industrial interest and it is expected that the material will be widely disseminated and used for internal training programs and short courses. Arrangements are being made to repeat the program this year.

Research in Machine Learning and Programming by Example

A strong research interest in machine learning has emerged like a phoenix rising from the funeral pyre of adaptive control systems in engineering (some of us have

murky pasts). The phenomenon of adaptivity underlies much of our work. So does a central fascination with human interfaces and the communication of information between man and machine. Thus we stress teaching as much as learning; the provision of a congenial environment for casual users to transfer their knowledge and skill.

Robot Programming by Example

Studies are being undertaken to improve communication of human requirements to robot systems. The aim is to enable computer-controlled systems to be taught everyday tasks by people skilled mainly at the tasks. The people should not need, and will not have, the kind of expertise of today's programmers. Existing computer controlled systems — for example, robots and office systems — lack instructability and adaptability. People find it difficult to translate their task skill into explicit procedures for robot, office and other systems. The research aims to enable non-programmers to specify procedures, without having to do this explicit translation.

A high-precision robot arm has been acquired for studies of robot instructability. Initially the robot will be used for research into techniques for non-programmers to specify tasks to robots, as applied to hospital drug dispensing. It will be tested as part of the Calgary Foothills Hospital automatic, robot-based drug dispensing system. The system will select unit doses of drugs and put them into individual patient trays. In a small operation such as this, the pharmacist himself will have to be capable of setting up the dispensing tasks and modifying the robot's performance.

A number of existing programming-by-example systems have been studied and reconstructed in the laboratory. An MIT scheme for creating robot programs from example traces has been reimplemented. A number of shortcomings which were not apparent in the original research for learning object transforms from a user's physical positioning of the arm were addressed. A partially complete program leaves undefined those transforms not available from standard CAD data for a task, and the user can conveniently show the required movements at run time. In addition, the use of quaternions is being investigated as a compact and coordinate-independent representation for robot limb rotations, suitable for inducing functional relationships in tasks comprising straight line motions.

Programming by Example in the Human Interface

The user interface provides a multitude of opportunities for programming by example which are being investigated. Rather than concentrating solely on technical methods of inducing programs from examples — an endeavor which became rather sterile in the mid-1980's after an initial flush of enthusiasm — this research emphasizes the central role that interaction can play in clarifying users' intentions. We have studied the acquisition of procedural knowledge, or "know-how", from end users in the domain of interactive graphics. Experts express procedures constructively, using any of the tools available in the interactive drawing environment, and well-structured procedures are inferred using a variety of weak generalization heuristics. A second application domain being investigated is that of casual-user interaction with office computer systems using the metaphor of an automated office clerk, while a third is in the realm of text editing. Another example of this kind of work is the "reactive keyboard", invented some years ago at the U. of Calgary to help disabled people interact textually with computers.

A central theme underlying this work is the importance of the teacher's view of the learner and his capabilities. Teacher and learner share a common world and have the same capacity for action, an "equal-opportunity" situation. By eagerly carrying out predicted actions (which the teacher can undo if incorrect) the learner may encourage the teacher to satisfy appropriate felicity conditions and make explicit the conditions underlying his actions. In case of ambiguity, dialogue boxes serve to allow teachers to clarify their intentions.

Machine Learning

Many more technical topics in machine learning are being pursued. Our methodology is to begin by reconstructing influential learning systems developed elsewhere. We have reconstructed well-known version space systems, example-generating systems, statistical concept learners, explanation-based learning algorithms, planners, the exploratory learning system AM, and numerous schemes for function induction. In so doing we have learned important lessons and built a springboard for developing our own ideas [13, 25].

Methods for creating structural descriptions from examples involve searching a huge space of possible structural descriptions to check consistency with incoming examples. Efficient ways of representing such spaces in terms of their boundaries are being studied and extended to deal with infinite sets of descriptions (which often arise in practice). Ways of automatically constructing crucial examples which discriminate effectively between competing hypotheses are also under investigation. Shortcomings have been discovered in existing systems for example generation (in particular, the examples generated may be insufficiently general); these are being rectified in a new program which has been built.

Explanation-based learning (EBL) is a semantically-based, knowledge-intensive paradigm for machine learning which contrasts sharply with syntactic or "similarity-based" approaches mentioned above. The EBL technique has been redeveloped from the perspective of problem-solving, and studies have been made on how to embed a learning capability into standard inference engines. The work is being extended to the domain of single- and multi-agent planning. We reject the current trend to isolate learning from other activity and study it separately, preferring instead to integrate it into the very heart of the problem solving [12].

Function induction attempts to synthesize a functional relationship from input-output examples. The data may be structured, with numeric and non-numeric parts. Primitive functions are provided to the system, as are known constants which may be used in functions. We are investigating a number of different algorithms for function induction and comparing their performance both theoretically and practically.

Research in System Theory and Organization

Our fascination with adaptation, mentioned above, also manifests itself lower on the phylogenetic scale of "artificial intelligence" in research on text modeling, prediction and compression. The representation and

management of uncertainty is another common thread which runs through many projects. Also, a strong interest in autonomous and parallel systems colours much of our work.

Text Compression

Complementing the structural work on machine learning is a long-standing and intensive research effort in adaptive text analysis and compression, which grew out of earlier work on adaptive modeling. A text compression method developed at the U. of Calgary in 1982/83 still outperforms all known techniques, most of them by a considerable margin. It typically achieves 2.2 bits/character on mixed-case English, and in a recent Australian competition for a compression program both joint winners used variants of our method. A wide variety of compression techniques have been studied and previously unsuspected relationships between them have been found. The two dominant techniques for adaptive coding are statistical and macro methods, and these have been compared and related. Moreover, a very extensive collection of previously described compression methods has been implemented, tested, and assessed [24, 1].

Good compression requires good prediction of text, and studies are being made of the application of the predictive methods to various areas within both the human-computer interface and machine learning; this relates to the programming-by-example research mentioned above [23].

Modeling Uncertain Data

As our systems move more and more into the real world, uncertainty management becomes increasingly important. Rapid prototyping of expert systems involved inferring relationships from uncertain or "fuzzy" data, and the KITTEN system mentioned earlier contains a novel mechanism for fuzzy inference [11]. Within machine learning, efforts are being made to address the problems of creating learning systems that can recover from errors, for it is unlikely that they will find much practical application until they are robust enough to cope with the inevitable vagaries of real-life situations.

Theoretical work on uncertainty management includes a new, unifying framework that encompasses both probability and fuzzy logic, as well as two-valued classical logic, as special cases of a general "standard uncertainty logic" based on valuation of lattice. A separate project has considered the problem of acquiring uncertain rules from examples within a three-valued logic under the ambit of logic programming [2]. A firm theoretical foundation for three-valued logic programming has been established, including a Horn clause subset, procedural interpretation, extension of the standard Herbrand universe and least fixed-point semantics, and a proof of the correctness of SLD-resolution. Finally, the use of stochastic processes in neural nets has been investigated as a basis for representing uncertain inference.

Autonomous Systems

It is apparent that while many future automated systems will have to operate autonomously, little progress is being made towards this goal. We are looking at the phenomenon of autonomy from three directions[21]. The first regards autonomy as self-government or self-motivation. This is represented by some AI research on representing and using goals, together with physiological, psychological, and philosophical accounts of motivation and goal-seeking behaviour. The second concerns the biological independence of organisms which have the ability to maintain their own organization in a capricious environment. The third aims to construct instructable systems that can learn and carry out instructions autonomously but are not self-motivated.

Work in self-motivation is related to the machine learning research discussed above; in particular the reconstruction of AM. The most concrete examples of artificially autonomous systems of the second genre are various kinds of "deviant" software: worms and viruses; and we have performed experiments and undertaken extensive studies of these phenomena [22]. The third kind includes programming-by-example systems, where the user interface gives learning a human-like autonomy.

Connectionist Architectures

The renewed interest in neural-like processing systems has stimulated a re-evaluation of older paradigms for system organization in terms of massively parallel architectures. For example, we have shown how neural-like systems can be related closely to other well-known formulations of computing such as production systems, finite-state automata, Markov decision processes, and Turing machines. We have studied how novel information representation schemes such as stochastic representations are eminently suited to massive parallelism; benefits of this approach are both theoretical and practical. We have made a detailed theoretical and empirical study of the Boltzmann machine from stochastic, Markovian and Bayesian viewpoints. We have designed a new VLSI architecture which serves as a building-block for connectionist systems and shown how this can be used to tackle such apparently sequential problems as the n-Queens puzzle and chess playing.

Research in Logic Programming

A major part of the research centers around logic programming, and theoretical and practical studies of programming in logic have been undertaken. (However, we have catholic tastes in language and our implementations are based on Prolog, Lisp — mostly Scheme — and Smalltalk in approximately equal proportions).

Logical Arithmetic

In the past, implementations of real arithmetic within logic programming have been non-logical. This is a fundamental deficiency which detracts seriously from the logical paradigm. The meaning of programs depends on the order in which statements are executed and on the details of the computer's handling of finite-precision arithmetic. We have discovered how a purely logical interpretation of arithmetic can be created by the use of interval arithmetic as the underlying representation [3]. This can be translated to an implementation within Prolog and invites a redefinition of the language's arithmetic capabilities to use intervals to represent numbers. As well as having a sound logical basis, the resulting system allows a very concise and powerful programming style and is potentially very efficient.

Parallel Prolog using Time Warp

Current research on parallelism in logic programming focuses on AND-parallelism, in which the goals of a conjunction are executed concurrently (the alternative is OR-parallelism which explores different ways of achiev-

ing a goal in parallel). The most difficult problem in implementing a distributed AND-parallel system is resolving conflicting variable bindings. Our scheme uses the ideas of "time warp", a mechanism first proposed to implement the virtual time paradigm in distributed simulation, to solve this problem. Simply put, bindings are given timestamps, and conflicts are resolved by comparing these timestamps.

AND-parallel implementations not using the virtual time approach either restrict the parallelism available, or adopt a "committed-choice" strategy and thereby sacrifice the full nondeterminism of standard Prolog. In contrast, our implementation preserves the semantics of sequential Prolog while allowing maximum parallelism. Two considerations motivate this choice: first, for many problems nondeterminism must be retained; and second, maintaining full compatibility with sequential Prolog allows application programs to be ported directly. Variants of the scheme which support non-terminating programs and provide smart backtracking in a sequential system are also envisioned. Another avenue of investigation is adapting Prolog for use in distributed simulation. This adaptation is also based on time warp, but requires parallelism and interprocess communication to be expressed explicitly.

Prolog Programming Environments

We also have a practical interest in constructing programming environments for Prolog. We have built interactive interfaces to the EMACS text editor, a system which displays debugging information graphically [4], a LINT-style utility that checks the internal consistency of Prolog programs, a library facility that allows easy construction of multi-module programs, documentation and typesetting aids in the style of Knuth's "literate programming", and are investigating the practical application of type inference schemes. We have also constructed a number of Prolog interpreters.

Facilities

The Computer Science Department in general, and the Knowledge Science Institute in particular, is well-equipped for research. The main departmental workhorses are several SUN-4 systems running UNIX (one dual-processor VAX-780 remains as a relic from the olden days). There are a number of high-performance workstations (Symbolics and Xerox Lisp machines for AI, IRISes for graphics) as well as many general-purpose SUN workstations. A network of Apollo workstations resides in the KSI, together with a robot arm and the usual assortment of Macintoshes and IBM PC's. A BBN Butterfly is used for work on parallel algorithms. We have access to sophisticated helmet-mounted eye-tracking equipment in the Faculty of Physical Education. The university possesses super-computing facilities (Cyber 205) and supports a large Honeywell Multics operation.

Software resources include Prolog, Scheme, and Smalltalk implementations on most machines (including, for many researchers, Macintoshes at home). The NEXPERT expert system shell is used for expert system prototyping and development. Important components of our support environment include Gnu EMACS, TeX, and electronic mail. Virtually all computers are fully networked with high-speed (10Mbits/s) links. In the summer of 1988 most large departmental research projects, including the AI research, are moving to newly-available space, which is being specially modified for our needs, and will be extensively wired with network and other communication facilities.

Researchers

Computer Science faculty engaged in this research include John Cleary, Brian Gaines (founder and director of the KSI), Paul Kwok, Bruce MacDonald, Mildred Shaw, and Ian Witten. Faculty from other departments who are associated with the KSI are Bruce Clark, Institute for Computer-Assisted Learning; Larry Katz, Faculty of Physical Education; Doug Norrie, Department of Mechanical Engineering; and Joan Vickers, Faculty of Physical Education. Notable visitors who have spent extended periods in the KSI recently include John Andreae, University of Canterbury, New Zealand; Tim Bell, University of Canterbury, New Zealand; Harold Thimbleby, University of York, UK; and Brian Woodward, Knowledge Science Institute.

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AI Research and Development at CompEngServ, of the CEMTECH Group Ltd.

by Archie Bowen

Recherche et développement en IA à CompEngServ, du Groupe CEMTECH Ltée.

RÉSUMÉ: CompEngServ Ltée., une compagnie entièrement contrôlée par des intérêts canadiens qui fait maintenant partie du Groupe CEMTECH Ltée., dispose d'une expertise dans la conception et l'implantation de logiciel temps réel et de logiciel d'intelligence artificielle. Les projects complétés ou en cours incluent des systèmes pour la gestion de la recofiguration des communications, la résolution de conflits en aviation, la résolution de l'interférence électromagnétique, la mesure de la qualité de l'air intérieur, le chargement en billets automatisé pour les caissiers automatiques, la simulation de jeux de guerre et le diagnostic de systèmes de communication.

CompEngServ Ltd., now part of the CEMTECH Group Ltd., is wholly Canadian owned and has special expertise in the design and implementation of real-time and artificial intelligence software. CompEngServ was originally established in 1975 by Dr. B.A. Bowen in Ottawa to service industry and government.

Our professional employees are in the fields of engineering, computing science and psychology. All expert systems and AI projects are located in our Ottawa office.

Completed Expert System Projects

Our expert systems group has completed several projects since 1983; these are discussed below.

Planning Systems — *Communications Reconfiguration Management*

The Reconfiguration Management Expert System was designed and implemented for a U.S. Air Force early warning radar surveillance system. This knowledge-based system uses intelligent databases and rules derived from the experience of senior managers. It supports the anticipated extensive modifications to the external flight data communications requirements of this new radar technology during the design, implementation and operational phases.

Dr. Bowen is the Chief Operating Officer of the CEMTECH Group Ltd., Ottawa, Ontario.

The system represents a unique integration of expert systems and databases — the state of the art in the use of a frame-based intelligent database and a knowledge base.

This system was implemented in Goldworks, a Lisp-based tool containing an extensive database, help menus and about 250 rules. The number of rules is augmented by the intelligence of the object-oriented database, and is not a true indication of the inferencing complexity.

Another consideration when building the expert system was the capacity to create scenarios for training new operators; situations could be proposed and analyzed as a method of providing a tutorial. Each prepared situation is analyzed, explained and the rules used to create the correct configuration given to the trainee.

Transportation-Related Systems — *Aircraft Conflict Resolution*

This work involved a detailed analysis of the way in which air traffic controllers operate. The results of this study were then analyzed further to determine which functions were best executed by classical software and which by knowledge bases. The findings were then organized into an overall algorithm which was implemented and tested against cases proposed by controllers.

The system was implemented in TIMM, an inductive reasoning tool. This provided high performance (ap-

proximately a 10-second response time) and contained 750 rules. TIMM rules have small antecedents and, in a more conventional language, this number would be closer to several hundred.

The utilization of expert systems, in this field, is a world-wide activity. Our approach has demonstrated a leading position for Canada in this field. Extensions to this work to include dense airspace have been published by invitation in an AGARD lecture series held in October 1987.

Diagnostic Systems *— Resolution of Electromagnetic Interference*

Electromagnetic Interference Resolution (EMIR) is a classical diagnostic package composed of three main components. The first component is a set of queries which attempt to form a set of hypotheses of possible causes. The next is a set of recommended tests to validate or to further reduce the set of hypotheses. The last component is a set of suggested remedial actions. The tests and the remedial actions have costs associated with them and the system attempts to offer minimum cost alternatives to the operator.

A particularly interesting aspect of this system is the requirement for use by qualified, but not expert, technical operators. Thus, the system has been designed such that the majority of questions are of the yes/no variety. Finally, the system must generate reports not only of the interference, but of the process of solving the problem for review by the centrally-located expert.

This system was implemented in Insight 2+, a Pascal-based tool. It contained 150 rules and an extensive database.

Studies

Artificial Intelligence and Expert Systems: Impacts on the Museum Community

We have conducted a study on the work being done in AI on expert systems, to determine if there were appropriate applications available for the activities and operations of the National Museum of Canada. The goal was to develop intelligent interfaces to the CHIN (Canadian Heritage Information Network) database for both the input and output requirements of archaeologists, research scientists and the general public. CHIN is a very large database used in part by non-professionals.

The requirement was to define the structure of the CHIN system and to determine if AI was sufficiently far advanced to form a useful interface to the CHIN system.

The major issues at the time were: i) to determine the state of maturity of AI, and ii) its real-world applicability in providing intelligent interfaces to an existing and structurally unalterable database. There were two further issues to be resolved: i) could the existing technology (e.g. methodology, hardware, software, etc.) be transferred to another computer environment; and ii) could the museum cost-effectively adopt such a technology, and when.

The use of artificial intelligence technology as an adjunct to enhance the access to a large database is still emerging from the research laboratories. The plan involved a detailed study of the current capabilities of expert systems to represent an outer shell around the database for interpreting and assisting in data entry and access.

Hydro Quebec Planification Project

The project involved the investigation of the feasibility and applicability of expert systems to Planification of Hydro Quebec. The Planification Group is concerned with making recommendations on new projects. The field requires basic engineering practice; however, large portions of the decisions were based on experience gained over the years by senior members of the design team. The question was: Could this expertise be captured, represented and organized in such a form that it could contribute to the process of preparing recommendations for future projects?

The application of expert systems to the Hydro Quebec planning environment was novel. The system requires both knowledge bases and conventional software. The resulting prototype (30 rules in PC+) clearly demonstrated that hybrid systems including knowledge bases and conventional engineering software could be incorporated into a planning system to enhance the productivity of the design team.

Applications in Ground Transportation

In cooperation with DeLCan Engineering, we have just completed a study of ground transportation problems and identified the areas for which expert systems might provide a solution. These areas were first identified using a Delphi-like technique and then analyzed and prioritized using an evaluation methodology developed at Comp-EngServ.

Current Expert System Projects

We are currently involved in the development of several expert systems; these projects are described below.

Aircraft Conflict Resolution: Phase II

This system (named CORES, for COnflict RESolution) is being developed for the Transportation Development Centre.

The system is based on previous work which resulted in a prototype for the resolution of conflicts involving only two aircraft. CORES extends this work in several areas including the user interface, the consideration of multiple aircraft and issues surrounding induced conflicts. The CORES system will function within airspace where solving an initial conflict may induce further conflicts. The issues of convergence from an airspace with induced conflicts to a conflict-free airspace is central to the project. Strategies involving constraint relaxation for tactic selection are also being examined.

The CORES system interface for the controller is being designed with maximum flexibility, ease of use and best use of available information in mind. Other proposed air traffic control systems are being examined to ensure a degree of compatibility.

The system is being implemented using the Lisp-based system builder KEE. The system will run on a 386-based workstation with a high resolution monitor and mouse.

The duration of the project is thirteen months with a project team of five people.

Indoor Air Quality

Determining the quality of indoor air requires knowledge and experience. The scope of knowledge and experience necessary to deal with this problem requires

several areas of expertise. Hence, sharing information and knowledge is critical to increasing the understanding of air quality problems. Traditional approaches to information dissemination and training have not been completely adequate.

Our task is to develop a "prototype" expert system on behalf of Public Works Canada. The objective of the expert system is to provide the necessary information and knowledge to a particular group of employees within Public Works Canada so that the employees can execute their role in a thorough and efficient manner.

The Automatic Teller Machine Expert System

The Automatic Teller Machine Expert System (ATMES) is a joint research project between the C.S. CO-OP and CompEngServ. Its purpose is to automate the determination of cash loading for automatic teller machines, and to discover new information that will better match the cash loads to cash needs. It is to reduce the cash residual in each automatic teller machine under normal usage, yet accurately forecast when heavier loads will be needed.

The system is being developed in Insight 2+ and Turbo Pascal.

War Games Simulation

This system is being developed in conjunction with MEL Defense Ltd. Its function is to conduct war games based on the characteristics of the red team. The initial phase will be to create the complete design and to estimate the size and complexity. The key attribute will be to allow the input of the known personality characteristics of the red team commanders.

Communications System Diagnostics

This system is a diagnostic system designed to assist in the diagnosis of faults in a complex computer communications system (the SHINPADs system marketed by Leigh Instruments). The expert system will have access to the capabilities for automatic testing and also call for technicians' input, when needed, to arrive at a decision.

The system will be implemented in either KEE or Insight 2+, depending on a decision to be made during the summer.

AI Research at Bell-Northern Research

by Dick Peacocke

La recherche en IA à Bell-Northern Research

RÉSUMÉ: Le programme de recherche en IA à Bell-Northern Research (BNR) vise à explorer et développer des techniques d'IA pour utilisation dans les produits et services comercialisés par BNR et ses compagnies mères et pour utilisation dans les processus de conception et de développement. En plus de faire de la recherche sur les systèmes experts et le traitement des langues naturelles, nous étudions des techniques et algorithmes pour automatiser la conception et le développement de logiciel et augmenter la productivité du développement. Parmi nos projets spécifiques, certains concernent l'entretien des commutateurs, la configuration d'équipements, la configuration de réseaux, le génie de conception de circuits et le filtrage de la poste électronique.

Bell-Northern Research (BNR) is the research and development organization for Northern Telecom and Bell Canada, with more than 6,700 staff in laboratories across Canada, USA, and in the UK. Speech and image processing have been the focus of research for more than a decade, and the artificial intelligence program has been running for four years.

