Artificial Intelligence in Canada:

A Review

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Abstract

Canadians have made many contributions to artificial intelligence over the years This article presents a summary of current research in artificial intelligence in Canada and acquaints readers with the Canadian organization for artificial intelligence—the Canadian Society for the Computational Studies of Intelligence/Societé Canadienne pour l'Étude de l'Intelligence par Ordinateur (CSCSI/SCEIO).

MOST CANADIAN AI research is carried out in universities (primarily in computer science departments), with only a small amount of research being pursued in government laboratories or in private industry, AI research and development is fairly evenly distributed across the country, with approximately as many AI researchers in the west as in the east, though there are relatively fewer AI researchers in the maritimes.

We summarize Canadian AI research efforts and provide a cross-reference from areas of interest to researchers in Appendix 1. In the discussion below we place the various research and development endeavors within the Canadian national AI context.

Our information was solicited by questionnaire, telephone and in-person conversations, and personal knowledge. Initially, a long questionnaire was circulated via the CSCSI/SCEIO Newsletter (vol 2, #1) in March, 1983. Poor response to the questionnaire prompted another, shorter

questionnaire to be sent directly to the CSCSI/SCEIO membership. Response to this questionnaire was somewhat better. Although the number of short questionnaires we received was substantial, we nevertheless undertook a telephone campaign in a third attempt to reach members who did not fill out the questionnaire. The telephone campaign paid handsome dividends and we were able to contact an additional 21 members. During the process of collating results from the questionnaire we made additional telephone calls to respondents and others to clarify possible misinterpretations. A CSCSI/SCEIO report summarizing all of the questionnaire responses is available by writing to any of the CSCSI/SCEIO executives (see Appendix 2).

Two universities have emphasized AI over the years to the extent of engaging professors who specialize in AI research and graduating AI Ph.Ds. The University of British Columbia [UBC] in Vancouver currently has five professors with primary interest in AI, over 20 AI-oriented graduate students, and several main research directions including computational vision, natural language understanding, and representation of knowledge. UBC is the home of the Laboratory for Computational Vision which provides facilities and coordination to the computational vision research effort. The University of Toronto [UT] currently has four professors with full-time AI interests, several professors with at least peripheral interest, and approximately 30 AI-oriented graduate students. Toronto's research areas include representation of knowledge, natural language understanding, computer vision, and medical expert systems. AI faculty at Toronto are members of the Computer Systems Research Institute which provides facilities to many experimentally oriented computer science research projects.

Five other universities also have made significant com-

mitments to AI. The University of Alberta [UA] in Edmonton has five professors with at least some AI orientation, interested in topics such as representation of knowledge, natural language understanding, game playing, image processing, adaptive systems, and cognitive science. Simon Fraser University's [SFU] young computing science department has five faculty with AI interests ranging from natural language understanding and representation of knowledge through logic programming, learning, and computer vision. SFU's Laboratory for Computer and Communication Research supports a number of projects including a major AI project: the automated academic advisor. Montreal's McGill University has AI research ongoing both in the computer science department with research into game playing and in its electrical engineering department investigating computer vision. At the University of Western Ontario in London, Ontario, there are researchers in the computer science department investigating logic programming, software engineering for AI, and robotics; and in the psychology department pursuing topics in cognitive science, coordinated through the Centre for Cognitive Science. The University of Waterloo has expanded its traditional interests in theorem proving to include a significant commitment to logic programming and recently signed on researchers interested in expert systems and natural language understanding.