The scope of the AI program is to explore and develop AI techniques for use in products and services provided by BNR and its parent companies, and for use in design and development processes. A core AI group was formed at the beginning of 1984 to handle basic technology issues, and to help define and support applications throughout the corporation. The core group is also responsible for liaison with AI activities in universities and government. This liaison is viewed as an important task, leading (it is hoped) to collaboration in some instances.

Telecommunications and information systems are major products of Northern Telecom. As they become more and more sophisticated in their capabilities in the future they must still be easy to use and manage. A central theme for AI work at BNR is coupling machines and people together in the performance of complex tasks.

At BNR we believe that many of the tasks involved in establishing and operating telecommunications networks can be done using expert systems, and indeed we believe that these types of system will soon be essential in helping people perform the complex network tasks required of them. Examples of such tasks are:

- planning and design
- engineering

Dick Peacocke is Manager of the Knowledge Technology group at BNR. He is President of CSCSI/SCEIO, and Adjunct Professor at Carleton University. He has a Ph.D. in computer science from the University of Toronto.

Application	Product Area	Function
Switch maintenance	DMS-100™ family of digital switches	Provide advice on trouble-shooting to technicians operating a digital telephone switch
Access maintenance	ISDN access	Provide advice to customers on loop access equipment and procedures
Monitoring and maintenance	DATAPAC™	Collect and analyze alarms from a packet switching network. Recommend appropriate maintenance actions
Configuration of equipment	Business Communications Systems	Transform user and site requirements as entered on a form into detailed hardware, software, and layout
Configuration of private data networks	Bell Canada data communications services	Choose the most appropriate data service(s) based on clients' terminals, hosts, protocols, transaction volumes, etc.
Circuit design engineering	Bell Canada Special Service Digital Network	Automate the circuit design process for certain types of special service circuits
Software engineering	DMS-100 software life cycle	Use a knowledge base to capture software design input. Derive documentation, test cases, design checks, etc. from the knowledge base
Natural language interface	Use on relational or entity-relationship databases	Provide a processor for database queries expressed in English instead of in a formal query language like SQL
Screening electronic mail	Business Communications Systems	Monitor, screen, and take action on mail based on organizational knowledge and personal rules specified by users

Table 1. Knowledge-based Prototypes at BNR

- operations
- maintenance
- administration.

Complexity of the telecommunications network is increasing rapidly with the introduction of new functions and services, increased connectivity, and the advent of new components. This means that fewer and fewer tractable algorithms exist for the tasks listed above. Expert systems allow implementation of procedures where more emphasis has to be placed on our experience and what we know about situations and events surrounding them, rather than on formal sequential algorithms. After articulating and transforming our knowledge of the network and its operations into suitable representations, we can then apply that knowledge to the tasks that need to be done. Our aim is to enhance the scope and effectiveness of these tasks, increasing the quality of work performed, and reducing the effort required. This has an impact on documentation and training, and it will increase the ability to absorb new technology.

The telecommunications network is a particularly fertile area for applying expert systems because the network and its equipment form a highly-structured synthetic domain. (This compares with domains such as medicine or geology where the underlying rules of operation are based on natural phenomena, and extensive — often visual — descriptions of these phenomena are required.) Some knowledge-based prototypes that have been built at BNR are shown in Table 1. Interesting issues include domain characterization, knowledge elicitation and representation, development of methodologies, selection of tools, and prototyping and testing expert systems.

Two of the entries in the table are not really expert systems. They represent work in natural language processing, and work in applying AI to software engineering.

Natural language research at BNR is aimed at intelligent human-machine dialogue. Natural language has been studied from both the computational and behavioural points of view. The strategy used is the "entire system strategy", viz. building and using entire natural language programs rather than concentrating on isolated phenomena. An experimental domain-independent natural language interface has been developed for an existing entity-relationship database management system. Both the in-house and a commercial natural language system have been used to study behaviour of users interacting with an operational database. Issues of interest include different modes of dialogue, how context is used, and dynamic patterns of focus.

In addition to research in expert systems and natural language processing, we have been investigating techniques and algorithms for automating the design and development of software systems and improving development productivity. This work places particular emphasis on specific BNR domains. The term "development" as used here includes all of the software life-cycle phases from requirements and specification

through to testing, release, and maintenance. Topics of interest include rapid prototyping, intelligent development environments, and automatic test generation.

As computing environments, we have been using Xerox Lisp machines with Interlisp-D, KEE™, Prolog, S.1™ and LOOPS™, Prolog on a proprietary 68000-based family of workstations, Prolog and Lisp on IBM mainframes, and several small shells for PCs and the Macintosh™.

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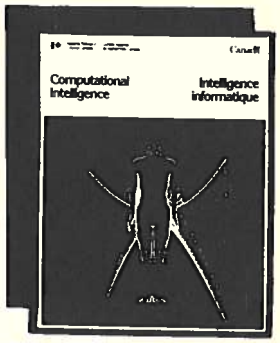

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During publication of Volume 3 **Computational Intelligence** introduced a new *Taking issue* section with an outstanding contribution debating logical approaches to artificial intelligence. This first "taking issue", edited by Hector Levesque, is a position paper by Drew McDermott entitled *A critique of pure reason.* The section includes commentaries by J. Allen and H. Kautz • D. Bobrow and M. Stefik • K. Bowen • R. Brachman • E. Charniak • J. deKleer • J. Doyle • K. Forbus • P. Hayes • C. Hewitt • R. Kowalski • R. Moore •G. Hinton • J. Hobbs • D. Israel • J. McCarthy and V. Lifschitz • N. Nilsson • S. Pentland •D. Poole • R. Reiter • S. Rosenchein • L. Schubert • B. Smith • M. Stickel and M. Tyson • R. Waldinger • T. Winograd • W. Woods, as well as a final response from McDermott.

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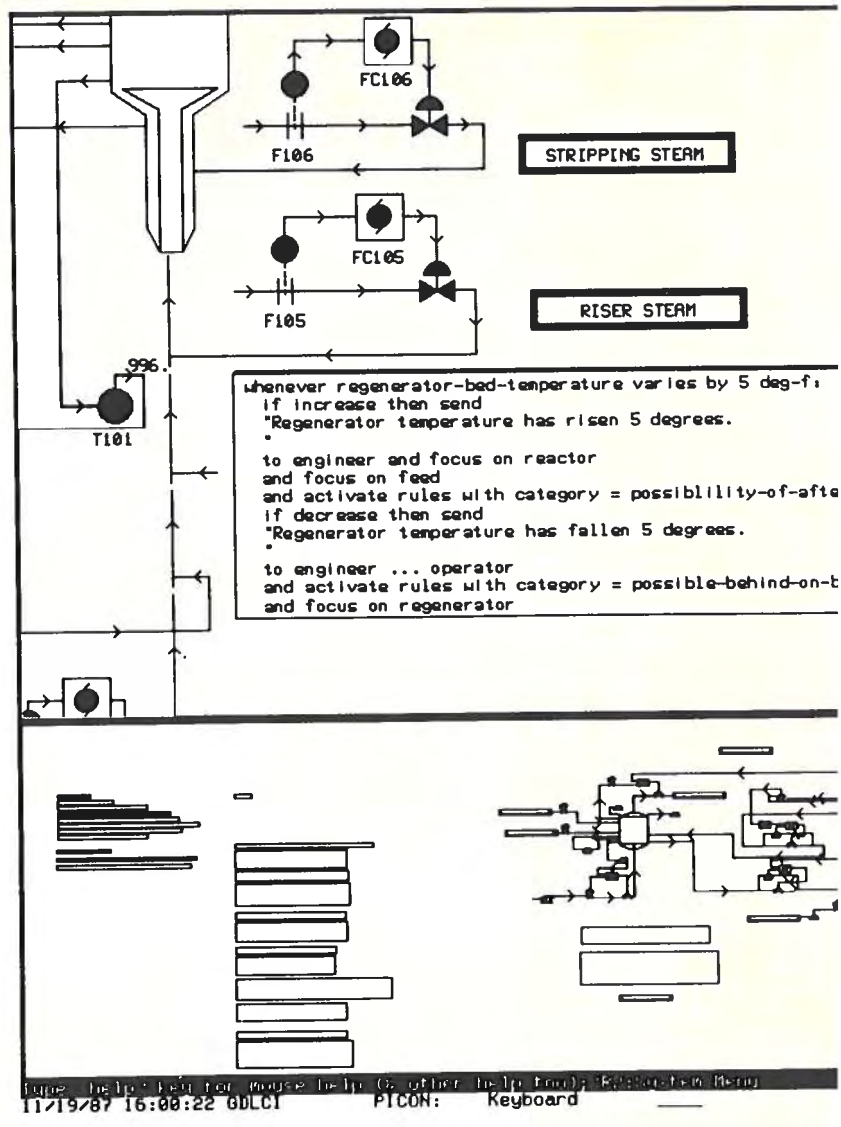

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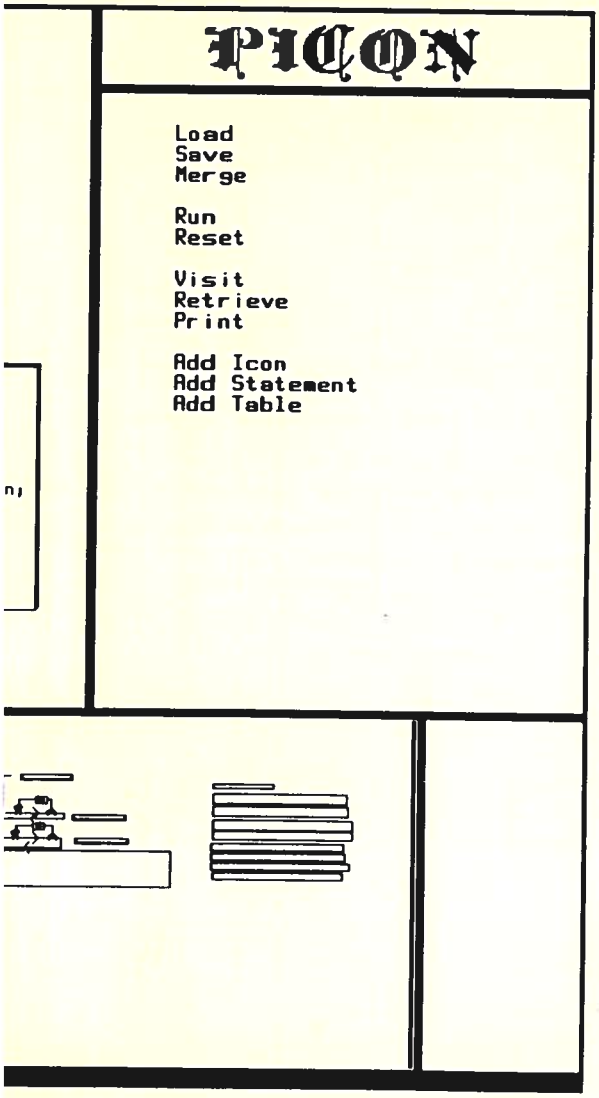

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CIAR Graduate Student Workshop on Knowledge Representation

Edited by Howard Hamilton and Sharon Hamilton

Colloque de l'ICRA pour étudiants diplomés sur la représentation des connaissances

RÉSUMÉ: Ce colloque, auquel assistaient 27 étudiants diplomés, fut subventionné par l'Institut canadien pour la recherche avancée (ICRA). L'ICRA vise à promouvoir la recherche dans des domaines stratégiquement et intellectuellement importants. Durant la première matinée, les participants présentèrent leur recherche au moyen d'affiches, suscitant ainsi des discussions intéressantes. La majeure partie du colloque fut consacrée à neuf sessions de discussions sur des sujets représentant des connaissances tels que la docilité (tractability), le temps et la causalité, le raisonnement non monotone, le diagnostic, la robotique, la compréhension des langues naturelles et le raisonnement qualitatif. Le texte du discours du banquet sur l'avenir de la recherche en représentation des connaissances, donné par Alan Mackworth, est inclus dans cet article.

4 - 7 June 1988, Edmonton, Alberta

In June, a CIAR Graduate Student Workshop on Knowledge Representation was held in Edmonton. The following three-part article resulted from the workshop. First Zenon Pylyshyn gives a description of CIAR and its reasons for supporting the workshop; then two participants, Howard and Sharon Hamilton, give a report on the workshop; and finally Alan Mackworth gives a written version of the banquet speech he presented at the workshop.

CIAR Program in Artificial Intelligence and Robotics

Zenon Pylyshyn

As many readers are probably aware, the Canadian Institute for Advanced Research (CIAR) is a privately funded institute (currently with some matching federal government funds) which promotes research in strategically and intellectually important program areas. The institute also receives public funding from the federal and provincial governments. It has concentrated its support in areas which are particularly likely to benefit from nonstandard financial aid because, for example, the fields are intrinsically interdisciplinary or because the talent is thinly spread through the country. CIAR does not provide operating grants for research, but provides funds for encouraging individuals to spend more time on research activities in Canada. It does this by awarding fellowships, scholarships, and associateships to deserving individual researchers in the program areas, and by providing "interaction funds" for collaborations, exchanges, and workshops such as the one described in this article.

The first and largest of CIAR's program areas is artificial intelligence and robotics (broadly conceived to include the study of intelligent systems, both artificial and biological). This is clearly an area of research that is inherently interdisciplinary and the Institute has been very concerned to promote the interaction among scholars in different fields and at different institutions. We also recognize, however, that senior researchers may have well-established productive research programs to which they are committed and that it would be counterproductive to force these people to establish new collaborative liaisons. In these cases, the most hopeful way of generating truly interdisciplinary activity may lie with their graduate students, who have the potential to establish research programs that cut across traditional boundaries. CIAR has been encouraging this kind of cross-disciplinary thinking through exchanges and through a series of workshops on broad problem areas that are organized by and for graduate students. Beginning with, but not confined to, students of CIAR members, these workshops are intended to allow top graduate students in fields that bear on the chosen problem area to interact freely, to learn of one another's work and approaches, and to establish linkages that may carry on after the workshops.

One of the central goals of the CIAR program in AI and Robotics is the development of a world class community of scholars in Canada, despite the vast geographical spread of our academic institutions. CIAR believes that graduate students are one of the best means of developing such a community. Consequently we have been examining various ways of encouraging the interaction among students and also the interaction of students with researchers across disciplines and across institutions. The workshop described in the following article (the second workshop of its kind) is just one idea with which we have been experimenting. Although we are still learning about what formats and mix of people are best for such workshops, there is already reason to

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Alan Mackworth is a Professor of Computer Science at the University of British Columbia, fellow of CIAR and co-director of the UBC Laboratory for Computational Vision.

believe that new research communities of students are being formed, that students' research experience has been enriched in the process, and that the basic idea is well worth pursuing.

Workshop Report

Howard and Sharon Hamilton

In early June, we attended the CIAR Graduate Student Workshop on Knowledge Representation in Edmonton, which was organized by Bart Selman (U. of Toronto) with assistance from Scott Goodwin (U. of Alberta) and Mike Gruninger (U. of Toronto). The workshop began on the evening of Saturday, June 4 and ended at noon on Tuesday, June 7, the day before the CSCSI '88 conference. Each CIAR member with an interest in knowledge representation (KR) and several other well-known Canadian researchers in the field were invited to recommend graduate students for the workshop. The graduate students who participated represented six universities: Simon Fraser University (3 people), University of British Columbia (7), University of Alberta(4), University of Toronto (10), University of Waterloo(2), and University of Western Ontario (1). The 27 students included 21 males and 6 females (all 6 from the three western universities). Inevitably, by the way attendance was organized, there were graduate students who would have liked to attend who were not invited: for example, no one from east of Toronto attended. However, the workshop goal of keeping the group small and informal was met.

During the first evening, we attended a wine and cheese reception sponsored by CIAR at the Department of Computer Science, University of Alberta. We wore calligraphic name tags and spent the evening meeting one another and associating new faces with familiar names. The only official event was a short speech by Stuart Taylor of CIAR who explained CIAR's purpose. CIAR currently funds six research programs of which the program in artificial intelligence and robotics is the oldest, best established, and most visible.

The remainder of the workshop consisted of a poster session, talks by invited speakers, and group discussions, interspersed with meals and coffee breaks. The sessions were held on the main floor of St. Joseph's College at the University of Alberta, and the meals and coffee breaks were held in the downstairs cafeteria. Many of the liveliest interactions took place around the cafeteria tables.

For three hours on the first morning, we held a poster session, which allowed us to learn about the other participants' research. Each participant had prepared a poster illustrating his or her work. For thirty minutes, we each stood by our posters and explained, discussed, or defended our research, as the occasion demanded. For the remainder of the time, we wandered around inspecting the other posters and talking to the students standing next to them. The poster format allowed more interaction than a series of brief presentations would have.

Four invited speakers presented talks. The two talks given by Dr. Yoav Shoham, of Stanford, and Dr. Ernest Davis, of the Courant Institute at New York University, were integrated into the schedule of discussion sessions. These talks are summarized below. Dr. Israel Werner, a physicist and CIAR member, broadened our minds with a special invited talk on what is currently believed to have happened in the first fraction of a second following the Big Bang. Dr. Alan Mackworth gave an entertaining banquet address on the future of knowledge representation research (to follow).

The major part of the workshop was the series of nine discussion sessions of approximately one hour each that took place on Sunday afternoon, all day Monday, and Tuesday morning. The topics for discussion were suggested by the participants before the workshop. Each session was moderated by two or three students, and since they typically came from different universities, they became somewhat acquainted before the workshop as they planned their sessions (ah, the wonders of electronic mail!). Most sessions consisted of about 10 minutes of introductory material presented by the moderators, followed by a general discussion. Summaries of the discussion sessions and the two invited KR talks follow.

McDermott's "Critique of Pure Reason"

Jim des Rivieres and Bart Selman

This very vigorous session was based on Drew McDermott's article in the August 1987 issue of *Computational Intelligence*. The purpose of this session was partly to establish a sense of the participants' views on KR research. In his article, Drew McDermott claims that the logicist approach to KR, inspired and exemplified by the work of Pat Hayes, has failed to meet its objectives because of one fatal flaw: its underlying assumption that human reasoning is essentially deductive is wrong. He then suggests and discards several common defences of the logicist approach, concluding with a tentative suggestion that a proceduralist approach might be a reasonable alternative, and a reluctant admission that until a KR tool is developed, he will continue to use logic.

The discussion revealed a core group of people (mainly from Toronto) who were articulate and vigorous in their defence of the place of logic within KR, and a less articulate group doubtful about the usefulness of logic in KR. The majority of the participants shared at least some of McDermott's concerns about the logicist approach to KR, but they would not go as far as to abandon logic altogether, and definitely were not willing to follow a Minsky-like, strictly proceduralist approach. It seemed that McDermott had become disillusioned after he tried to use logic to represent certain problems and failed to do so. Two possible responses to this failure are either to conclude, as McDermott has, that the method is at fault and to search for alternatives, or to conclude that the problem is a difficult one, and to keep on trying. Two alternatives to logic were discussed: evidential reasoning was suggested as a method of dealing with nonmonotonicity and connectionism was mentioned as an alternative to logic for describing human thinking. In general, the majority view seemed to be that more research is still needed to settle the issue. The issue as to what extent thinking is like deduction was left open.

K's and B's and Tractability

Sharon Hamilton and Gerhard Lakemeyer

This session was the most technically detailed at the workshop; it dealt with the tractability of modal logics of knowledge and belief. According to the initial presentation, logics of knowledge and belief are attractive extensions to first order logic for KR systems because of their expressiveness. In particular, they provide a way of representing meta-beliefs and, in their multi-agent versions, beliefs about another agent's beliefs. As well, they permit a distinction between "knowing what" ($\exists$ K P (x)) and "knowing that" (K $\exists$ x P(x)). The standard

semantics for these logics has been possible-world semantics. However, KR systems based on this formalism are bound to be intractable, because the logical omniscience implicit in the model requires them to derive all the logical consequences of the explicitly stated "beliefs". One approach to this problem is to study alternatives and extensions to possible-world semantics that can be used to specify tractable KR systems. Some progress has been made, but the resulting logics have been very weak with respect to reasoning power (for example, they do not have modus ponens). This may not be a problem, since it is not clear how much "hard" reasoning, if any, is involved in tasks like commonsense reasoning.

The discussion centered around finding the correct approach to achieving tractability. Some members of the audience argued that it was a mistake to focus on restricting the kinds of inferences allowed, and that a more realistic model of reasoning would result from allowing all kinds of inferences, but restricting the amount of computation allowed. The other side countered that this approach would lead to unprincipled, unpredictable and unmanageable systems, while restricting the types of inferences allows an exact specification of the system's behaviour and functionality. As well, careful restriction of the kinds of inferences may lead to a better understanding of the trade-offs between the complexity of representation and the complexity of reasoning.

Challenges to Traditional KR: (a) Situated Automata (b) Connectionism

Jim des Rivieres and Evan Steeg

The situated automata viewpoint is that it is naive and simplistic to represent all knowledge that an agent has and uses as an explicit set of facts encoded in some variant of logic. A large amount of useful "knowledge" is, in fact, present in the environment, and can be exploited by an agent with relatively small "memory" of "facts". Therefore, as theoreticians, we should define semantics as relations between an agent and an environment, and say that an agent "knows" a proposition P if it acts as if it knows P, regardless of what facts are explicitly encoded. The group agreed with this point, and noted that this is really a call for something that already exists in the realm of programming, where knowledge is encoded implicitly in control decisions and environments. With regard to general reasoning, explicit representations and explicit planning are required for some domains and problems; however, in other cases, simpler action-reaction interactions with an environment will suffice. "Traditional KR" is therefore still needed, although more attention should be paid to the idea of an agent situated in an information-filled environment.

The connectionist viewpoint is that standard KR schemes are very thin and barren because they represent only a relatively small number of high level facts from a domain. This is insufficient for generating robust and powerful reasoning. Connectionist schemes, based upon combinations of large numbers of microfeatures, are claimed to be robust and have the potential to be very powerful. Connectionism is also more biologically plausible, and helps explain how learning and perception might arise in cognitive systems. Finally, it provides a way to exploit high degrees of parallelism, which may lead to more efficient representation and reasoning schemes. The result of the discussion was that connectionism might well be useful at a particular level of description, but that traditional KR might prove more suitable for another level of description. That is, even if connectionist systems can be made to "work" for complex KR problems, we will still need a careful, formal way of characterizing what they are doing and how they do it. Traditional KR languages and semantics (e.g., logic and model theory) will likely be necessary to specify and explain the reasoning process, at a higher level.

The overall conclusion from this session was that situated automata, connectionism, and standard KR are complementary, and all three are valid areas for KR/AI research. Researchers from these areas should communicate more!

Invited Talk — Time for Action: On Time, Knowledge, Actions, Nonmonotonicity and Causation

Yoav Shoham

This talk was partially based on Dr. Shoham's book *Reasoning About Change: Time and Causation from the Standpoint of Artificial Intelligence*. (See Publications). He first described three change-based approaches to modeling temporal relations: situation calculus, dynamic logic, and process logic. These approaches have several shortcomings, which can be overcome by using time-based systems (temporal logics), such as a modal temporal logic or a first order reified logic. Temporal logics give time a special place in the encoding of events, allowing for a considerable variety of temporal properties. Dr. Shoham argued strongly for a point-based ontology rather than an interval-based one because it is hard to define points in terms of intervals, but not vice versa. He then moved on to describe two approaches to representing actions. In his earlier approach, actions take place at choice points. More recently, he has considered a model with a set of possible histories, including one real history; a sequence of events serves to restrict the set of possible histories as time progresses. Unfortunately the time allocated to this talk ran out before our interest did and we moved on to a general discussion on time and causality.

Time and Causality

Jean-Francois Lamy and Stephanie Miller

The discussion followed Yoav Shoham's talk and related to two topics: the nature of causation, and the implementation of temporal reasoners. The Yale shooting problem was raised as an example of a problem whose solution seems to require the notion of causation. Is there actually such a thing as a cause-effect relation? Perhaps a causal relation is nothing more than an observed regularity in precedence relations. This view cannot explain cases where cause and effect are overlapped in time; for example, the wind blowing in sails caused the boat to move across the lake. As well, causality must capture more than an observed regularity; for example, suppose that many people eat ice cream cones and then later some of them suffer from heat stroke. We do not want to conclude that eating ice cream causes heat stroke — in fact, both conditions have a common cause, hot weather. The point was raised that the more exact a science is the less it relies on causal theories. For example, it was argued that physics does not use causation in its formal representations, but that economics does. Qualitative physics has a "mythical time" in which you can see causation happening. On the

other hand, reasoning among humans, and notably among children, contains a large causal component. Since AI is concerned largely with modeling less exact, human-like reasoning, it is probably reasonable to work on finding representation of cause-effect relations. Some applications for causal reasoning in AI programs are: generating explanations that make sense to people, making predictions of possible consequences of actions, suggesting which symptom to check, and exploiting counterpositives for planning.

The discussion of implementing temporal reasoners was shorter. One of the moderators described specialized representations for reasoning about time. Special inference methods can be incorporated into a general resolution-based theorem prover to accelerate proofs done by the system. When temporal reasoning is implemented, detailed questions come up about representing time, such as whether one time point can be inserted between two others and still remain on the same time chain. Such questions raised the issue of the relationship between formal work on temporal reasoning and existing implementations. So far, the formal work from philosophy has not been directly applied in the task of implementing temporal reasoning.

Nonmonotonic Reasoning

Craig Boutilier, Scott Goodwin, and Mike Gruninger

The discussion session on nonmonotonic reasoning (NMR) began with a disagreement over whether there is or should be a distinction made between NMR and belief revision (e.g., as in de Kleer's ATMS). For example, Reiter included belief revision in his survey article on NMR. Eventually, it was agreed that the argument was just over terminology.

Then one of the moderators suggested that all current nonmonotonic reasoning formalisms can be usefully compared along a continuum where the degree of explicitness of assumptions and preferences varies. For instance, in negation as failure, both assumptions and preferences are implicit (e.g., "p <- not q" and "q <- not p" are logically equivalent, but under negation as failure the first statement expresses a preference to minimize q before p while the second expresses the opposite preference). In a system like Theorist, on the other hand, both assumptions and preferences are explicit. Circumscription with priorities seems to lie somewhere between negation as failure and Theorist, although this statement sparked some disagreement. It is not clear if there is a trade-off between explicitness and efficiency. It was agreed that the idea of such a continuum seems worth exploring further.

Finally, the topic of minimal models was discussed. Some participants expressed doubts about the utility of this approach as a general framework for NMR, while others felt that it is a ubiquitous phenomenon in such systems. All agree that more research needs to be done in this area.

Theory Revision and Diagnosis

Greg Provan, Alex Kean, and Paul van Arragon

In this session, the moderators first introduced issues in diagnosis by describing Poole's classification of approaches to diagnosis. According to Poole, the three approaches are: (1) minimizing abnormality assumptions (in Reiter's framework, a diagnosis corresponds to an extension), (2) abductive diagnosis (in Poole's work on Theorist, a diagnosis corresponds to an explanation), and (3) rule-based diagnosis using symptom-cause rules (a diagnosis corresponds to a set of fault assumptions). The first and second approaches give similar results; they use fairly complex reasoning steps but lack a firm grounding in probability theory for dealing with uncertainty. A good example of the third approach is Pearl's work on evidential reasoning. Pearl's method uses simple reasoning steps and loses the structure of the problem, but often gives good results because of the strength of its probabilistic reasoning based on conditional probabilities. For some problems, the structure of deep diagnosis, featured in the first two approaches, is crucial to producing a good solution. Other non-logical techniques were also argued to be useful in diagnosis.

The ensuing discussion centred around the idea of whether diagnosis should be based on an even deeper knowledge of the physics underlying the diagnosed object. For example, de Kleer uses the first type of approach, but does not represent the full complexity of the physics of a device being diagnosed, such as an electrical circuit. The disadvantage is that only problems within the scope of the model of the device can be diagnosed. On the other hand, the power of reasoning comes from suppressing unnecessary detail and the reasoning with de Kleer's style of models is already complex.

KR in Robot Vision and Action

Roy Eagleson and Jane Mulligan

This session was an overview of the different forms of knowledge that can exist within an intelligent system that must perceive and act within its world. The study of KR in perceptual robotics typically covers spatial representations of objects and their states, trajectories, and surrounding spaces; but also includes representations of goal-oriented actions and beliefs, planning, and spatial reasoning. In addition, knowledge of the physical world may be explicitly stored, or be implicit in the algorithms that provide the "observability" of sensory information and "controllability" of actuated mechanical systems. The analysis or design of such complex systems generally assumes a hierarchical structure, such as the sensorimotor hierarchies proposed by Bernstein (1896-1966) and others. Knowledge can exist at any of these abstract levels from low level natural constraints in vision, to high level qualitative reasoning about the motion of a robot arm. The form and nature of these various representations can be constrained by requirements such as the descriptive and procedural adequacy criteria for visual knowledge representation proposed by Mackworth (87). These criteria make explicit the idea that representations must be useful for acquiring and using knowledge, at whatever level in the hierarchy they occur, as well as capturing significant features of an object or environment.

The discussion session was a question-and-answer session in which the other participants tried to gain a more concrete understanding of the proposed hierarchy. For example, some participants wanted to know how information had been extracted from the world, or how the stored information could be used to act within that world. Not enough time was available to obtain firm ideas of how particular problem domains could be represented in the hierarchy, but people had fun trying!

KR and Natural Language Understanding

Chung Hee Hwan, Stephanie Miller, and T. Pattabhiraman

This was an unusual session because it was more of a question and answer session than a discussion. The moderators began by presenting a description of the use of knowledge representation in natural language understanding and generation. They distinguished three levels of analysis for natural language: syntax (encoded in the grammar), semantics (i.e. aspects of meaning, which includes model theory, structural semantics, and lexical semantics), and pragmatics (effect of context). For natural language, the questions of representation concern choosing an appropriate logical form for a canonical, internal form and specifying world knowledge, such as general knowledge of regularities and specific knowledge about individuals. Also, for natural language, one must be able to reason about the world, the language, the speaker-hearer relation, the communication process, and the mental states of the communicating agents. The difficulty with many "cute" AI programs which process natural language text is that they do so in a complex, ad hoc fashion that is not easily analyzed. More recent logic- and grammar-based approaches are attractive because of their formal properties.

Some of the questions and points that the moderators presented for discussion were as follows:

- What makes natural languages "natural"?
- Theoretical work needs to focus on discourse models and text representations
- Given the above points, what representations beyond first order logic and its derivatives should be seriously considered?
- Logical forms for natural language sentences should accommodate "extra" aspects (e.g., episodic variables) to represent and use contextual information
- Is natural language discourse a sequence of sentences, or a sequence of communication acts? What are the "punctuators" of discourse?

Afterwards, the audience asked questions related to the initial presentations and other aspects of natural language understanding. The questions suggested that the participants had some knowledge and interest in the issues, but not enough for vigorous debate. Looking back, we would say that what we missed in debate and discussion was compensated for by interesting questions and answers.

Invited Talk — Logical Framework for Commonsense Predictions of Solid Object Behaviour

Ernest Davis

Dr. Davis began by noting that the first step towards predicting the behaviour of solid objects is to decide whether to look for the answer to a specific query or for all of the relevant information about the object. He believes that logic is the wrong language for describing solids and their behaviour; physics is the language that has been developed for this task and therefore should be exploited as far as possible. His sample problem was that of dropping an object into a funnel. If the object is smaller than the funnel's tube, it (naturally) falls through. Many variations on the basic problem are possible, but it is always easy for us to see at a glance which ones will affect the outcome. For example, we can vary the shape of the object, the texture of the interior surface of the funnel, or the entry speed. It is this kind of fast reasoning about solid objects that he wants to simulate. Two problems he worked on were handling collisions and representing shapes. He also looked at providing an overview of the expected result for a particular scenario. For example, we know that if we drop a quarter on the table, it will not likely roll out of the room. He produced axioms for some of the knowledge necessary for reasoning about solid objects. After describing his initial work, he told us that extending it to more complicated situations has proven to be difficult. It seems likely that the problems can be attacked at many levels and perhaps the use of special purpose techniques may help in some instances, but the problem of determining which alternatives are even worth considering is a hard one. Perhaps the answer lies in using more qualitative rules in place of detailed mathematical analysis, so as to focus on qualitatively distinct outcomes. Many suggestions were put forward, but no solutions were forthcoming. It seems fair to say that this problem will provide a fruitful area of research for some time to come.

Qualitative Reasoning

Heidi Dangelmaier and Howard Hamilton

This very active, long session began with a presentation that defined qualitative reasoning as any type of reasoning about a qualitative model. A qualitative model is a representation of a physical system that is restricted to a few types of relations and a small number of qualitatively distinct values. The term "qualitative" describes a limitation in the complexity of the representation, not the reasoning process. Qualitative reasoning is powerful because the simplicity of the representation allows for simple reasoning to simple conclusions. Qualitative reasoning is an attractive concept for several reasons: it can be used in the presence of incomplete data, it generates all possible behaviours of the system, it provides an explanation of its reasoning and it may simplify subsequent quantitative analysis by providing a higher level view of the system being modeled. It efficiently produces each single possible behaviour, but if there are many possible behaviours, it becomes inefficient. As well, some of the "possible" behaviours may in fact not be possible. Other disadvantages of qualitative reasoning are that its results are ambiguous (because all possible behaviours are generated rather than one best alternative) and imprecise (because qualitative values are used rather than quantitative values).

The majority of the discussion time was taken up with the claim that qualitative reasoning is impractical because of its inefficiency. (The theoretically inclined claimed that it looked NP hard.) The proposed alternative was to choose a series of actual quantitative values for the variables within the ranges of interest, and use a known quantitative technique to determine the system's behaviour. For example, the human vision system does not produce a number of ambiguous possibilities; it always chooses a single one. However, without some kind of qualitative model to guide the selection of "interesting" values, this technique will not provide any insight into the behaviour of the system for values other than the chosen ones. A qualitative model of the system would provide a way of distinguishing qualitatively different behaviours and of grouping values that appear to lead to the same qualitative behaviour. Also, studying ways of managing an exponential number of possible behaviours may lead to better techniques for handling those that are interesting, just as studying exponential algorithms for natural language parsing has

led to more progress than studying n-cubed algorithms. In particular, the work on higher order derivatives, order-of-magnitude reasoning, and summarizing continuous processes might help in this direction.

Other Remarks on the Sessions

The discussion sessions were valuable because we heard so many ideas in a short period of time and had some opportunity to voice our reactions. The workshop also gave all of us an opportunity to lead and participate in technical debates, which is an art that none of us has mastered. Sometimes too few people were involved in the discussions, sometimes points were repeated over and over without any new insights being gained, and (dare I say it?) sometimes the unrelenting sessions of debate in a hot stuffy room seemed to produce more drowsiness than insight! As always in artificial intelligence, with its closeness to philosophy, it was easier to talk in abstract terms than to make descriptions and comments concrete. However, these comments aside, the sessions were good.

One suggestion we would make to future workshop organizers is to have at most two moderators for each session. In cases where there were three moderators, it seemed that not all of the moderators had enough time to direct the discussion to the points that they were interested in. As well, the sessions seemed to be less coherent and organized than those with two moderators.

Besides those already listed as moderators, the participants were as follows: John de Haan, Brian Nixon, Marc Romanycia, Abdul Sattar, Andre Trudel, Zhang Ying, and Rayan Zachariassen.

Conclusion

Thinking back to the workshop, we find that the specific details blur. We each recall stimulating and thought-provoking exchanges of ideas on topics that included, but were not restricted to, the discussion topics. We had the opportunity to meet other Canadians interested in KR research, in most cases for the first time. We established academic and social contacts and look forward to encountering the workshop participants again in the coming years.

The breadth of topics discussed at the workshop revealed the vast number of issues facing KR researchers and the interdependencies among researchers in all the subfields of AI. The diversity of the topics reflects the wide range of interests of the participants. In fact, each of us found only a few other participants fully conversant with the exact issues we are facing in our own research. As a result, we realize that we are not alone in Canada, but that Canada contains only a small portion of the world-wide research community.

Acknowledgements

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Banquet Speech

Alan Mackworth

One of the pleasures of getting older is that one can be mildly retrospective on occasions like this without seeming to be too pompous. When I was asked to give this banquet speech, I started to worry, "Am I now doomed to give political speeches on the rubber chicken circuit? I'd better get that draft for my next paper drawn up quickly and keep writing code in case I have been asked to do this because someone thinks I'm past it!" Luckily, I've rediscovered the joys of implementation and discovered, in addition, that Prolog is a mixed blessing, as we implement the logic of depiction. But you've had a full day of technical talk so I won't give our logic of depiction talk — besides most of you have heard it.

As a senior statesman, I can't compete with Fraser Mustard, the President of CIAR or with Zenon Pylyshyn, the Director of the AIR Program. They have much more grey hair. But I was asked to give an address to this collection of Young Turks on the nature of scientific life, the universe and everything. Now, you have heard more from Werner Israel about the state of the universe than I will ever know, so I'll skip that topic.

But rather, I'll allow myself a non-technical retrospective and prospective look, and risk giving some advice. Twenty years ago (or even five years ago), a gathering like this would simply not have been possible for many reasons, some of which I'll consider. It also strikes me that if such a gathering had occurred it would have been a gathering of young men only. Times have certainly changed for the better.

Another sign of change is obvious to those of us with twenty years of hindsight. The fact that you, men *and* women, are here at all is evidence of it. The story starts with a Monty Pythonesque line, something like, "When I was a lad, I had to walk thirty miles to school in snowshoes and bare feet." When I graduated from the University of Toronto in 1966, I had to leave the country for computer science graduate studies. In fact being "good" at something and leaving the country, or being outside it, were synonymous. That was the sixties state of mind in Canada; it still persists in many circles. All of us had to leave Canada to do graduate work in the 1960's. Some of us actually returned.

In the 1970's, as grad schools in computer science were formed and developed, artificial intelligence was still considered a subject that was studied outside the country. A brief anecdote illustrates the point. David Lowe graduated from UBC in 1978 with an NSERC Fellowship. He wanted to go to Stanford, but NSERC would only allow fellowship holders to leave if there were, certifiably, no equivalent opportunities in Canada. I had to write a very delicate letter explaining how the University of Toronto and the University of British Columbia were very good but, in David's area, he would be better off at Stanford. There's a happy ending. Last year, we hired David back from the Courant Institute as a CIAR Scholar at UBC.

Now, in the 1980's across Canada we have first class research groups in knowledge representation, vision, robotics and natural language. You are in Canada doing AI graduate studies simply because Canadian AI is excellent. We have the researchers, the infrastructure, the facilities and, most important of all, fresh talent, namely, you. The CSCSI, *Computational Intelligence, Canadian Artificial Intelligence,* international conferences and workshops, good NSERC support, Precarn, and the CIAR AI and robotics program are all part of the infrastructure. They demonstrate the vitality of the community. None of them happened by themselves. They need people like Roy Eagleson, Bart Selman, and all their helpers, the organizers of the two CIAR student workshops, to make them happen. Keep it up; it's up to you.

CIAR itself has been a major player. By choosing AI and robotics (AIR) as its first (and still flagship) program, it confirmed the intellectual and strategic importance of our area. Besides AIR, programs in cosmology, evolutionary biology, population health, superconductivity, and law and society among others have been established. There are about one hundred fellows, scholars and associates associated with these programs. The slogan, "An Institute Without Walls" is not empty. It describes CIAR. Without the Institute's support, AI in Canada could have been fatally weakened; with it, we are flourishing. Any ideas or proposals for future activities such as this are welcomed by Zenon and his program committee: let us know.

The AIR program is structured around the three poles: perception, cognition and action, with an orthogonal discipline dimension spanning computer science, engineering, psychology and neurophysiology. The first two student workshops have covered perception and cognition (knowledge representation). Should the next student workshop be on action (robotics)?

Knowledge representation is the core of AI. The rest of AI, areas such as vision, natural language and planning, can be seen as merely applied KR. But, as you have discovered in preparing for this workshop, KR is not an area with a single accepted paradigm. Even the proof-theoretic FOL approach has its major challengers: non-monotonic and higher-order logics, theory revision, model-theoretic approaches, connectionism, situated automata theory, and schema theory to mention but a few.

A few years ago, I wrote a question-answer "Catechism for the Neat AI Person" (*Canadian AI,* No. 2, 1984) which started as follows:

To be chanted by Apostles
of the Unification Church, and their Disciples

Q: What is First-order Logic?

A: It is the one and only Knowledge Representation Language with a precise semantics. All other KRLs are false pretenders, or disguised and disfigured variants of FOL.

Q: What is a semantic net?

A: A semantic net is to a set of wffs as Lucifer is to Gabriel.

There followed a printed exchange with Brian Nixon (who is here tonight) on the meaning of "catechism". My "exegesis" of the catechism repeated the old drunk-and-the-keys joke and pointed out that:

"The story illuminates the fundamental tension in any science between theory and reality. That gap produces the underlying dialectic that drives the scientific process. (Of course, the story is usually told by experimentalists to ridicule theoreticians who promote sterile formalisms with unrealistic restrictions.)

"The theory-reality gap in AI is a chasm. Actually, it is many chasms. In knowledge representation there are plenty of streetlights, but they are all far removed from the key. It is important for the drunks under any given streetlight to keep up their spirits as they grovel around. This they do by singing hymns and chanting catechisms. Given the political and sociological nature of scientific activity it is also important that new drunks coming onto the scene be convinced that there is only one true streetlight and that its wattage is increasing. Other streetlights are either pale reflections of ours or total

Alan Mackworth gives a witty banquet speech while workshop coordinator Bart Selman looks on.

mirages. The declarative-procedural controversy is a classic case study in behaviour of this kind. There is only one way to enter God's kingdom.

"So, my harmless little catechism was a not-very-funny parody designed to remind us that AI paradigms are like religious sects that must keep up the faith even when faced by overwhelming isolation and rejection or, as is more common these days, tempted by Mammon."

Amusingly, McDermott's "Critique of Pure Reason" in *Computational Intelligence* reads like a lapsed Catholic's attack on the Church! Hayes' response, "A Critique of Pure Treason", explicitly carries forward the betrayal theme and Woods remarks on the loss of faith.

To the practical AI person, who thinks that foundational and theoretical debates (such as you are having) are a waste of time, a word of warning is necessary. The prototypical working scientist may often safely ignore foundational treatises and debates. Smugly ensconced in the enfolding security of a received framework, he twiddles symbols or knobs, enjoying the simple pleasures of puzzling out nature's secrets. Tempting as that idyll may be, the prototypical researcher in AI should renounce it. For us, it is premature — both illusive and elusive.

The underlying subtext here (as post-modernists say) is the *social* nature of research. Just don't forget that the key may not be under the brightest streetlight; you might do better going off into the dark with a flashlight. You might have to ignore or rewire your supervisor's streetlight.

So what are the challenges facing you for the 1990's?

First, find a key. There are many — to each his own door key. Only work on topics that excite you. Use workshops like this to build a network of colleagues who stimulate you and stay in touch. "Only connect." (E.M. Forster's phrase does *not* mean connectionism is the key!)

Second, if you can arrange it, study in a foreign country. It's still an excellent way to broaden the mind. For those of you living in the-centre-of-the-universe-as-we-know-it, Toronto, come and work with us in B.C. — it's a foreign country.

Third, do not spurn applications as second-rate work. The best theory is informed by practice and vice versa. Some of you should move into applied work in Canadian industry or government labs. Or, even better, be unCanadian — take a risk. Start your own small AI company like Bev Smith and Brian Schaefer have done

at Acquired Intelligence in Victoria. The climate is ripe. Precarn, a CIAR spinoff, is encouraging the formation of industrial research consortia and collaborative university teams. We eagerly await the results of its first competition. One of the healthiest aspects of Canadian AI is that we are not dependent upon massive military project-oriented funding. Let's keep it that way. Search out AI applications in Canada's resource-based, manufacturing, or high-tech industries, and in the service sector.

Fourth, those of you who want an academic research and teaching career will already realize that U. of Toronto, Simon Fraser, McGill, Alberta and UBC will not be the only centres of research strength in AI. Sally forth, strike out and build AI labs on your own! Learn from our generation's mistakes. Politics and science cannot be separated nor have they ever been. But the term "political scientist" has taken on a new meaning. Remember, politics can be a constructive art.

Fifth, as free trade in goods becomes established in the 90's, we'll also get free trade in people and even, God forbid, in ideas. The world is shrinking. We'll see a reversal of the outflow of the 60's and 70's. As we've seen, in the 80's we first stabilized the Canadian research community and then grew it — keeping and attracting all of you here. In the 90's, if we keep it together, we'll see a substantial flowering of AI in Canada and major inflow from all over the world including the U.S.

Sixth, and finally, all this is far too serious. The best research comes from a spirit of playfulness. Don't forget the words to the song that Cyndi Lauper should have sung, "AIers just wanna have fun!"

CSCSI '88 Conference

by Howard Hamilton

Conférence SCEIO '88

RÉSUMÉ: SCEIO '88 fut la septième dans une série de conférences bisannuelles canadiennes sur l'intelligence artificielle. Six communication invitées et 37 communications arbitrées furent données durant les trois jours de la conférence. Les sujets touchés inclurent le traitement des langues naturelles, le raisonnement, la perception, les systèmes à base de connaissances et les applications.

8 - 10 June 1988, Edmonton, Alberta

CSCSI'88 was the seventh in a series of biennial conferences on artificial intelligence in Canada. Its predecessor was AI-86 in Montreal. CSCSI '88 was held at the Edmonton Convention Center in conjunction with two other conferences, Vision Interface '88 and Graphics Interface '88, under the grand title of Conference '88. The architecture of the Edmonton Convention Center is unusual: one enters at normal downtown street level and then immediately rides a series of escalators down to the useful portion of the building, which is in the river valley. I kept trying to estimate how many million dollars worth of building I passed before reaching the useful areas!

I enjoyed the conference. Why? During his talk on the first morning of the conference, Mark Young gave the following example:

enjoy_conference(X) <-- studious(X)
enjoy_conference(X) <-- party_animal(X)

This example suggests two possible reasons for my enjoyment and I will claim that the first applies to me. As evidence, I can point out that I attended almost every session and almost every talk during those sessions. (Anyone wishing to suggest the other explanation will have to find their own evidence.) As well, I enjoyed frequent encounters with people I knew because the conference was relatively small (158 people for CSCSI'88 and 300 for Conference '88 as a whole). I kept noticing how much smaller and friendlier the conference was than AAAI-87 in Seattle. On the other hand, at AAAI-87 I met the authors of several papers I had recently read, which did not happen at CSCSI '88.

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What did the conference offer the "studious"? Six invited talks and 37 talks based on refereed papers were given during the three days. The invited talks were as follows:

- Wolfgang Bibel (UBC): "Finding Proofs, Programs and Plans"
- David Etherington (AT&T Bell Labs): "Non-Monotonic Reasoning: Is the Answer Harder than the Question?"
- Charles Morgan (U. of Victoria): "Bets, Logic and Monotonicity"
- Geoff Hinton (U. of Toronto): "Connectionist Symbol Processing"
- David Lowe (UBC): "Recognizing Objects with Curved Surfaces and Moving Parts"
- Renato De Mori (McGill): "Neural Networks, Markov Models and Programming in Automatic Speech Recognition"

Alone of the invited speakers, Wolfgang Bibel provided a printed version of his presentation for publication in the proceedings. I wish the others had done so too, but I suppose that that is not one of their responsibilities.

Of the invited talks, I most enjoyed those by David Etherington and Charles Morgan, perhaps because they were speaking on subjects close to my interests. David Etherington's talk surveyed previous work in nonmonotonic reasoning and outlined current research topics. According to Etherington, the question is: "How should

assumptions be made to fill gaps in knowledge?" The goal is to make assumptions quickly when they are appropriate and not to make them at all when they are inappropriate. Commonsense reasoning techniques make reasoning easier because they provide shortcuts to avoid determining all possibilities. It appears that for a default reasoning system to be complete and correct, it must be intractable; for example, Reiter's default logic is semi-decidable and its consistency is undecidable. Since intractability is unacceptable in practical systems, various tractable alternatives are being studied. To avoid intractability, one must either sacrifice completeness or correctness. If completeness is sacrificed, as is done with inheritance hierarchies, TMS's, restricted logics, and databases, then some information is inexpressible and must be represented in an approximate form. If, on the other hand, correctness is sacrificed, overgeneralizations or inconsistencies result. We need to find a favorable, controlled trade-off between correctness and tractability, a way of characterizing the incorrectness that remains, and a way of showing that the method leads to correctness in the limit. Etherington suggested using a limited context containing only relevant information as a means of obtaining the desired trade-off. However, he noted that finding a method for determining such a context is an open research problem. One approach might be to add new information only when it is explicitly presented or when it is obviously related. Etherington concluded by describing three jobs for future research:

- Determine where defaults come from, i.e., how are they learned?
- Find a basis other than intuition for describing what conclusions "intuitively follow" in default reasoning, i.e., determine by experiment the nature of human non-monotonic reasoning
- Build some practical nonmonotonic systems, whose performance can be studied and improved.

Charles Morgan gave the most memorable talk of the conference. He was introduced by Nick Cercone as a sheep farmer from Duncan, B.C. who happened to have advanced degrees in Philosophy, Computer Science, Applied Mathematics, and Astrophysics. Morgan presented his ideas in an unusual style, which someone compared to that of a Southern preacher giving a sermon, but which nonetheless kept everyone's interest for the duration of the talk. Morgan suggested that for an organism trying to survive in the physical world, reasoning is only useful if it allows predictions to be made in advance of events and at a lower cost than the prediction's usefulness (utility). Thus, time and energy efficiency prohibit totally accurate models and totally accurate predictions. Logic tells us what it is rational to believe, but it is not a description of organisms' reasoning methods. His slogan, which he chanted three times with increasing volume, was "Logic is not Psychology." Morgan went on to argue that nonmonotonic reasoning cannot be formalized as a logic because logic is inherently monotonic. Using probability theory, he presented a proof that logic is monotonic; therefore, the so-called "nonmonotonic logics" must be, at best, algebras. He presented the "Simple Secret of True Nonmonotonicity": create an ordered sequence S of sets of sentences (models of the world), define a relation which tells when a set of sentences is "compatible" with another set, and define nonmonotonic entailment from a set of sentences G simply as logical entailment from the union of G and the first member of S that is "compatible" with G. Finally, Morgan strongly urged AIers to pay attention to the utility, not just the probability, of the various consequences of actions.

The principal content of the conference was the talks based on the 37 refereed papers. I did some calculations about the sources of these papers; for papers with two or more authors, I assigned a fraction to each of their institutions. By institutions, the sources of the papers were: U. of Alberta 6.5, Simon Fraser 4.33, McGill 2, U. of California at Irvine 2, U. of Waterloo 2, U. of Ottawa 1.33, and all others at most 1. (I can only speculate about the low rate of participation from the U. of Toronto, Canada's largest concentration of AI researchers.) Summarizing the same data by global areas, the sources were Canada 23, U.S.A. 9.17, Europe 3.83, and Japan 1. By province within Canada, the breakdown was Alberta 8.50, Ontario 6.17, B.C. 4.33, Quebec 3, and Saskatchewan 1. These numbers suggest that there was high interest in the conference in Western Canada, a smaller (proportionately) degree of interest in the rest of Canada, some interest in the U.S., and even less interest elsewhere among the researchers of the world.

The breakdown of the topics of the sessions was as follows: reasoning 3, perception 2, knowledge representation (KR) 1, Knowledge based systems 1, natural language 1, and applications 1. In terms of areas of AI, the greatest number of papers was in the area of knowledge representation, with a total of 11 papers in the KR session and the first two reasoning sessions. The heavy concentration of KR papers perhaps occurred because there is no specialized KR conference to attract papers. (This may change after next year's "First International Conference on Principles of Knowledge Representation and Reasoning" in Toronto.) The relatively light concentrations in natural language, vision, and machine learning may have resulted from the approximately concurrent specialized conferences for these areas (ACL88, ICML-88, and Vision Interface '88). In fact, with the growing strength of such subfields of AI, the CSCSI may soon have to reconsider the appropriateness of a general conference on AI: after all, general conferences on computer science no longer make sense. But that's a problem for the future; CSCSI '88 was a good general conference on AI with many fine papers.

The prize for the best paper of the conference was awarded to Bart Selman (U. of Toronto) and Henry Kautz (AT&T) for their innovative and clearly written paper on "The Complexity of Model-Preference Default Theories". Bart Selman presented an excellent talk based on this paper. The paper provides a model-theoretic account of default inference with exceptions using a system of propositional model-preference defaults. In this system, rules are used to define constraints on the set of preferred (or most likely) models of a situation. Performing a default inference in the system is equivalent to finding the most preferred model. The system is strongly reminiscent of recent work by Shoham on chronological preference of models and by Delgrande on least exceptional worlds. Selman and Kautz also consider the complexity of finding such a most preferred model. Even in the limited case of propositional Horn defaults, the problem is shown to be NP-Hard. This excellent paper will appear in revised form in the *Artificial Intelligence* journal, which also provided a $1000 prize.

The papers by Miller & Schubert and by Bischof & Ferraro also received honorable mention. "Time

Revisited", by Stephanie Miller and Len Schubert, presents an efficient implementation of temporal reasoning and explained how it was incorporated as a temporal specialist into a general system for natural understanding. This paper represents a good example of incremental progress in AI: the authors began with Taugher & Schubert's temporal reasoner (see *Computer,* Oct. 1983) and increased its effectiveness. In particular, the ability to handle both strict and non-strict orderings of time points in time chains was added. Then the improved temporal specialist was incorporated in a resolution theorem prover to avoid the computational explosions that otherwise occur when working with the transitive relations involved in temporal inference.

"Curved Mondrians: A Generalized Approach to Shape from Shading" by Walter Bischof and Mario Ferraro was one of the few vision papers at the conference. The authors noted that in natural scenes, objects are made up from different materials. Thus, the surface reflectance is not constant within large image regions, as is assumed in most shape-from-shading methods. To overcome this difficulty, they considered the case of a Mondrian image painted on a smooth curved surface. In this case, the surfaces are smooth and the albedo is piecewise constant. By making the same assumptions, they devised a method for determining shape and albedo for natural scenes containing objects of differing materials.

One major theme that I noted in several talks at CSCSI '88 was probabilistic approaches to reasoning. Romas Aleliunas presented a new normative theory of probabilistic logic, Thomas Dean and Keiji Kanazawa described a theory of probabilistic causal reasoning, Fahiem Bacchus gave his ideas on statistically founded degrees of belief which involved mixing probabilities with first-order logic, and, of course, Charles Morgan argued for greater use of utilities from statistical decision theory.

Another major theme was nonmonotonic reasoning. Charles Morgan talked about its relation to logic, and Selman & Kautz and Etherington both discussed efforts to achieve tractable nonmonotonic reasoning. Bob Mercer considered using default logic to derive natural language presuppositions. Phillippe Besnard gave axiomatization for properties of nonmonotonic inference systems. Scott D. Goodwin discussed some unexpected results when considering nonmonotonic reasoning in temporal domains.

Specialized logics for knowledge representation were considered in two papers. Sharon Hamilton and Jim Delgrande outlined how modal structures could be used as an alternative to Kripke structures for representing extensions to logics of knowledge and belief. In another paper, Jim Delgrande proposed a new logic that can be used to solve Hempel's paradox of confirmation, (e.g., in a system based on logic, a flying bird seems to provide some evidence for the hypothesis that all non-flying things are non-birds). Other papers on knowledge representation included Anthony Maida's description of a syntactic approach to mental correspondence and Dennis Kibler and David Aha's instance-based strategy for predicting real-valued attributes.

There were four papers dealing with natural language processing, but they did not have a unified theme. Erik Knudsen presented a method for expressing unrestricted grammars as extended definite-clause grammars. Mark Young and Robin Cohen described an implementation of an *Evidence Oracle,* which tests for evidence between statements by a speaker and builds a model for the speaker based on the evidence relations found. Bob Mercer, in the paper already mentioned, explained why a question such as "Have you stopped beating your wife yet?" confuses a person because it presupposes that the person is male, adult, has a wife, and has been beating her, and suggested how to derive the presuppositions in complex sentences using default logic. Finally, Paul McFetridge and his co-workers described a natural language interface for a SQL database that achieved a degree of portability across applications because it was capable of heuristically finding query paths in the database and of learning new words.

Besides Bischof & Ferraro's paper (already summarized), there were four other papers dealing with perception. Michael Dawson described a co-operative application of several natural constraints to the motion-correspondence problem in vision. Paul Cooper provided a formal analysis of structure recognition using connectionist relaxation. The structure recognition task that he analyzed was matching labeled graphs, a problem derived from previous work in recognizing Tinker-Toy objects in images. Dale McNutly described a improved method for recognizing alphabetic characters. The method handles structural variations in the characters by extended moment analysis. Yoshua Bengio and Renato De Mori described their recent work on automatic speech recognition. They applied a Boltzmann Machine algorithm to the task of speaker normalization using spectral lines derived from speech samples.

Several papers on planning, learning, and knowledge acquisition were presented. Dennis Bahler described his research toward the automated synthesis of nondeterministic plans using generalized condition-event networks. Sam Steel proposed a method for including iterative constructs in non-linear precedence planners. Patrick Constant and co-workers described LEW-P, their system for learning by watching while planning. Douglas Hofstadter and Melanie Mitchell described a program that detects patterns in sequences of letters, by spotting groups, repetitions, and forward and reverse alphabetic orderings. Given "abc —> abd" and "ssrrqqpp —> ?" as input, the program produces several possible answers, including "ssrrqqoo". Toshiharu Sugawara described a method for learning statistically valid default rules from large amounts of data containing exceptions. Mildred Shaw described the application of techniques derived from clinical psychology to the task of knowledge acquisition for knowledge-based systems.

Research on searching was presented in two papers. Norbert Klingbeil and Jonathan Schaefer described several variations on McAllester's "conspiracy numbers" search strategy. Briefly, the "conspiracy number" which is attached to a possible value for a node in a search tree represents the minimum number of leaf nodes that must change their values to cause the value at the root to change to the particular possible value. Klingbeil and Schaefer's variations improve performance by reducing the amount of depth-first search and increasing the amount of breadth-first search. Jia-Huai You and Yigong Wang described context resolution, a resolution-based backtracking procedure that associates terms with contexts to permit more intelligent backtracking than is ordinarily available in Prolog.

Developments in knowledge-based systems were featured in several papers. Anne Bergeron and co-workers described a development system for exploratory environments, such as LOGO on the

Macintosh. Their system features functional, logical, and object-oriented tools for developing exploration environments or microworlds. Xueming Huang and Gordon McCalla discussed a hybrid approach, which includes theorem-proving and knowledge-based techniques, to finding programming-language errors and equivalences among programs. The context of their research is an automated advisor for software debugging and evaluation. Jaiwei Han and co-workers described search strategies for finding partial answers in large knowledge bases (also called expert databases). M.E. Malowany and A.S. Malowany proposed a hierarchical approach to performing assembly and repair tasks within a robotic workcell. Their proposal featured a rule-based framework for controlling the upper levels of the hierarchy of tasks.

Applications of AI techniques to commercial tasks were also described. Innes Ferguson and Dan Zlatin identified several generic tasks and knowledge types in the domain of selling communication networks. Sheila McIlraith discussed the application of qualitative modeling to the task of interpreting data; the intention is to capture explicitly the type of reasoning used by experts when inspecting graphical data. Bruce Smith and David Middleton described a method for exploiting fine-grained parallelism in production systems written in the OPS5 language by using low-level parallelism in the implementation of the RETE network. Doug Skuce discussed a prototype expert advisor system capable of answering "how" and "why" questions about fourth-generation software, such as the QUIZ language for report writing. Finally, K.D. Rueb and A.K.C. Wong presented a method for finding and identifying modeled objects through an analysis of single- or multiple-perspective images.

The greatest disadvantage of the presentations was that the writing on the overheads was hard to read (an old complaint of mine). Now, I admit that I do not have great eyesight, but nonetheless I felt that the writing should have been clear from the back half of the audience. In many cases I could not decipher the writing and neither could the people around me. I would strongly urge everyone preparing transparencies for conferences to write using large letters (say twice the normal height). Or perhaps the program committee, which enforces such strict guidelines for the papers that appear in proceedings, might give appropriate guidelines for overhead transparencies. The transparencies that were typed using a large point size were the clearest.

Overall, the conference was well organized, to the credit of Wayne Davis, the general chairman of Conference '88; Nick Cercone and Bob Woodham, the program co-chairmen for CSCSI '88; and Randy Goebel, the registration chairman and proceedings editor for CSCSI '88. I have only two suggestions to make about the organization of future conferences. At recent AAAI-87 conferences, award winning papers have been prominently featured in the program. At CSCSI '88, Bart Selman started speaking at 8:30 on the second morning with approximately five people in the audience. Perhaps, at future CSCSI conferences, a better time slot should be selected for the recipient of the best paper award. The second suggestion is relayed from people at Graphics Interface '88: provide more coffee. When their coffee break followed that of CSCSI '88, they found no coffee left. In general, food and drink seemed to be in short supply and on a first-come first-serve basis.

By the end of the conference sessions, I was suffering from the perhaps inevitable "conference burn-out" syndrome, in which it seems that the brain will not absorb any more information, but I returned from the conference filled with new ideas and reinspired with my own work. (Of course, I stopped at the waterpark at West Edmonton Mall first, but that's another story for another audience.)

26th Annual Meeting of the Association for Computational Linguistics

by Dan Lyons and Mark Ryan

26e conférence annuelle de l'Association for Computational Linguistics

RÉSUMÉ: Cette conférence traitant des modèles computationels de la compréhension et génération des langues naturelles, donna lieu à des cours intensifs, une série de démonstrations, une communication invitée et quelques 29 autres communications. Les sujets des cours intensifs furent les théories syntactiques, la compréhension et génération de textes, la génération des langues naturelles et les algorithmes d'analyse. La communication invitée de Dedre Gentner était intitulée "L'analogie et l'interprétation des métaphores". Les communications données traitèrent de toute une gamme de sujets incluant l'analyse, la sémantique et la représentation des connaissances, l'interprétation sémantique, le discours, la traduction automatique, la génération et divers formalismes syntactiques.

7 - 10 June 1988, Buffalo, New York

Approximately 330 computational linguists from North America, Europe, and Japan gathered at the Amherst Campus of SUNY Buffalo (UB) for the twenty-sixth annual meeting of the Association for Computational Linguistics. Because of its location, the conference was attended by a large number of participants from Ontario,

including a large delegation from University of Toronto. Also represented were Trent University, the University of Ottawa, the University of Waterloo, the University of Windsor, and IBM Canada. The conference consisted of a day of tutorials on Tuesday, June 7, followed by three days of presented papers and social events.

The tone of the week was set by a friendly reception, sponsored by IBM, on June 7. The reception featured a variety of local Buffalo delicacies including stuffed mushrooms and Buffalo wings. The conference schedule was busy but comfortable. Thirty-five papers were presented over the course of three days, and all of the presentations were well-attended. There were frequent breaks for informal conversation and for snacks. This meant that no more than four papers were ever given consecutively.

Eight publishers had well-stocked tables set up in a room adjacent to the main conference hall. In addition to the publishers' displays, eight natural language software systems were demonstrated by their developers.

The cultural event of the week was a visit to the Albright-Knox Art Gallery on Wednesday evening. On Thursday evening, ACL President Don Walker addressed the association at the banquet held at Erie Community College/City Campus. This event was sponsored by Barrister Information Systems Corporation, Digital Equipment Corporation, and Erie Community College.

It was obvious that a great deal of planning had gone into the conference, and the members of the program committee are to be congratulated for their efforts. (Jerry Hobbs chaired the program committee; William Rapaport was responsible for local arrangements.) A good time was had by all.

Tutorials

On Tuesday morning tutorial-goers had the choice between hearing Peter Sells talk about "Contemporary Syntactic Theories" and hearing Martha Palmer, Lynette Hirschman, and Deborah Dahl discuss "Text Processing Systems". In the afternoon, there was a choice between David McDonald speaking about "Natural Language Generation" and Masaru Tomita discussing "Efficient Parsing Algorithms." The tutorials dealt with interesting subjects, but there was some feeling that their cost (US$75) was excessive for a half-day session. For instance, it was felt that Sells' tutorial had too much material to cover adequately in too little time. Tomita's tutorial, on the other hand, had too little material to fill the allotted three hours, and finished early.

Exhibits and Demonstrations

Software was demonstrated concurrently with the presentation of papers. Calspan-UB Research Centre (CUBRC) presented CUBRICON, a multi-media human-computer interface system. The Cornell University Department of Linguistics demonstrated a piece of foreign-language learning software. The IBM Marketing and Support Group, together with New York University, showed PROTEUS, a text-understanding system, at work on a U.S. Navy application. The SNePS Research Group at UB presented their system for knowledge representation and reasoning. SRI International demonstrated Tacitus, a text interpretation package. Sun Microsystems exhibited their Symbolic Programming Environment, a software development environment which they say is "based on the same style of tools that were developed at MIT for Lisp programming." Unisys Paoli Research Center demonstrated their PUNDIT Text Processing System. The Information Sciences Institute (ISI), affiliated with USC, exhibited Penman, a text generation system based on their Nigel grammar, as well as a parser based on the same grammar.

Dan Lyons and Mark Ryan both have a B.math. in Computer Science from University of Waterloo, and are currently in their second year of masters of computer science at University of Toronto.

Invited Talk

On Thursday afternoon, Dedre Gentner gave the invited talk on "Analogy and the Interpretation of Metaphor". This talk was well received, although it was essentially a reworking of her previous research. In her talk she contrasted analogy and metaphor with literal similarity, and with each other. She compared her ideas on metaphor and analogy with those of Sternberg and those of Bertoni.

Presented Papers

The scheduling of papers was organized according to their thematic content. Papers that dealt with some aspect of parsing included those by Byrd and Tzoukermann; Linebarger, Dahl, Hirschman, and Passonneau; Rayner and Bank; Haigh, Sampson, and Atwell; Salton; Beale; Ahlswede and Evens; Tomita; Johnson; and Schabes and Joshi. Papers that dealt with semantics and knowledge representation included those prepared by de Bruin and Scha; Moran; Karlin; and Dalrymple, Pollack and Pereira.

Both Charniak and Goldman, and Hobbs, Stickel, Margin, and Edwards had papers dealing with semantic interpretation. These two papers, which were delivered consecutively by Charniak and Hobbs, offered contrasting views on the use of logic for semantic interpretation. Charniak proposes an inference engine that is guided by probabilities, while Hobbs proposes using abductive inference (inference by assuming that a hypothesis that *could* explain observable evidence is true). Both papers propose integrating syntax with semantics and pragmatics. The papers on discourse included those by Webber; Whittaker and Stenton; Davis and Hirschberg; and Wiebe and Rapaport.

Miike, Hasebe, Somers, and Amano prepared a paper on online translation. Various aspects of generation were discussed in papers by Appelt and Konolige, Davis and Hirshcberg, Bateman, and Hovy. Unification was the focus of the paper by Eisele and Doerre and the paper by Kasper. The papers by Pareschi and by Weir and Joshi looked at Categorial Grammar.

Additional Information

Copies of the conference proceedings can be ordered from: Donald E. Walker (ACL), Bellcore, MRE 2A379, 445 South Street, Box 1910, Morristown, NJ 07960-1910, USA.

The twenty-seventh annual meeting of the ACL will be held June 26-29, 1989 in Vancouver, at the University of British Columbia.

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ico '89

May 29 to June 1,1989 **Québec city, Canada**

INTERNATIONAL WORKSHOP ON COGNITIVE INFORMATICS APPLIED TO ORGANIZATIONS

Impact of artificial intelligence and cognitive sciences in organizations in the nineties

Call for papers

Original papers are being sought in all areas related to applications of artificial intelligence (AI) and cognitive science (CS) in organizations. Papers concerning basic research, tools and techniques should focus on one or more aspects of: representation, acquisition, processing and communication of knowledge; machine learning; problem solving; natural language processing; person / machine interfaces; impact of AI and CS in organizations, knowledge-based system design methods, intelligent tutoring systems; applications of AI and CS in industry; expert systems.

author's submission:	**August 30, 1988**
notification of acceptance:	**October 30, 1988**
camera-ready final papers:	**December 10, 1988**

Instructions to authors

Authors are invited to submit four copies of their papers, not exceeding 4000 words, double spaced, in French or English. Submitted papers should include a page with :
title of paper, author's name and address, phone number, a 10 lines abstract, a list of keywords. Submitted papers should reach the program committee chairman before August 30 at the following address :

The workshop will include:
tutorials (May 29), industrial conferences (May 30), technical conferences (May 31 and June 1).
An exhibition will be held concurrently with the worshop. Commercial products (hardware and software) and research prototypes will be exhibited.

For information : Prof. Bernard Moulin
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phone: (418) 656-5580 or 656-7979

20–25 August 1989
Detroit, Michigan, USA

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Eleventh International Joint Conference on Artificial Intelligence

20–25 August 1989 ••• Detroit, Michigan, USA

Call For Papers

The International Joint Conferences on Artificial Intelligence (IJCAI) continue to be the premier forum for international scientific exchange and presentation of AI research. The next conference will be held in Detroit, Michigan, USA from August 20-25, 1989. The conference is sponsored by the International Joint Conferences on Artificial Intelligence Inc. (IJCAII), co-sponsored by the American Association for Artificial Intelligence (AAAI), and hosted by a broadly-based consortium of academic, industrial and governmental institutions in the Southeastern Michigan region.

The conference is designed to give representation to all subfields of AI. The conference will also highlight the relationship of AI to other related disciplines. The technical program will comprise a Paper Track focusing on empirical, analytical, theoretical, conceptual, foundational aspects and applied research; and a Videotape Track focusing on applications in all subfields best suited for this form of presentation.

The Eleventh IJCAI will feature:

- an outstanding technical program;
- state-of-the-art exhibit of AI-related hardware and software;
- stimulating and informative tutorials;
- special events that include prizes, awards, panels and workshops;
- visits to academic and industrial research centers and automobile manufacturing plants; and
- an interesting variety of social and cultural activities.

The official language of the conference is English, for papers and videotapes. The major areas and subareas are indicated below.

A. AI Tools and Technologies
A1. Machine Architectures, Languages, Shells
A2. Parallel and Distributed Processing
A3. Real-Time Performance

B. Fundamental Problems, Methods, Approaches
B1. Search Methods
B2. Knowledge Acquisition, Learning, Analogy
B3. Cognitive Modeling
B4. Planning, Scheduling, Reasoning about Actions
B5. Automated Deduction
B6. Patterns of Commonsense Reasoning
B7. Other issues in Knowledge Representation

C. Fundamental Applications
C1. Natural Language, Speech Understanding and Generation
C2. Perception, Vision, Robotics
C3. Intelligent Tutoring Systems
C4. Design, Manufacturing, Control

D. Perspectives and Attitudes
D1. Philosophical Foundations
D2. Social Implications

Submission Requirements and Guidelines for Papers and Videotapes

Important Dates

December 7, 1988	Submissions must be postmarked
December 12, 1988	Submissions must be received
March 27, 1989	Notification of acceptance or rejection
April 27, 1989	Revised version due
August 20–25, 1989	Conference dates

Sponsored by the International Joint Conferences on Artificial Intelligence, Inc,. (IJCAI)
Co-sponsored by the American Association for Artificial Intelligence (AAAI)

Program Track

Questions regarding paper submissions, reviewing, invited talks, panels, awards and all matters related to the technical program, contact Dr. N. S. Sridharan, Program Chair.

Videotape Track

Questions regarding submission, editing and scheduling of video presentations, contact Dr. John Birk, Hewlett-Packard Labs, 3500 Deer Creek Road, P.O. Box 10350, Palo Alto, CA 94304-1317, USA, (415) 857-2568, birk@hplabs.hp.com

Tutorials Registration, Exhibits and other Logistical Support Matters

Questions about tutorials, exhibits, registration, meeting rooms, audio visual equipment, transportation and accommodations, contact the AAAI, co-sponsors of IJCAI 89.

Local Arrangements

Questions about trips to local sites and special events, contact Dr. Ramasamy Uthurusamy, the Local Arrangements Chair.

General

For all general conference-related matters, contact Professor Wolfgang Bibel, Conference Chair, or Dr. Donald Walker, the IJCAII Secretary-Treasurer.

Paper Track Submission Requirements

Authors should submit six (6) copies of their papers in hard copy form. Papers should be a minimum of four pages to a maximum of ten pages (single-spaced text only). Papers should be printed on 8.5" x 11.0" or European A4 sized paper, with 1.5" margins, using 12 pt type and be of letter-quality print (no dot matrix printouts). Each full page figure counts as one of the four to ten pages.

Each paper should contain the following information:

- Title of paper
- Full names of all authors and complete addresses
- Abstract of 100-200 words
- The area/subarea in which the paper should be reviewed
- Declaration of multiple submissions.

If the paper submitted to IJCAI 89 is similar in substance or form to another paper submitted to other major conferences in 1989, this **must be declared** by the author.

Papers will be uniformly subject to peer review. Selection criteria include accuracy and originality of ideas, clarity and significance of results and the quality of the presentation. Late submissions will by automatically rejected without review. The decision of the Program Committee will be final and cannot by appealed. Papers selected will be scheduled for presentation and will be printed in the Proceedings. NO on-line submissions will be accepted.

Videotape Track Submission Requirements

Authors should submit one (1) copy of a videotape of 15 minutes maximum duration, of applied research, accompanied by a submission letter that includes:

- Title
- Full names of authors and complete addresses
- Tape format (indicate one of NTSC, PAL or SECAM; and one of VHS or .75" U-matic)
- Duration of tape in minutes
- An abstract not to exceed 100 words.

Late submissions will be automatically rejected without review. Tapes will not be returned; authors must retain extra copies for making revisions. All submissions will be converted to NTSC format before review. **Permission to copy** for review purposes is required and authors should indicate this in the submissions letter.

This track is reserved for displaying interesting applications to real-world problems arising in industrial, commercial, space, defense and educational arenas. This track is designed to demonstrate the current level of usefulness of AI tools, techniques and methods.

Tapes will be reviewed and selected for presentation during the conference. The following criteria will guide the selection:

- Level of interest to the conference audience
- Clarity of goals, methods and results
- Presentation quality (including audio, video and pace)

Preference will be given to applications that show a good level of maturity. Tapes which are deemed to be advertising commercial products, propaganda, purely expository materials, merely taped lectures or other material not of scientific or technical value will be rejected.

Send papers and videotapes to:

IJCAI 89
c/o AAAI
445 Burgess Drive
Menlo Park, CA 94025-3496 USA

Intelligent Tutoring Systems International Conference – 88

by members of the ARIES Lab at U. of Saskatchewan

1 – 3 June 1988, Montréal, Québec

The beautiful city of Montréal was the setting for the International Conference on Intelligent Tutoring Systems (ITS-88) held June 1-3, 1988. The aim of the conference was to bring together international specialists from the areas of artificial intelligence, education and psychology to share ideas and review advances in this multi-disciplinary field. The conference was highly successful in achieving this objective. Congratulations go to the conference chairman, Claude Frasson, Université de Montréal, and all those who worked with him.

The enthusiasm and excitement felt in this evolving research discipline was evident from the international participation both in organizing and attending the conference. The conference was sponsored by the Université de Montréal, the Canadian Society for Computational Studies of Intelligence (CSCSI), the Association française pour la cybernétique économique et technique (AFCET), and the British Computer Society (BCS) in cooperation with the Association for Computing Machinery (ACM) and the special interest groups SIGART, SIGCUE, and the Inter-American Organization for Higher Education. The National Sciences and Engineering Research Council of Canada (NSERC) and the Québec Research Council (FCAR) lent their support to the organization of the conference.

The program committee, chaired by Marlene Jones of the Alberta Research Council (ARC) and Gregor V. Bochmann of the Université de Montréal, included representatives from 8 countries. One hundred forty papers from 16 countries, were submitted for refereeing. Of these, 66 papers representing 12 countries were selected for presentation at the conference. Presenters spoke in English or French, with simultaneous translation provided for a large number of the talks. The contributed papers covered topics such as learning environments, student modeling, curriculum and knowledge representation, design issues, empirical studies, tutoring programming concepts, practical use of ITS, architecture and methodology.

The conference program also featured nine invited speakers from four countries. In addition to their individual talks, many of the invited speakers participated in two panel discussions. One of these, led by Stuart Macmillan of Sun Microsystems, USA, reviewed "What ITS can do NOW", while the other, chaired by Gord McCalla of the University of Saskatchewan, Canada, raised the question "What is Wrong with ITS Research?" The panels provided an opportunity for provocative discussion between invited speakers, presenters, and conference attendees.

Where many of the papers presented at the conference focused on the particular applications of ITS, the invited speakers and the panel discussions tended to overview the field and address broader issues and concerns. The two perspectives complemented each other and gave participants a sense of the emergence of ITS as a research area, one which is drawing on many related areas, but also identifying its own concerns and defining its own boundaries. One theme of the conference was the importance of a multi-disciplinary approach, and the richness and excitement that can result from such an approach. The importance of building actual implementations was emphasized as a strength of ITS, while the need to evaluate and learn from our work was seen as a weakness that needs to be addressed.

Invited Speakers

Conference chairman Claude Frasson, Université de Montréal, opened the conference Wednesday morning with a warm welcome to Montréal and ITS-88. Pierre Robert, Vice-President of Planning, Université de Montréal, then greeted everyone on behalf of the President of the Université de Montréal. Leonce Beaupre, General Director of University Education and Research, addressed the conference on behalf of Honorable Claude Ryan, Québec Minister of Education and Science.

The opening speeches were followed by a presentation from invited speaker Jacques Arsac, Université Pierre et Marie Curie, France. Arsac addressed the questions of meaning and of knowledge, placing the current areas of AI and ITS research in the broader context of a rich history of philosophers and thinkers, from Aristotle to the present day. His talk gave listeners a sense of being part of a long and admirable tradition; a community, over time, of scholars and thinkers who have loved their work.

Two more invited speakers were featured Wednesday afternoon. Pat Suppes of Stanford University, USA, spoke about the history of traditional CAI, in which he has worked during the last two decades. He described the tutoring systems on logic, set theory, and differential and integral calculus that have been developed at Stanford University. All these systems have classroom applications, but they fall far short of the type of intelligent system that researchers such as Suppes were predicting in the 1960's. They lack the epistemic and cognitive analysis of teaching, learning, and diagnosis that would be desirable features for an ITS. Suppes suggested that by building large-scale, real-world systems such as those at Stanford, we will identify and address real problems and eventually be able to build the ITS systems that we would like.

Masoud Yazdani of the University of Exeter, U.K., discussed how his experience in using Prolog to build a system which teaches the grammar of a language has influenced his views on building tutoring systems. Prolog's nature as a declarative language allows the programmer to keep the definition of what is to be done separate from how it is to be done. Yazdani proposes a four-part system architecture with each part composed of a knowledge source and a set of procedures necessary to put the knowledge to use: domain knowledge +

This report was prepared under the supervision of Jim Greer, the ARIES Lab technical director. Contributions were made by Mary Mark, research assistant, and by graduate students Shawkat Bhuiyan, Barb Brecht, Judy Escott and Xueming Huang. Eight ARIES Lab members attended the conference.

inference engine, bug catalogue + user modeler, tutoring skills + planner, and explanation patterns + interface. His goal is to develop a system which would allow teachers to specify their knowledge of a language using a clearly defined format, and then use that language and its own knowledge to design tutoring.

Thursday morning began with an address by Philip Winne, an instructional psychologist. Winne views an ITS as an aide to planning and analyzing instruction, rather than a replacement for a human teacher. With the above objective in mind, Winne and his group at Simon Fraser University, B.C., are developing DOCENT, an AI planning system which teachers can consult about teaching methods. DOCENT has a library of information containing knowledge extracted from research publications in education, teachers' expertise, and pedagogical knowledge. Knowledge is represented in a special frame-based language called BLEEP, developed by the group. DOCENT helps teachers to design instruction plans and instructional aids, using the library's information and adapting it to the teacher's needs. DOCENT will also learn from the teacher, incorporating into its databases information about instructional effects and student performance. This research promises to be a valuable contribution to knowledge engineering for ITS, and DOCENT's acceptance by teachers will judge its success as an implemented system.

Conference translators made an heroic attempt to keep pace with Elliot Soloway of Yale University, USA, but were understandably overwhelmed. Soloway presented a fast-moving action-packed talk outlining current trends in AI and education, possible future options, and the relevance of political policy for the field. According to Soloway, current educational practice is adversely affected by three gaps: between what we teach in schools and people's out-of-school experience, between our theories of education and our educational practice, and between the technology available in society and in schools. To bridge these gaps, Soloway suggests that we adopt a "Dialog Paradigm" which integrates theory and practice at all levels, rather than a "Knowledge Transmission Paradigm" in which information moves one way. Soloway then outlined a proposal (presented to the U.S. government) which would establish long-term CITES (Centers for Interactive Technologies in Education) to associate multi-disciplinary research groups with schools and students.

John Self, University of Lancaster, England, discussed student modeling. Building a detailed student model potentially involves most of the issues of cognitive science. Self discussed practical possibilities for limiting this overwhelming task. A student model needs to be developed in cooperation with diagnosis and remediation; if something cannot be treated, there is little point in knowing about it. There is little point in storing information unless it can be used. Self suggested that in many situations an ITS could ask a student for information rather than inferring or guessing what it needs to know. It may also be preferable for a student model to see information as reflecting a student's beliefs, rather than judging it in terms of truth or correctness. Finally, Self emphasized that the "omniscient judge" idea of student modeling may be neither necessary nor desirable. An alternative approach to student modeling is to see the tutor as a collaborator, which admits fallibility and works in cooperation with the student. This is a much more obtainable goal, and may be more effective from an instructional viewpoint as it involves the student as an active and equal partner. It may also be a more ethical approach, since student information would be open to the student rather than hidden.

Jeffrey Bonar discussed a particular project that has been developed at the University of Pittsburgh. The Bridge Tutor provides an intermediate language which is used by students to specify problem solving descriptions which can then be translated into actual Pascal code. Bonar argued that the use of an intermediate representation gives the tutor direct information about the student's intentions without having to reconstruct them from Pascal code. He suggested that this can benefit students, by helping them to conceptualize programming tasks above the language level.

A major theme of Beverly Woolf's talk was the importance of incorporating both an explorative research-oriented approach, and an implementation-oriented engineering approach into ITS work. As an illustration, she used the development of the Gothic church in which successful developments over time built upon both the ideas of the "researcher" and the experience of the "engineer". In adapting AI techniques to education, Woolf suggests that we need to develop both theories and systems, and that exploration and experimentation are essential tasks in this development. In reviewing progress in ITS up to the present time, Woolf was largely positive, emphasizing accomplishments, while noting that problems remain to be explored. She closed her talk by giving a brief overview of a four-layered discourse control architecture for tutoring systems, which she is currently working on at the University of Massachusetts, USA.

The final invited speaker of the conference was John Seely Brown, Xerox Palo Alto Research Center, USA. He noted that our beliefs about learning have important implications for the systems that we build. He emphasized that learning is not a passive transfer of fixed information, but an active process of reconceptualization which requires the learner to recollect and to construct. AI and cognitive science need to study and develop new technologies for learning, and build systems such as reactive learning environments which incorporate this view. We can also use knowledge of everyday cognition to design systems that take advantage of the student and the environment as resources. Because ITS deals with people, it involves a broader range of concerns and problems than AI.

Panel Discussions

As part of the periodic review that must be done in any discipline, two panel discussions tackled the following questions.

What can ITS do NOW?

Albert Corbett, Stellan Ohlsson, Elliot Soloway, Pat Suppes, and Beverly Woolf, members of the panel, raised the following issues.

While research on intelligent tutoring systems is still grappling with many difficult issues and many of the goals for intelligent tutoring systems have not yet been met, intelligent tutoring systems are available and they are teaching. They are teaching a wide range of subjects including languages, programming, mathematics, and medicine and they are teaching everything from facts to meta-cognition. The systems today are not toy systems being used only in research laboratories. They are real systems being used by real people.

The systems that are functional today are teaching effectively. They are being tested and evaluated to quantify how long it takes to teach students and how well students are being taught.

The future looks promising for developing more systems in affordable time frames. Systems being built now are taking advantage of the architectures that have already been developed. Development times are becoming shorter and the systems are being developed to run on hardware accessible to a wider audience. Each year, more and more systems are becoming accessible to more and more people.

Intelligent tutoring systems may be aiming toward the wrong goals. ITS has been aiming to be better than teachers. This is possibly missing an opportunity to use intelligent tutoring systems to fill the holes in the education system. Tutoring systems that don't surpass traditional teaching methods are still extremely beneficial. They are a reasonable alternative for providing specialized courses in situations where there are no teachers and courses are not currently given or when the number of pupils requiring a course does not justify offering it.

Although intelligent tutoring system research has come a long way, we need to be more practical on the issues we are dealing with in this area. We need to confront real issues and develop a theory to deal with them. Having developed a theory we need to do something with it. We need to collect data, real data, and to incorporate our ideas into something that validates them. We then need time to reflect — to evaluate where we have come to and where we are going to.

What is Wrong with ITS Research?

The second panel discussion, chaired by Gord McCalla, involved William Clancey, Gerhard Fisher, Marlene Jones and David Littman. Taking a critical look at ITS research raised a number of issues. There are essentially three types of research required in this field:

- research dealing with AI issues such as the subject matter system, the reasoning process, and communication between the system and the user
- research dealing with program architecture issues such as knowledge representation and control
- research dealing with evaluation: running programs, psychological experiments, testing one architecture on multiple cases, in multiple domains, and with multiple students.

The issue of evaluation is an important one. It is not sufficient to come up with good ideas, theories, and potentially good systems. We need to push to failure each type of system we build and then explain why it failed. We need to continue to analyze prior attempts to build systems and to relate out current goals to alternative designs so that we continue to build the theory underlying the field.

To date there have been too many engineers building systems and too few theoreticians working on building a solid base of theory. We need to draw on other disciplines for this theory, and transfer technology because of the multi-disciplinary needs of the field.

We need to tackle real domains with real problems. Too often the problems are so big that we end up building "toy" systems. It is true that real problems and real domains necessitate compromises, but these compromises may give valuable insight into the issues we are dealing with. In our desire to reach our ultimate goals, we too often criticize the missing luxuries and overlook the fact that a system is usable, useful, and has many practical accomplishments.

We also need to report the results of the successes and the failures. Lack of success in a venture is equally as important to share as the success. We need to report honestly, without making grandiose claims. We also need to make clear our refereeing and publication standards to show that sharing what doesn't work contributes to the greater body of knowledge as equally as what does.

The research we do must ask (and answer) these questions:

- What well-known problem are you attempting to solve?
- What can your program represent or teach that other programs cannot?
- What do you "make possible"?
- What successes of others have you built on?

In addition, we need to take a more active role in convincing educators of the benefits and promises of intelligent tutoring systems. We need to look at making sure the learning that intelligent tutoring systems provide is enjoyable. We need to look at the role of intelligent tutoring systems in (or outside of) the education system. We have to get serious about the non-technical issues of ITS.

All presented papers and invited talks are included in the ITS-88 conference proceedings. Conference proceedings may be ordered prepaid from: Claude Frasson, Departement d'informatique et de recherche operationnelle, Université de Montréal, CP 6128, succursale A, Montréal, Québec, Canada H3C 3J7. Price: Cdn$50.00.

Systèmes d'enseignement intelligemment assistés par ordinateur Conférence Internationale – 88

par Anne Parent

1–3 juin 1988, Montréal, Québec

La conférence internationale portant sur les systèmes d'enseignement intelligemment assistés par ordinateur eut lieu à Montréal du 1 au 3 juin. Malgré le fait que beaucoup de questions importantes soient restées sans résponses, la conférence fut un succès. Environ 350 personnes étaient inscrites. La conférence comportait

neuf conférenciers invités, deux tables rondes et plusieurs sessions reliées aux domaines suivants: environnements d'apprentissage, environnements d'IA pour l'éducation, modélisation de l'édudiant et diagnostique cognitif, représentation du curriculum et de la connaissance, acquisition de la connaissance en EIAO, design et mise en oeuvre des systèmes d'EIAO, utilisation pratique des systèmes d'EIAO et des méthodologies et architectures de systèmes éducatifs.

Conférenciers invités

Le premier conférencier était Jacques Arsac de l'Université Pierre et Marie Curie à Paris. Il discuta de l'intelligence artificielle et de l'EAIO face au problème du sens et posa la question meta-informatique des relations entre la forme et le sens. "Je crois personnellement qu'il n'y a que deux attitudes possibles. Ou bien on pense que le sens est contenu dans les mots, impliqué par les mots. En conséquence ...rien n'est perdu dans la représentation des connaissances au moyen d'informations, si la représentation est bien faite... Ou bien on pense que le sens des mots existe vraiment. Alors, il est distinct de la forme, qui ne l'implique qu'imparfaitement. Il existe alors une réalité qui n'est qu'imparfaitement représentée par les informations que l'on traite en machine." Le conférencier a conclu que l'imformatique ne pourrait trancher cette question sur laquelle les philosophes demeurent partagés.

Masoud Yazdani résuma l'architecture d'un système d'enseignement développé dans le but d'aider l'apprentissage d'une langue seconde. Ce système analyserait les phrases de l'utilsateur puis commenterait ses erreurs grammaticales. Masoud Yazdani travaille aussi sur le développement d'une coquille dans laquelle pourront s'ajouter d'autres bases de connaissances grammaticales. L'architecture du système comprend une base de connaissances et un moteur d'inférence, un catalogue d'erreurs et un modèle de l'utilisateur, des connaissances tutorielles et un module de planification pédagogique, des schémas d'explications et un interface.

Philip Winne a décrit l'architecture d'un système en voie de développement nommé DOCENT. Ce système aura pour fonction d'aider les enseignants à planifier et analyser des activités pédagogiques.

Jeffrey Bonar présenta le système BRIDGE, un système d'enseignement intelligemment assisté par ordinateur conçu pour aider des programmeurs débutants au cours de la conception, de l'implémentation et de l'évaluation de leurs programmes. Il pose la difficulté d'inférer les connaissances et erreurs de l'étudiant en fonction de sa performance. Pour pallier à ce problème, il met en valeur l'utilisation de représentations intermédiares correspondant à l'élaboration partielle de la tâche c'est-à-dire propre au modèle cognitif de l'apprenant. Dans ce système, la représentation intermédiaire constituerait un tremplin pour les interventions tutorielles dirigées vers l'élaboration des structures incomplètes de résolution de problèmes de l'étudiant.

John Self évoqua l'intérêt et la nécessité de développer une représentation des connaissances particulières de chaque utilisateur d'un système d'enseignement informatisé. Il a offert des suggestions pratiques dans le but de faciliter l'élaboration du modèle étudiant telles que le questionnement direct et l'ajustement du modèle par l'étudiant, permis par la transparence d'un modèle. Il note l'importance de relier de façon explicite le contenu du modèle étudiant aux actions tutorielles spécifiques et aux données dont il découle. Il souligne de plus, le rôle de collaborateur que doit jouer le système d'apprentissage.

Elliot Soloway a résumé les résultats d'une étude effectuée pour le gouvernement américain ayant pour but d'identifier d'abord les réalisations et les orientations de la technologie dans les sciences de l'éducation puis de suggérer des politiques permettant d'améliorer recherches et pratiques. L'étude révèle des distances trop grandes entre les milieux académiques et industriels, entre chercheurs et praticiens, entre potentiel d'application et utilisation des technologies. Il conclut en la nécessiteé de promouvoir le dialogue entre les intervenants (e.g. chercheurs, enseignants, administrateurs) et propose pour ce faire la mise en place de centres de technologies éducatives.

Pour sa part, Beverly Woolf souligna la disparition graduelle de certaines limites de l'EIAO telles que le coût élevé associé au développement de ces systèmes et le potentiel d'application limité des coquilles résultantes. Puis, elle énuméra certains problémes qu'il nous faudra encore résoudre tels que l'intégration des tuteurs intelligents au curriculum scolaire et las résistance du système d'éducation.

Tables rondes

Les tables rondes ont interrogé l'avenir de l'enseignement intelligemment assisté par ordinateur, les difficultés et lacunes des recherches en ce domaine. De façon générale, on s'accorde sur les progrès de l'EIAO et sur la généralisation grandissante des applications et des projets de développement en milieux industriels et militaires. Les chercheurs s'accordent sur le besoin de cadres conceptuels (e.g. modèle de communication, théorie de l'apprentissage), sur la nécessité de poursuivre des travaux de développement et de recherche portant sur les modèles étudiants, sur le raisonnement qualitatif et l'apprentissage machine. Ils mettent en relief l'importance de préciser les normes de publication et l'intérêt d'articles relatant les procédés sous-jacents non seulement aux succès mais aussi aux échecs encourus.

Conclusion

Cette conférence était bien organisée et la qualité des présentations était très bonne. Il semble que beaucoup de systèmes d'enseignement intelligemment assistés par ordinateur soient en voie de développement mais que peu aient été complétés. En conséquence peut-être, très peu de recherches comparatives étaient rapportées et peu de résultats empiriques permettaient de guider le développement des systèmes actuels. Aussi, quoique le grand besoin de cadres conceptuels ait été reconnu, peu de chercheurs indentifiaient leurs appuis théoriques. Doit-on conclure que des systèmes de plus modeste dimension permettant une évaluation plus rapide s'avérent nècessaires, ou plutôt conclure à la nécessité de ralentir le processus de développement par une validation systèmatique des composants des systèmes actuels? Il apparait important que les conceptions sur lesquelles repose le développement de ces systèmes fassent l'objet d'une plus grande formalisation théorique afin de rendre possible l'évaluation empirique. Ce processus de validation apparait critique si l'EIAO doit faire la preuve de sa crédibilité scientifique et de sa valeur éducative en lieux décisionnels.

Anne Parent est agent de recherches au Laboratoire des systèmes intelligents du Conseil national de recherches.

KR '89

CALL FOR PAPERS

FIRST INTERNATIONAL CONFERENCE ON PRINCIPLES OF KNOWLEDGE REPRESENTATION AND REASONING

Royal York Hotel
Toronto, Ontario, Canada

May 15-18, 1989

Sponsored by the Canadian Society for Computational Studies of Intelligence;
with support from AAAI, IJCAI, the Canadian Institute for Advanced Research, and the Information Technology Research Centre of Ontario; in cooperation with AISB and ACM SIGART

The idea of explicit representations of knowledge, manipulated by general-purpose inference algorithms, underlies much of the work in artificial intelligence, from natural language to expert systems. A growing number of researchers are interested in the principles governing systems based on this idea. This conference will bring together these researchers in a more intimate setting than that of the general AI conferences. Authors will be expected to give presentations of adequate length to present substantial results, and the number of parallel sessions will be limited. Accepted papers will be collected in a conference proceedings, to be published by Morgan Kaufmann Publishers, Inc.

The conference will focus on principles of commonsense reasoning and representation, as distinct from concerns of engineering and details of implementation. Thus of direct interest are logical specifications of reasoning behaviors, comparative analyses of competing algorithms and theories, and analyses of the correctness and/or the computational complexity of reasoning algorithms. Papers that attempt to move away from or refute the knowledge-based paradigm in a principled way are also welcome, so long as appropriate connections are made to the central body of work in the field.

Submissions are encouraged in at least the following topic areas:

- Analogical Reasoning
- Commonsense Reasoning
- Deductive Reasoning
- Diagnostic and Abductive Reasoning
- Evidential Reasoning
- Inductive Reasoning
- Nonmonotonic Reasoning
- Qualitative Reasoning
- Temporal Reasoning
- Planning and Plan Recognition
- Knowledge Representation Formalisms
- Theories of the Commonsense World
- Theories of Knowledge and Belief
- Belief Management and Revision
- Formal Task and Domain Specifications

REVIEW CRITERIA

The Program Committee will review *extended abstracts* (not complete papers). Submissions will be judged on clarity, significance, and originality. An important criterion for acceptance is that the paper clearly contribute to principles of representation and reasoning that are likely to influence current and future AI practice.

Extended abstracts should contain enough information to enable the Program Committee to identify the principal contribution of the research and its importance. It should also be clear from the extended abstract how the work compares to related work in the field. References to relevant literature must be included.

Submitted papers must be unpublished. Submissions must also be substantively different from papers currently under review and must not be submitted elsewhere before the author notification date (December 15, 1988).

SUBMISSION OF ABSTRACTS

Submitted abstracts must be at most *eight (8) double-spaced pages.* All abstracts must be submitted on 8-1/2" x 11" paper (or alternatively, a4), and printed or typed in *12-point font* (pica on standard typewriter). Dot matrix printout is not acceptable.

Each submission should include the *names* and *complete addresses* of all authors. Also, authors should indicate under the title which of the *topic areas* listed above best describes their paper (if none is appropriate, please give a set of keywords that best describe the topic of the paper).

Abstracts must be *received* no later than November 1, 1988, at the address listed below. Authors will be notified of the Program Committee's decision by December 15, 1988.

Authors of accepted papers will be expected to submit substantially longer full papers for the conference proceedings. Final camera-ready copies of the full papers will be due on February 15, 1989. Final papers will be allowed at most twelve (12) double-column pages in the conference proceedings.

Send five (5) copies of extended abstracts [one copy is acceptable from countries where access to copiers is limited] to

Ron Brachman and Hector Levesque, Program Co-chairs
First Int'l. Conference on Principles of Knowledge Representation and Reasoning
c/o AT&T Bell Laboratories
600 Mountain Avenue, Room 3C-439
Murray Hill, NJ 07974
USA

INQUIRIES

Inquiries of a general nature can be addressed to the Conference Chair:

Raymond Reiter, Conference Chair
First Int'l. Conference on Principles of Knowledge Representation and Reasoning
c/o Department of Computer Science
University of Toronto
10 Kings College Road
Toronto, Ontario M5S 1A4
CANADA
electronic mail: reiter@ai.toronto.edu

IMPORTANT DATES

Submission receipt deadline:	**November 1, 1988**
Author notification date:	**December 15, 1988**
Camera-ready copy due to publisher:	**February 15, 1989**
Conference:	**May 15–18, 1989**

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ITS Survey / Revue des systèmes d'EIAO

The NRC Associate Committee on Instructional Technology, Subcommittee on AI, is attempting to gather information on ITS-related projects currently ongoing in Canada. If you or any of your colleagues are involved in an ITS-related project, please complete the brief questionnaire below. Completed questionnaires should be mailed to:

Le comité associé au CNR en technologie éducative, sous comité sur l'IA, souhaite réunir les informations sur les projets reliés aux systèmes d'EIAO en cours de développement au Canada. Si vous ou un de vos collègues êtes impliqués dans un tel projet, veuillez s'il vous plaît compléter le bref questionnaire indiqué ci-dessous. Celui-ci doit être envoyé ensuite à:

Jim Greer
ARIES Laboratory
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Saskatoon, SK S7N 0W0
Email: aries@sask.bitnet

Principal Researcher / Chercheur principal:_____

Project Title / Titre du projet:_____

Other Participants / Autres participants:_____

Mailing Address / Adresse d'expédition:_____

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_____

Sources of Funding (amount of funding may be included if you wish):
Sources de financement (le montant peut être inclus si vous le desirez):

Brief Abstract (30 to 50 words) / Bref resumé (30 à 50 mots):

Book Reviews

edited by Graeme Hirst

Logical Foundations of Artificial Intelligence

Genesereth, Michael R.; Nilsson Nils J.
[Stanford University]

Los Altos, CA: Morgan Kaufmann, 1987, xviii+405 pp
Hardbound, ISBN 0-934613-31-1, US$36.95

Reviewed by
Randy Goebel
University of Alberta

Introduction

At a time when the issues of logicist versus proceduralist have again become heated, it is appropriate that someone record the current state of the logicist approach in a textbook level presentation. That is precisely what Michael Genesereth and Nils Nilsson have done in their book *The Logical Foundations of Artificial Intelligence.*

Before discussing a few details, and to keep the eager reader from skipping to the last paragraph for the typical review's stylish critical summary, we summarize up front: the book is well-written, quite uniform in detail and style of presentation over all topics, includes topics yet to appear in any textbook form, and provides a relatively objective view of the role of logic in artificial intelligence. It is well worth the money, for logicists and non-logicists alike.

Chapter-by-chapter Highlights

Chapter 1: Introduction

The opening chapter is brief, and in being so, avoids any lengthy polemic concerning a definition of artificial intelligence. Quite simply, their task is to present the use of logic as the fundamental tool for analyzing and developing representation and reasoning systems as the basis for artificial intelligence. With this said, the introduction begs no further controversy than already exists.

Chapter 2: Declarative Knowledge

The logicists understand that the role of logic is to provide a normative semantic theory as a tool for attempting to capture descriptions of the world in symbols. This point is well-made here, but another less discussed issue is also brought to the forefront: the problem of appropriately conceiving one's domain of interest so that it can be naturally captured in the symbols of a logical language. This most difficult problem of deciding what to assert is acknowledged up front, and implicitly permeates the remainder of the book.

The authors provide a clear explanation of the components of a logic, emphasizing the role that semantics plays in providing the vital link between semantic domain and language symbols. They use the term *conceptualization* to refer to the set of non-logical symbols which defines an applied logical theory, and explain how different conceptualizations can profoundly affect the computational and conceptual efficiency of problem representation.

Although the difficulty of obtaining a good conceptualization is acknowledged, this early chapter doesn't say much about principles that support the development of good representations, or whether there are such principles. For example, the section that defines first order semantics could say something about the desire for simplicity and directness in a conceptualization. Without departing from the focus of the logicist approach (e.g., to cognitive psychology) it is difficult to say much about appropriate conceptualizations, but one would like to acknowledge strong claims by critics. For example, MIT's Rod Brooks claims that much of AI has ignored important issues by being so compartmentalized that representations are tailored to the problem solution rather than dealt with directly in their most appropriate form. Brooks points out that it might be appropriate to take the world as it is, rather than to arbitrarily adjust one's conceptualization of a problem domain in order to fit the reasoning solution one has in mind.

Other minor caveats include a claim that the atomic formulas (*Age*(*Confucius*)=100) and *Age*(*Confucius*,100) express the same fact. But the former is consistent only if Confucius has no other age, while the latter imposes no such restriction. The point is minor, except that it might mislead the naive into believing that the above formulas really are equivalent in some deeper sense. Another misleading point concerns a brief discussion concerning first-order languages and categoricity. The authors assert that there is no way in general of ensuring a unique interpretation of a set of first-order sentences no matter how many sentences are asserted. While this is true of predicate calculus (first-order logic without equality), full first-order logic with equality can express theories that are categorical in the sense that all their models are isomorphic. Points such as these are perhaps excusable as the book is not a logic text, but a text about the role of logic in representing and reasoning systems. As such, the brief discussion of logical concepts is superior to no discussion at all.

A final minor criticism is that logics of higher-order are mentioned only in passing, with no mention of why they may or may not be appropriate. In fact the problem of appropriate conceptualizations is related to the potential role of higher-order languages as there are problem domains where it seems natural to use higher-order conceptualization (e.g., knowledge about reasoning by analogy has been claimed to be such). It is admittedly difficult to say anything deep about appropriate conceptualizations, but the reader is left with the feeling of an unaddressed problem.

Even under these criticisms, Chapter 2 is a very good introduction to what one should expect from a declarative approach to representation. It provides a good foundation for studying the logicist approach, and sets a good pace for the rest of the book.

Chapter 3: Inference

Chapter 3 is clearly motivated by a desire to take one step back from typical AI theorem-proving-based logical representation systems, and provides a discussion of the more abstract foundations of inference. In particular, the process of inferencing is that of showing what follows from what, and the authors attempt to provide a very general foundation for how one can argue that something follows from something else.

While the chapter's overall motivation is clear, the motivation for each individual section is not. Initial discussions about general inference procedures and their relation to Markov algorithms is somewhat mysterious; it is not clear whether the authors want the reader to serendipitously rediscover the relationship between logical deduction and other forms of computation, or whether the reader is being set up for a later foray into the power of meta-reasoning. While it is important to relate computation and deduction (cf. the thesis of logic programmers), the presentation in the early portion of the chapter is not clearly motivated.

Subsequent to the general discussion on inference, the chapter continues with a rather better presentation of provability and the fundamental theorems of first-order logic. Although the section is noted as "advanced," it is a good background for all formally inclined students.

Chapters 4 and 5: Resolution and Resolution Strategies

Chapters 4 and 5 bring the abstract concepts of Chapter 3 down to earth with a detailed discussion of resolution theorem proving and resolution theorem-proving strategies. Although not nearly as comprehensive as current theorem-proving texts, the two chapters provide all that one should know about resolution for the purposes of comprehending general purpose deductive reasoning.

The introduction and use of the Horn clause subset of first-order logic is both a strength and a weakness, in some sense, as the reader is never clearly informed that a major strength of this subset of first-order logic is the availability of underlying logic programming technology. One gets the feeling that actual implementations of good Horn clause theorem provers are not quite out of the closet, although it could be argued that any discussion of such details would be inappropriate. (The historical notes at the end of Chapter 5 mention that Prolog embodies a restricted form of resolution.)

Rather than level a general criticism at this particular text, it is probably more appropriate to criticize the general logicist community, whose research seems to widen rather than close the gap between theory and practice. More emphasis on identifying implementable subsets of proof theories for the growing population of exotic logics would help reduce the gap between theory and practice in the logicist camp, and will presumably be reflected in subsequent textbooks of this kind.

Chapter 6: Nonmonotonic Reasoning

For those still struggling with the details of circumscriptive schemas, this chapter provides some textbook level relief. Although the title is misleadingly general, one brand of nonmonotonic reasoning is redeveloped, beginning with the concepts of closed worlds, unique names, and predicate completion. After briefly describing an application to hierarchical reasoning, the remainder of the chapter is devoted to circumscription, with a small section on Reiter's default formalism.

It is nice to see a textbook presentation of circumscription and its redevelopment in terms of earlier concepts, but it is misleading in the sense that there are other approaches to nonmonotonic reasoning that are grounded in *reasoning* methods that actually draw conclusions (e.g., Nute's defeasible reasoning; Poole, Goebel and Aleliunas' hypothetical reasoning). Indeed, circumscription is not a reasoning method but a specification method for restricting the inferences derivable from a first-order theory. In this regard, the presentation is not about reasoning, but about axioms which can be added to a first-order theory in order to specify the theory's closure as that expected or desired. (The brief discussion of Reiter's proposal doesn't provide any insight into actually building reasoning systems, but only another view of their possible formalization.)

Still, a chapter on circumscription is appropriate as a presentation of how nonmonotonic reasoning can be understood in terms of ordinary classical logic. In fact, it may be that the authors concentrated on circumscription in order to avoid the complex model-theoretic confusion associated with many other nonmonotonic formalisms.

Chapter 7: Induction

While Chapter 7 admits that learning is a central aspect of AI, the chapter's length and depth reveal the relatively immature stage of the logicist foundation of learning.

An old philosopher's stone, the problem of induction, is quickly simplified to that of constraining the search for good candidate hypotheses in the construction of explanatory proofs, and continues with a discussion of version spaces. After presenting some formal statements about the theory of version spaces, the chapter concludes with a discussion of experiment generation: selecting critical hypotheses for actual testing in the world, in order to distinguish competing theories.

Though the discussion is brief, it is well organized and clear. The framework of constrained induction and experimentation is ample to understand most logically-based work in the area. Again, there is little mention of the ease with which such schemes can be implemented (e.g., as in the Theorist system of Poole, Goebel, and Aleliunas). In addition, the presentation does not make any mention of related work in the logic programming community (e.g., Shapiro's model inference system). That, however, is a general reflection of the separate genesis of hypothetical reasoning in two different research camps. Even without that acknowledgement, the chapter is worthwhile reading.

Chapter 8: Reasoning with Uncertain Beliefs

If one is comfortable with the view that nonmonotonic reasoning systems address the problem of formalizing the process of completing incomplete information with assumptions, then the recent flurry of activity in probabilistic logic and probabilistic reasoning (cf. more ad hoc methods such as certainty factors and fuzzy logic) can be seen as an alternative to nonmonotonic reasoning.

The chapter on reasoning with uncertain beliefs does a very nice job of addressing this issue, by providing a good overview of the fundamental problem, a presentation of standard Bayesian probability, followed by a presentation of a probabilistic logic and associated reasoning method based on Nilsson's earlier work.

Because Nilsson's probabilistic logic is just one of many possible formalizations, readers are advised to keep in mind the fundamental trade-off between MYCIN-like

certainty factors (where all propositions are assumed independent) and standard probability theory (where all propositions are dependent, unless otherwise noted). Intuitively, the representation and reasoning problem is to develop a conceptually clear formalization that is consistent with probability axioms and also allows convenient expression of independence so that the actual calculation of probabilities (numeric or algebraic, objective (i.e., statistical) or subjective) is computationally feasible.

The authors state what seems possible about the computational properties of their probabilistic entailment specification, but admit that there is much work left to be done on developing feasible algorithms for computing probabilistic entailment. With all that said, the chapter is really just a brief taste of a rapidly expanding research topic.

Chapter 9: Knowledge and Belief

The earlier criticism about logicists widening the gap between theory and implementation is most evident in this chapter which describes two alternative conceptions of knowledge and belief. It is ironic that the chapter is not about "knowing" and "believing", but rather about approaches to representing the elusive and difficult concepts of knowledge and belief.

To be fair, the chapter does a good job of introducing the logical basis for belief interpreted as a set of sentences, combined with a deductive procedure for extending beliefs. And, of course, that's what logic is about. What is missing, however, is any skepticism whatsoever about why one would identify a belief as something that results from a deduction in *any* logic.

The chapter presents what are identified as two alternative conceptions of an agent's beliefs: as a set of sentences, and as a set of possible worlds. The presentation of the former deals with the standard interpretation of modal operators and the problems of referential opacity, iterated modality, and quantifier scoping. It is not, however, acknowledged that these are problems of any such logic, nor specifically of belief. The presentation of these standard problems is otherwise well done.

The possible-worlds conception of belief is presumably included for comparison with the set-of-sentences approach. Similar problems arise in both conceptions (e.g., the problem of canonical names), so including both allows the reader to compare, for example, the appropriate nestings of sets of believed sentences versus appropriate definitions of accessibility of possible worlds. And the problem of multiple agents exchanging information is compared as an application of the two models of belief (e.g., a multiple-spot version of the three-wise-men puzzle).

What seems to be missing is any acknowledgement that belief is related to nonmonotonic reasoning, and any explicit acknowledgement that real beliefs are typically supported by lots of different kinds of information, e.g., "I believe theorem X because Dana Scott said it was true, even though I don't have the ability to prove it." The former is especially important for the logicist, as the conception of beliefs as sentences makes belief revision as important as belief derivation (if not more important). Again the gap between theory and implementation could be narrowed here by considering relationships between what is described here and existing specifications of reasoning systems that maintain consistent sets of assumptions. The latter is more subtle. It seems important to identify the problems for which some notion of belief is required, rather than to simply elaborate on what might seem like an almost arbitrary choice of belief model. In other words, the concept of belief is so controversial and ephemeral that one would expect a rather broader discussion of the major uses of the two models of belief proposed. But this chapter does seem to reflect the state of the logicists' understanding of belief.

Chapter 10: Meta-knowledge and Meta-reasoning

The intuition behind the words "meta-knowledge" and "meta-reasoning" is fairly obvious to anyone who has developed any kind of database or knowledge base software. As suggested by the authors, the logic theme suggests that the description of both a problem and associated problem-solving strategy might be given a logical interpretation by suitably conceiving appropriate meta-language relations as object level predicates (e.g., terms and sentences as individuals, related by grammatical and inferential relations).

The intuition becomes murky, however, when coupled with the desire to interpret the amalgamation of object and meta levels as a model of mechanical introspection. With only the relatively weak motivation of modeling "belief", the properties conceived as "introspectively faithful" and "compulsive introspection" quickly abandon intuition. It's not that the idea of a logical model of introspection is uninteresting — only that it is complex enough to demand sound motivation. Meta-level logical reasoning conceived as *logic programming*, in the computation as deduction sense, is the same idea with a much simpler motivation.

Again the authors are excused because of their attempt to capture a tricky topic in textbook form. Still, the idea of meta-theory as logic programming is currently a more practical alternative.

Chapters 11 and 12: State, Change, and Planning

Nilsson's presentation of planning has always been pristine, even if sometimes tedious. These two chapters are a good basis for understanding the foundation of manipulating situations within a logical calculus, and they present a thoroughly digested view of the second author's previous presentations.

It would have been nice to consider other issues, especially that of alternative logical conceptions of time (e.g., tense logic, interval calculi, etc). Despite this shortcoming and very little discussion of more recent issues (e.g., completeness and linearity), the chapter is fine.

Chapter 13: Intelligent Agent Architecture

Any discussion of "tropistic agents" is not yet ready for a textbook entitled *Logical Foundations of Artificial Intelligence*. There are simply too many possible conceptions of the way agents (programs!) might represent and interact with the world (cf. Rosenschein's situated automata and Brook's artificial insects), but every textbook needs a chapter with some "blue sky".

Summary

Buy it, you'll like it.

Randy Goebel is a faculty member in the Department of Computing Science, University of Alberta. He is the author of a number of papers on logic programming and the role of logic in AI.

Readings in Nonmonotonic Reasoning

Ginsberg, Matthew L. (editor)
[Stanford University]

(The MIT Press series in artificial intelligence)
Los Altos, CA: Morgan Kaufmann, 1987, 481 pp
Paperback, ISBN 0-934613-45-1, US$26.95

Reviewed by
Fahiem Bacchus
University of Waterloo

This book is another in the series of reading collections published by Morgan Kaufmann, this time covering the topic of nonmonotonic reasoning. I find these collections to be very useful, and this one is no exception. A number of very interesting articles on current AI approaches to nonmonotonic reasoning are conveniently gathered together in one place.

The collection is separated into five sections. The first section is an introduction by the editor. The second section contains some early papers including the famous "Some Philosophical Problems from the Standpoint of Artificial Intelligence" by McCarthy and Hayes. It is quite amazing just how influential this paper has been — something which becomes apparent when one reads through the rest of the papers in the collection. Also included in this section are some critiques of current AI approaches to nonmonotonic reasoning by D. Israel and also by D. Perlis. The third section contains papers on the three major AI formalisms for dealing with nonmonotonicity — Reiter's default logic, modal approaches (McDermott and Doyle's Nonmonotonic logic, Moore's Autoepistemic logic), and McCarthy's circumscription. This section also has some very interesting attempts at unifying these different formalisms, including an extended version of Konolige's unification of default and autoepistemic logic. The fourth section has a couple of articles on truth maintenance. And finally, the fifth section has articles on various applications of the nonmonotonic formalisms — formalizing the closed world assumption in database theory, semantics of negation as failure in logic programming, diagnosis from first principles, and some work on theories of action and the frame problem.

It's a good selection of articles and one certainly learns a lot by reading them. If you want to do research in this area of AI this collection covers the background required for profitable examination of recent work which has followed along similar lines. Even if one doesn't agree with these approaches to nonmonotonic reasoning it is still necessary to be aware of this work. Pointers to other AI work in nonmonotonic reasoning are supplied in two bibliographies, one by the editor and one by D. Perlis.

There are some production bugaboos. Some of the articles from *Artificial Intelligence* journal were reproduced from originals which had sentences underlined. Also, the choice of reproducing two pages of that journal on one page makes for rather small type which is difficult to read.

The major complaint I have about this collection lies in some of the comments provided by the editor. In particular, the introductory article by Ginsberg paints a rather rosy picture of the outlook of current approaches to nonmonotonic reasoning, an optimism which is not, to my mind, fully warranted. For example, he notes that all of these approaches can be viewed as depending on the notion that default reasoning can be thought of as a minimization of some sort. The generality of this notion seems to be unquestioned by Ginsberg, who encourages the reader to try to find *additional* principles of nonmonotonic reasoning to complement this one. It is not so clear to me that the notion of minimization will, in the end, turn out to be that useful for nonmonotonic reasoning. It is certainly a useful notion for dealing with such things as the closed world assumption and negation as failure, and may also be useful for dealing with communication conventions, e.g., conventions of not leaving out relevant information when stating puzzles. However, it strikes me to be quite counter-intuitive for an agent that has to deal with the real world and incomplete information gathered through its sensors to assume that things that it can't deduce are false are in fact true. Such a policy will surely lead the agent to some very irrational behaviour, or at the very least, to some very suboptimal behaviour. An agent simply cannot assume that it knows enough about the *real* world for such a policy to make sense, as for example it does in databases.

A useful conjunct to this collection is Reiter's review article "Nonmonotonic Reasoning", in *Annual Review of Computer Science*, 1987. Reiter presents a much more balanced view of the contribution of AI approaches to nonmonotonic reasoning.

It is also misleading to view nonmonotonic reasoning as something special to AI. Nonmonotonic reasoning has been studied extensively in philosophy as inductive logics. Another way of viewing monotonicity in deductive logics is as soundness — any sound rule of inference is going to be monotonic; the conclusion is necessarily true if the premises are. As long as the premises are held to be true so must be the conclusion, and this will not change when additional premises are added. Inductive logics have studied non-deductive rules of inference, and once one gives up soundness one gets nonmonotonicity. Since the conclusion is not a necessary consequence of the premises it is always possible that its negation is true. If its negation is subsequently added to the set of premises, any reasonable inductive logic must retract the conclusion. Similarly, nonmonotonic logics give up soundness when they circumscribe, or when they activate a default. It is well worth the time of anyone interested in nonmonotonic reasoning to read some of the philosophical work. There are, however, no references given to this literature. I would recommend the book *Probability and Inductive Logic* by H. E. Kyburg (Macmillan, 1970) as being a good introduction.

One other point not discussed by the editor is that once one gives up soundness it becomes important to justify one's rules of inference through some other means other than the preservation of truth. The formal characterizations of such justifications remain an important open question, a question which has not been addressed in current AI work in nonmonotonic reasoning. For example, researchers claim that circumscriptions is intuitive, but have not been able to offer any formal justifications. Nor has this question been given any adequate answers by the philosophers. It is a very difficult question, but one which deserves some attention.

Fahiem Bacchus recently returned to Canada after pursuing post-doctoral studies at the University of Rochester, examining the application of statistical knowledge and inductive logics to AI. He is now an Assistant Professor at the University of Waterloo.

Reasoning about Change: Time and Causation from the Standpoint of Artificial Intelligence

Shoham, Yoav
[Stanford University]

(The MIT Press series in artificial intelligence)
Cambridge, MA: The MIT Press, 1988, xvi+200 pp
Hardbound, ISBN 0-262-19269-1, US$25.00

Reviewed by
James P. Delgrande
Simon Fraser University

This book describes a specific, formal approach to the problems of representing and reasoning about time and causation as they arise within the general framework of artificial intelligence. The book consists essentially of Shoham's doctoral dissertation and is part of the MIT Press series in artificial intelligence, whose purpose is to provide "timely, detailed information" concerning recent AI research. Given this goal, it is not surprising that the book is neither a survey nor an introduction to the area (despite its subtitle), but rather provides a specific account of how such problems may be addressed. As such, it succeeds not only in being timely and detailed, but also interesting, thoughtful, and well-written.

As suggested above, the book is not intended for the neophyte. Consequently, a familiarity with work in temporal reasoning in AI is assumed; for example, without such knowledge, the author's comments on James Allen's work make little sense. While a familiarity with modal logics is not, strictly speaking, assumed, the description provided is quite terse and a knowledge of this area would also be very helpful. Similar remarks apply to nonmonotonic reasoning.

The book is written in a clear, economical style. If anything, it is perhaps a little over-brief in places. At times, decisions are simply stated with minimal motivation or supporting argument. For example, as is discussed below, the model preference criterion given in the section on nonmonotonic reasoning may be a little less general than it could otherwise be. Similarly, there are times when an additional example or two would have helped clarify a point. On the other hand, the author has clearly thought long and hard about the various issues; while it would be nice on occasion to hear of the reasons leading up to a particular decision, a full addressing of this point might have unreasonably lengthened the book.

The book can be divided into four major parts. The first two "set the stage" by developing a framework for temporal reasoning. The last two apply this framework to a number of problems both inside and outside of AI. The first part is concerned with developing a general logic of time, as a means of expressing the various phenomena of interest. The second presents a general model-theoretic approach to nonmonotonic reasoning. Given this, the author shows how the *qualification* problem and the problem of *extended prediction* may be resolved. Lastly, an account of the notion of causation deriving from these considerations is given.

The first part of the book (Chapter 2), provides a discussion of pertinent distinctions concerning temporal structures, followed by a brief critique of James Allen's and Drew McDermott's work in temporal reasoning. The former work, which takes the time interval as primitive, is argued to be somewhat awkward in some instances. In the end, a variant of McDermott's system is adopted: time points are taken as primitive, and (primitive, timeless) propositions are identified with sets of pairs of such points. That is, a proposition is identified with a set of intervals over which (in the semantics) it is true. Syntactically, formulas are constructed from base sets of primitive propositions and time point symbols (constants or variables) in the expected fashion. The central temporal construct in the set of well-formed formulas is the formula $TRUE(u_1, u_2, p)$ where u_1 and u_2 are time point symbols, and p is a possibly-negated primitive proposition. This formula is read as "p is true over the interval $<u_1, u_2>$". A proposition true at a point in time then would simply have the same first two arguments to *TRUE*.

The semantics is based on a limited ontology, and avoids introducing events, properties, facts, and other such entities as primitive objects; rather these entities are introduced by definition. As a result, the logic rests on a conceptually clean foundation that is at the same time very general. In the propositional case, an interpretation is a tuple $<TW, \leq, M>$ where TW is a set of time points, $\leq$ a binary relation on TW, and M maps time constants onto time points, and primitive propositions onto sets of pairs of time points. The extension to a first-order logic is straightforward. The resultant formal systems appear sufficiently broad to capture most aspects of temporal reasoning. Thus, for example, there is no commitment made as to whether time is discrete or not, or branching or not. On the other hand, this generality seems to leave the systems open to the same criticism that Shoham directs at Allen's work: that the semantics is perhaps too general, or too loose, and thus may admit unintuitive models. Thus, for example, in an interpretation, $\leq$ is *any* binary relation. This seems perhaps overly general, and presumably we can at least assume that $\leq$ is a partial order. However, even if this is the case, it would seem that we might want to add further constraints on this relation, and moreover, claim that these constraints are crucial in any temporal logic. Thus we might want to say that any two time points are connected via a path through $\leq$ or its inverse. In addition, once these systems have been developed, the remainder of the book assumes a much more constrained system: that points of time are isomorphic to the integers.

Again, the brevity of presentation appears to obscure some fine points in the semantics. Thus, for example, somewhat later in the book when time is assumed to be isomorphic with the integers, the symbol ∞, representing infinity, is introduced as an explicit time-point symbol. But this presumably is a non-trivial addition, ∞, whatever it is, is not an integer. But this being the case, the question is left open as to what precisely the symbol ∞ denotes, or what special properties it may have.

The second part of the book presents an approach for developing and analyzing nonmonotonic systems based on model-theoretic considerations. The general idea is elegant, simple, and consequently, highly appealing. In brief, one orders the models of a logic by some *preference criterion*, and an interpretation M is said to preferentially satisfy a sentence A, just when A is true in that interpretation and there is no less preferred M' satisfying A. Circumscription, for example, is easily shown to fit into this framework and Reiter's system for default reasoning is shown to fit with a little coaxing.

The treatment given here is brief (which is perfectly understandable, given that the purpose of the dissertation

was not to address nonmonotonicity per se) and leaves unanswered a number of questions. On the more mundane side, the preference criterion is assumed to be a strict partial ordering, and so if $M < M'$, then we cannot have $M' < M$. However there would appear to be good arguments for allowing the criterion to be non-strict, and so allow both $M \leq M'$ and $M' \leq M$ (or models that are equally preferred). In addition, there appear to be strong ties between this approach and that of conditional logics (Hi Mom!), wherein a preference criterion is an explicit part of the semantics of the system.

The third part of the book (Chapters 4 and 5) resolves the *qualification* problem and problem of *extended prediction*. The first of these problems deals with the apparent requirement that, for reasoning in a realistic domain, an inordinate number of conditions must be satisfied before a conclusion is forthcoming. Thus, before concluding that a loaded gun makes a noise when the trigger is pulled, one would need to first ensure that the gun wasn't immersed in water, that it had a firing pin, that there was air to carry the sound, and so on. For this problem, the notion of a *causal theory* is introduced: a causal theory is a set of sentences $(\Phi \wedge \Theta) \supset \Box\phi$, where ϕ is a sentence of the form $TRUE(t_1, t_2, p)$, or $\neg TRUE(t_1, t_2, p)$, and where p may be negated, Φ (roughly) is a conjunction of sentences that must be known to be satisfied, and Θ (roughly) is a conjunction of sentences whose negation isn't known. Assuming that certain reasonable time constraints are met, Shoham shows how temporal nonmonotonic consequents can be determined and, moreover, can be determined in $O(n \log n)$ time. Thus, while this formulation is not totally general, it does lead to very good complexity bounds.

For the problem of extended prediction, which amounts to the difficulty of easily yet accurately predicting things over extended periods of time, Shoham extends Hayes' notion of space-time *histories*. The idea here (again, roughly) is that *potential histories*, entities that by default extend into the future until explicitly blocked, are introduced. In an extension of the preceding causal theories, the author again shows how a particular model can be efficiently constructed.

In the final part of the book (Chapter 6), it is argued that the preceding work provides a sound basis for a new account of causation. The sentence "$TRUE(t_1, t_2, p)$ directly causes $TRUE(t_3, t_4, q)$" is taken to be true in a causal theory just when that theory contains a causal rule $(\Box TRUE(t_1, t_2, p) \wedge \Theta) \supset \Box TRUE(t_3, t_4, q)$, where Θ is a conjunction of conditions where the negation of none of the conjuncts is known, and where various reasonable conditions concerning temporal precedence hold. Thus, if one does indeed pull the trigger of a loaded gun, and one doesn't know that there is no air, and that there isn't a firing pin, etc, then one can conclude that pulling the trigger causes a noise in the next time instant. From this, an account of the statement "$TRUE(t_1, t_2, p)$ actually causes $TRUE(t_3, t_4, q)$" is given. While the remarks given below are directed at the notion of "directly causes", they apply also with simple modification to the latter notion of "actually causes".

This account of causation has a certain appeal, but it is unclear the extent to which it provides a full account of this phenomenon. First, only primitive propositions can be "caused" by something. This arises from the fact that *TRUE* takes only primitive propositions as its third argument, and that causal theories apply only to statements with conclusions of the form $\Box TRUE(t_1, t_2, p)$. A second limitation is that this account appears to admit some counterintuitive statements of causation. Thus, it is possible to assert that some condition causes some other condition, where the second condition already happens to be true. Hence, in this account, if I painted a fire hydrant red, which was already red, I could nonetheless claim that I caused the hydrant to be red. While it seems reasonable to assert the counterfactual "if the hydrant wasn't already red, then my actions would have made it red", it seems somewhat less reasonable to assert "painting the hydrant red caused it to be red." As well, stranger examples can be constructed. For instance, statements that happen to be known to be true seemingly can have arbitrary causes. Thus, for example, I have a friend, Art, who is an avid drummer, and who always drums on weekends. If we now assume that he catches a cold, it seems that we can equally well assert "catching the cold on Saturday caused Art's blocked sinuses" and "drumming on Saturday caused Art's blocked sinuses." Lastly, it can be observed that any theorem may be "caused" in any causal theory. Thus, for example, it seems that we could assert that "Art's drumming last Saturday caused De Morgan's laws."

A conceivable way around these difficulties would be to simply exclude such statements from causal theories. However, this solution then defers the problem of deciding when something causes something else, since we would now have to decide which statements should or should not be admitted into these theories. However, if we could make this decision, then the suggested approach would allow us to reason about causality; it just wouldn't furnish us with a definition of causality. It seems then that a reasonable conclusion may be that this account doesn't provide a definition of causality per se, but if we have settled the question of what things in general cause what other things, then we can draw conclusions of causality concerning contingent information by means of this approach.

To summarize: this is a highly interesting and useful book for a researcher in AI, particularly one interested in temporal reasoning and related areas (including not just action and causality, but also problem solving, planning and others). The adoption of a formal framework leads to a clear, principled investigation and solution to recalcitrant and fundamental problems in temporal reasoning. The notion of model preference is appealing, not just as an approach to apply to temporal reasoning, but as an approach to the much broader problem of nonmonotonicity in general. Causal theories and potential histories provide a satisfying resolution to problems of reasoning with and about temporal aspects of propositions. The section on causality, while perhaps not providing a general definition or specification of the phenomenon, does allow one to decide when something causes something else, given a prior set of statements of causality.

James Delgrande received his Ph.D. in artificial intelligence from the University of Toronto. His paper on default reasoning in first-order conditional logics won an award for Best Paper at the 1987 AAAI conference.

Next Issue

Howard Hamilton reviews *Automated Reasoning: 33 Basic Research Problems*, by Larry Wos.
Dick Peacocke reviews *Applications of Expert Systems*, edited by Ross Quinlan.

Books Received

Books listed below that are marked ‡ will be reviewed in a future issue. Readers who wish to review books for the magazine should write, outlining their qualifications, to the book review editor, Graeme Hirst, Department of Computer Science, University of Toronto, Toronto, Ontario, Canada M5S 1A4. Obviously, we cannot promise the availability of books in anyone's exact area of interest.

Authors and publishers who wish their books to be considered for review in *Canadian AI* should send a copy to the book review editor at the address above. All books received will be listed, but not all can be reviewed.

The Computational Analysis of English: A Corpus-Based Approach
Garside, Roger; Leech, Geoffrey; Sampson, Geoffrey (editors)
[University of Lancaster and University of Leeds]
London: Longman, 1987, xii+196 pp
Paperback, ISBN 0-582-29149-6

Computer Models of Mind: Computational Approaches in Theoretical Psychology
Boden, Margaret A.
[University of Sussex]
(Problems in the behavioural sciences)
Cambridge, Eng.: Cambridge University Press, 1988
xi+289 pp Hardbound, ISBN 0-521-24868-X, US$42.50
Paperback, ISBN 0-521-27033-2, US$15.95

Computer-Supported Cooperative Work: A Book of Readings
Greif, Irene (editor)
[Lotus Development Corporation]
San Mateo, CA: Morgan Kaufmann, 1988, viii+783 pp
Hardbound, ISBN 0-934613-57-5, US$36.95

‡ **Computer Vision: A First Course**
Boyle, Roger D.; Thomas, Richard C.
[University of Leeds]
(Artificial intelligence texts)
Oxford: Blackwell Scientific Publ., 1988, ix+220 pp
Paperback, ISBN 0-632-01577-2, US$29.25

Linguistic Theory and Computer Applications
Whitelock, Pete; Wood, Mary McGee; Somers, Harold L.; Johnson, Rod; Bennett, Paul (editors)
[Centre for Computational Linguistics, UMIST]
London: Academic Press, 1987, x+329 pp
Paperback, ISBN 0-12-747220-7

Machine Translation Systems
Slocum, Jonathan
(Studies in natural language processing)
Cambridge, Eng.: Cambridge University Press, 1988
ix+341 pp, Hardbound, ISBN 0-521-35166-9, US$49.50
Paperback, ISBN 0-521-35963-5, US$16.95

Machine Translation Today: The State of the Art
(Proceedings of the Third Lugano Tutorial, April 1984)
King, Margaret (editor)
[Institute for Semantic and Cognitive Studies, University of Geneva]
(Edinburgh information technology series 2)
Edinburgh University Press, 1987, xii+447 pp
Hardbound, ISBN 0-85224-519-X, UK£45.00

Natural Language Processing
Noble, Hugh M.
[Robert Gordon's Institute of Technology, Aberdeen]
(Artificial intelligence texts)
Oxford: Blackwell Scientific Publ., 1988, xii+240 pp
Paperback, ISBN 0-632-01502-0, US$33.50

Natural Language Understanding and Logic Programming, II: *Proceedings of the Second International Workshop*
Dahl, Veronica; Saint-Dizier, Patrick (editors)
[Simon Fraser University; IRISA, University of Rennes 1]
Amsterdam: North-Holland, 1988, viii+345 pp
Hardbound, ISBN 0-444-70408-6, US$84.25

Programming in POP-11
Laventhol, Jonathan
[GLH Limited, Brighton, England]
(Artificial intelligence texts)
Oxford: Blackwell Scientific Publ., 1988, xiv+221 pp
Hardbound, ISBN 0-632-01736-8, US$56.25
Paperback, ISBN 0-632-01528-4, US$33.50

Starting Lisp for AI
Coxhead, Peter
[University of Aston]
(Artificial intelligence texts)
Oxford: Blackwell Scientific Publ., 1987, vii+168 pp
Hardbound, ISBN 0-632-01697-3, US$56.25
Paperback, ISBN 0-632-01544-6, US$21.95

Systemic Text Generation as Problem Solving
Patten, Terry
[The Ohio State University]
(Studies in natural language processing)
Cambridge University Press, 1988, xii+214 pp
Hardbound, ISBN 0-521-35076-X, US$34.50

Technical Reports

University of Guelph

An Intelligent System for Research in Dolphin Cognition
Karl Baden Langton
Dept. of Computer Science
University of Guelph
Guelph, Ontario

This thesis examines the usefulness of artificial intelligence techniques which can be used to develop intelligent systems. These techniques are applied to the design of an information system of both data and knowledge. The database of the system consists of data collected from seven years of language tutoring sessions performed with bottlenosed dolphins at the University of Hawaii's Kewalo Basin Marine Mammal Laboratory. Part of the intent of this project is to design a knowledge base of the dolphins' strengths and weaknesses in learning artificial languages.

In particular, we present the application of methods which have been reported to aid interactions with information systems. The techniques dealt with here include natural language processing, strategies for generating cooperative responses to queries, and some issues necessary for the design of intelligent tutoring systems. These concepts have only recently become popular and hence are not yet widely available as commercial products. We claim that through the application of these concepts, interactions with computer systems can be more informative. Further discussions involve the relevancy and implications of this work.

University of British Columbia

Teaching Prolog Using Intelligent Computer-Assisted Instruction and a Graphical Trace
Earl Fogel
Dept. of Computer Science
University of British Columbia
Vancouver, British Columbia

Two methods for improving the quality of computer assisted instruction are examined. They are: using intelligent computer assisted instruction techniques to make the CAI system more flexible, and using graphics to increase the efficacy of teaching.

Two computer systems for teaching the logic programming language Prolog were developed. The first is an ICAI system which uses the prerequisite relationships of the course material to plan a course of study. It distinguishes between methods of instruction and topics of instruction, giving students a great deal of freedom in choosing either one. The second is an animated trace which graphically illustrates the execution of Prolog programs. Information is displayed in three windows — one for Prolog goals, one for the database, and one for output from the program being traced.

Results indicate that ICAI and graphics can both be used effectively in the teaching of programming languages, particularly in combination.

University of Alberta

Representing and Reasoning with Probabilistic Knowledge
Fahiem Bacchus
Dept. of Philosophy
University of Alberta
Edmonton, Alberta

This thesis presents a logical formalism for representing and reasoning with probabilistic knowledge. The formalism differs from previous efforts in this area in a number of ways. Most previous work has investigated ways of assigning probabilities to the sentences of a logical language. Such an assignment fails to capture an important class of probabilistic assertions — empirical generalizations. Such generalizations are particularly important for AI, since they can be accumulated through experience with the world. Thus, they offer the possibility of dealing with domains where no experts are available from which to gather subjective probabilities.

A logic is developed which can represent these empirical generalizations. Reasoning can be performed through a proof theory which is shown to be sound and complete. Furthermore, the logic can represent and reason with a very general set of assertions, including many non-numeric assertions. This also is important for AI as numbers are usually not available.

The logic makes it clear that there is an essential difference between empirical, or statistical, probabilities and probabilities assigned to sentences, e.g., subjective probabilities. The second part of the formalism is an inductive mechanism for assigning degrees of belief to sentences based on the empirical generalizations expressed in the logic. These degrees of belief have a strong advantage over subjective probabilities: they are founded on objective statistical knowledge about the world. Furthermore, the mechanism of assigning degrees of belief gives a natural answer to the question "Where do the probabilities come from?" They come from our experience with the world.

The two parts of the formalism offer combined, interacting, but still clearly separated, plausible inductive inference and sound deductive inference.

Time Revisited
Stephanie Miller
Dept. of Computing Science
University of Alberta
Edmonton, Alberta

Theorem provers are prone to combinatorial explosions, especially when dealing with certain kinds of inference. To compensate for this, special purpose inference methods have been developed that are more efficient within their subdomain than any general method. By exploiting properties of those domains, such mechanisms can shorten chains of reasoning with types, temporal relations, colors, arithmetic relations, and sets, to name a few.

The problem investigated here is one of how best to use these efficient but limited methods in a more general environment. Although much research has been done on this problem, most of the resulting systems either restrict what they can represent and reason with, limit the types of special mechanisms that can be used, or are difficult to extend with other specialists.

A uniform interface to the specialists is developed which allows them to assist a resolution-based general theorem prover in function evaluation, literal evaluation, and generalized resolving and factoring. The special mechanism used as the main test bed for this research was a temporal specialist. This dissertation takes an efficient temporal reasoner and extends its inferential capabilities to handle both strict and non-strict ordering. Further enhancements enabled the temporal specialist to do generalized resolving and factoring, as well as function and literal evaluations. The resulting temporal specialist is incorporated into the system using the specialist interface.

The emphasis throughout is on applied rather than theoretical issues. Experience with the interface confirms that new specialists can be added with relative ease. This is because the specialists interact with the general theorem prover in a small, fixed set of ways. Each new specialist was found to make possible fast proofs of questions previously beyond the scope of the theorem prover. The combined system can, in a few steps, do some proofs that would normally require numerous steps. Examples from the fully operational hybrid system are included.

Upcoming Conferences

In Canada

First International Conference on Principles of Knowledge Representation and Reasoning
15 - 18 May 1989, Toronto, Ontario
See announcement on pages 58 - 59 for details.

3rd AAAI Workshop on Knowledge Acquisition for Knowledge-Based Systems

7 - 11 November 1988, Banff, Alberta

Topics include: Transfer/modeling of expertise; Learning systems; Extracting and modeling of knowledge; Integration of Knowledge Acquisition (KA) techniques and systems; KA methodology and training.
Contact: John Boose, Advanced Technology Center, Boeing Computer Services, 7L-64; via mail: PO Box 24346, Seattle, Washington, USA 98124; via courier: Bldg 33.07 2760 160th Ave. SE, Bellevue, Washington, USA 98008. Phone: (206) 865-3253. Brian Gaines, Dept. of Comp. Sci., U. of Calgary, 2500 University Dr. NW, Calgary, Alberta T2N 1N4. Phone: (403) 220-5901.

6th Canadian Symposium on Instructional Technology

3 - 5 May 1989, Halifax, Nova Scotia

Focus: Computer-assisted learning — theory and reality.
Topics include: AI in education training; Innovations in instructional technology and courseware development; Technology transfer from researcher to user; Impact of ES and AI on CAL; User perspective on CAL.
Contact: F. Kewley, Sixth Canadian Symposium on Instructional Technology, Conference Services Office, NRC Canada, Ottawa, Ontario, K1A 0R6. Phone: (613) 993-9009. Telex: 053-3145.

2nd International Conference on AI and Law

13 - 16 June 1989, Vancouver, British Columbia

Topics include: Legal expert systems; Conceptual information retrieval; Case-based reasoning; Analogical reasoning; Representation of legal knowledge; Computational models of legal reasoning. Also invited are papers on relevant theoretical issues in AI (e.g. mixed paradigm systems using rules and cases) and in jurisprudence/legal philosophy (e.g. reasoning with precedents and rules).
Submission material: 6 copies of extended abstract, max 8 pages. Submission deadline: Jan 10, 1989.
Contact: Edwina L. Rissland, Dept. of Comp. and Info. Sci., U. of Massachusetts, Amherst, MA 01003.
Phone: (413) 545-0332. Email: rissland@cs.umass.edu.

27th Annual Meeting of the Association for Computational Linguistics

26 - 29 June 1989, Vancouver, British Columbia

Topics include: Pragmatics, discourse, semantics, syntax, and the lexicon; Phonetics, phonology, and morphology; Interpreting and generating spoken and written language; Linguistic, mathematical, and psychological models of language; Machine translation and translation aids; Natural language interfaces; Message understanding systems.
Submission material: 12 copies of extended abstract, max 8 pages. Submission deadline: Jan 6, 1989.
Contact: Julia Hirschberg, ACL89 Program Chair, AT&T Bell Laboratories, 2D-450, 600 Mountain Ave., Murray Hill, NJ 07974. Phone: (201) 582-7496.
Email: julia@btl.att.com.

In the United States

4th Aerospace Applications of AI Conference

25 - 27 October 1988, Dayton, Ohio

Tutorials will be held Oct 24 and workshops on Oct 28.
Topics include: Integrating neural networks and expert systems (ES); Machine learning, cognition and the cockpit; Neural networks and human-machine interfaces; Parallel processing and neural networks; Back propagation with momentum, shared weights or recurrent; ES development tools; Aerospace scheduling; Real-time expert systems; Verification and validation of ES; Natural language recognition and synthesis.
Contact: James Johnson, AFWAL/AAOR, WPAFB, OH 45433.

2nd IEEE Conference on Neural Information Processing Systems (Natural and Synthetic)

28 November - 1 December 1988, Denver, Colorado

Topics include: Neurobiological models of development; Cellular information processing; Synaptic function, learning and memory; Connectionist models of learning and cognitive processing; Training paradigms; Generalization and complexity; Applications to signal processing, vision, speech, motor control, knowledge engineering and adaptive systems; Advances in hardware technologies — neurophysiological recording tools, VLSI or optical implementations of neural networks.
Contact: Scott Kirkpatrick, IBM T. J. Watson Research Center, P.O. Box 704, Yorktown Heights, NY 10598.

Expert Systems for Numerical Computing

5 - 7 December 1988, W. Lafayette, Indiana

Topics include: AI and ES; Analysis and design of user interfaces for ES; Knowledge-based systems for scientific applications; ES for mapping applications to parallel architectures and to support parallel processing; Advisory ES for general-purpose scientific software libraries; Sophisticated user interfaces for scientific/engineering systems.
Contact: Professor E. Houstis, Dept. of Comp. Sci., Purdue U., W. Lafayette, IN 47907-2004. Phone: (317) 494-6003.
Email: enh@cs.purdue.edu.

5th IEEE Conference on AI Applications

6 - 10 March 1989, Miami, Florida

Focus: Application of AI techniques to real-world problems. Topics include: Knowledge acquisition; Task-specific knowledge rep.; Task-specific reasoning; Verification and validation; Diagnosis; Intelligent

interfaces. Papers should focus on principles or case studies (in science, medicine, law, business, engineering, manufacturing, robotics).
Contact: Mark Fox, Robotics Institute, Carnegie Mellon U., Pittsburgh, Pennsylvania 15213. Phone: (412) 268-3832. Fax: (412) 268-5016. Telex: 854941.
Email: msf@isl1.ri.cmu.edu.

IEEE Workshop on Visual Motion
20 - 22 March 1989, Irvine, California
Focus: The representation and analysis of motion in image sequences. Topics include: Motion detection mechanisms; Optical flow and motion correspondence; Structure from motion; Event recognition and representation; Temporal planning and inferences; Control structures for dynamic scene analysis; Uncertainty in dynamic scene analysis; Applications in navigation, object manipulation and recognition.
Contact: Ellen Hildreth, AI Laboratory, 545 Technology Square, Cambridge, MA 02139.

1989 Spring Symposium Series
27 - 30 March 1989, Stanford, California
Eight three-day symposia on a variety of topics. Details were not available at the time of press.
Submission deadline: Dec 7, 1988.
Contact: 1989 Spring Symposium Series, AAAI, 445 Burgess Dr., Menlo Park, CA 94025-3496. Phone: (415) 328-3123.

ICCAL '89: 2nd Conference on Computer-Assisted Learning
9 - 11 May 1989, Dallas, Texas
Topics include: AI applications and instruction; Intelligent tutoring systems; Knowledge acquisition and representation; Student modeling and cognitive diagnosis; Human computer instruction; Computational models of reasoning and learning; Evaluation of learning environments; Knowledge-based CAI systems; Authoring systems.
Contact: Prof. Hermann Maurer, IIG, Schiesstattgasse 4a, A-8010 Graz, Austria. Phone: 0043-316-70255/12.
Email: maurer@btx.uucp.

IJCAI 11th Joint Conference on AI
20 - 25 August 1989, Detroit, Michigan
The technical program consists of a "paper track" and a "videotape track". The paper track focuses on empirical, analytical, theoretical, conceptual, foundational aspects and applied research. The videotape track focuses on applications in all subfields best suited for this type of presentation.
Topics include: AI tools and technologies; Machine architectures, languages, shells; Search methods; Knowledge acquisition, learning, analogy; Real-time performance; Parallel and distributed processing; Cognitive modeling; Planning, scheduling, and reasoning about actions; Natural language, speech understanding and generation; Perception, vision, robotics; ITS; Design, manufacturing, control; Philosophical foundations, perspectives and attitudes, social implications.
Submission material: 6 copies in hardcopy, of 4-10 single-spaced pages, with 100-200 word abstract, or 1 copy of 15 minute video, with written abstract and indication of tape format (NTSC, PAL, SECAM; VHS, .75" U-matic). Submission deadline: Dec 7, 1988.
Contact: IJCAI 89, c/o AAAI, 445 Burgess Drive, Menlo Park, CA 94025-3496.

Outside North America

1st Symposium on AI
24 - 28 October 1988, Monterrey, Mexico
Topics include: Knowledge-based systems; Knowledge acquisition and representation; Inference engine; Certainty factors; Vision; Robotics; ES applications in industry; Natural language processing; Speech recognition.
Contact: ITESM, Centro de Investigacion en Informatica, David Garza Salazar, Sucursal de Correos J. 64849 Monterrey, N.L. Mexico. Phone: (83) 59 57 47, (83) 59 59 43, (83) 59 57 50. Telex: 0382975 ITEMSE.
Fax: (83) 58 59 31. Email: siiacii@tecmtyvm.bitnet
Applelink: IT0023.

1st Australian Knowledge Engineering Congress
2 - 4 November 1988, Melbourne, Australia
Topics include: Expert systems case studies; Knowledge engineering methodologies; Design and use of conceptual schemas; Natural language interfaces; Evaluation of tools and expert systems; Role of consultants in knowledge engineering; Design of intelligent tutors.
Contact: B.J. Garner, Deakin U., Victoria 3217, Australia.

AI'88: Australian Joint AI Conference
15 - 18 November 1988, Adelaide, Australia
Focus: To bring together business, industry and researchers; To help business and industry understand the potential in AI; To provide a forum for research topics; To gain insight into the process of going from research to product.
Contact: AI'88 Secretariat, Dept of Comp. Sci., U. of Adelaide, GPO Box 498, Adelaide, South Australia 5001, Australia. Phone: (08) 228-5586.
Telex: UNIVAD AA89141. Fax: (08) 224-0464.
Email: AI88@uacomsci.ua.oz.au.

Neural Networks and Applications
15 - 17 November 1988, Nanterre, France
Topics include: Languages, models, simulation, tools, implementation techniques; Vision and image processing; Acoustics; Speech recognition; Character recognition; Robotics; Learning; Knowledge acquisition; Optimization and combinatorics; Diagnostic techniques and quality control; Surveillance, security, reliability, fault tolerance.
Contact: Workshop Secretary, EC2, Neuro-Nimes, 269, rue de la Garenne, 92000 Nanterre, France. Phone: (1) 27 80 70 00. Telex: 612 469 F. Fax: (1) 47 80 66 29.

International Computer Science Conference '88 AI: Theory and Applications
19 - 21 December 1988, Hong Kong
Topics include: AI architectures; Expert systems; Knowledge engineering; Logic programming; Machine learning; Natural languages; Neural networks; Pattern recognition; Robotics; CAD/CAM; Chinese computing; Distributed systems; Information systems; Office automation; Software engineering.
Contact: Jean-Louis Lassez, Rm H1-A12, IBM Thomas J. Watson Research Center, P.O. Box 218, Yorktown Heights, NY 10598. Email: JLL@ibm.com.

5th Israeli Symposium on AI
27 - 28 December 1988, Tel-Aviv, Israel
This year, the conference is held in cooperation with the SIG on Vision, Image Processing and Pattern Recogni-

tion, and in conjunction with the Tenth Israeli Conference on CAD and Robotics. Topics include: AI and education; AI languages; Logic programming; Automated reasoning; Cognitive modeling; Expert systems; Image understanding, pattern recognition and analysis; Inductive inference, learning and knowledge acquisition; Knowledge theory, logics of knowledge; Perception, machine vision; Planning and search; Robotics.
Contact: Ehud Shapiro, 5th ISAI, The Weizmann Institute of Science, Rehovot 76100, Israel.

4th European Chapter Conference
Assn. for Computational Linguistics
10 - 12 April 1989, Manchester, England

Topics include: Morphology; Knowledge representation and expert systems; Computer-assisted language learning; Machine translation; Lexical semantics; Computational models for the analysis and generation of language; Speech analysis and synthesis; Computational lexicography and lexicology; Syntax and semantics; Discourse analysis; Computational aids to translation; Natural language interfaces.
Contact: Harold Somers, Centre for Computational Linguistics, UMIST, PO Box 88, Manchester M60 1QD, England.

AISB '89
17 - 21 April 1989, Sussex, England

Held by the Society for the Study of Artificial Intelligence and Simulation of Behaviour (AISB).
Topics include: Knowledge acquisition and representation; Automated reasoning; Vision; Cognitive modeling; Commonsense reasoning; Learning; Psychological, philosophical or social implications; Search; Planning.
Submission material: 5 copies of paper with abstract max 5000 words. Submission deadline: Nov 1, 1988.
Contact: Dr T. Cohn, Dept. of Comp. Sci., U. of Warwick, Coventry CV4 7AL, UK. Email: agc@uk.ac.warwick.cs, agc%uk.ac.warwick.cs@nss.cs.ucl.ac.uk.

4th Conference on AI and Education
24 - 26 May 1989, Amsterdam, The Netherlands

Topics include: Intelligent tutoring systems (ITS); Development methods of ITS; Relevant cognitive and educational research; Advanced ITS architectures; Domain representation; Student modeling and diagnosis of student problems; Interaction/teaching strategies; Evaluation of ITS; AI-based learning environments; Modeling/simulating worlds.
Submission deadline: December 1988.
Contact: AIED '89 Secretary, SWI, U. of Amsterdam, Herengracht 196, 1016 BS Amsterdam, The Netherlands.
Email: aied@mcvax!swivax.uucp.

International Symposium
on Multiple-Valued Logic
29 - 31 May 1989, Guangzhou, China

Topics include: Automated reasoning; Algebraic and formal aspects; Circuit/device implementation; Fault detection and diagnosis; Logic design and switching theory; High speed computation; Probabilistic and variable-valued systems; Optical computing; Fuzzy logic; Philosophical aspects.
Submission material: 5 copies of paper with abstract.
Submission deadline: Nov 1, 1988.
Contact: Prof. J. Muzio, Comp. Sci. Dept., U. of Victoria, Box 1700, Victoria, B.C., Canada V8W 2Y2.

IEEE ICIP '89
Image Processing Conference
5 - 8 September 1989, Singapore

Topics include: AI vision techniques; VLSI implementation; Image restoration/enhancement; Machine vision; Video communications; Office image processing; Image pattern recognition; Biomedical imaging; Remote sensing; System architecture.
Submission material: 4 copies of extended summary min 1000 words. Submission deadline: Jan 9, 1989.
Contact: Technical Program Chairman, ICIP'89, c/o Meeting Planners, 100 Beach Road, #33-01, Shaw Towers, Singapore 0718, Republic of Singapore.
Email: (Dr. Cho-Huak TEH) eletehch@nusvm.bitnet, chteh@nuseev.bitnet.

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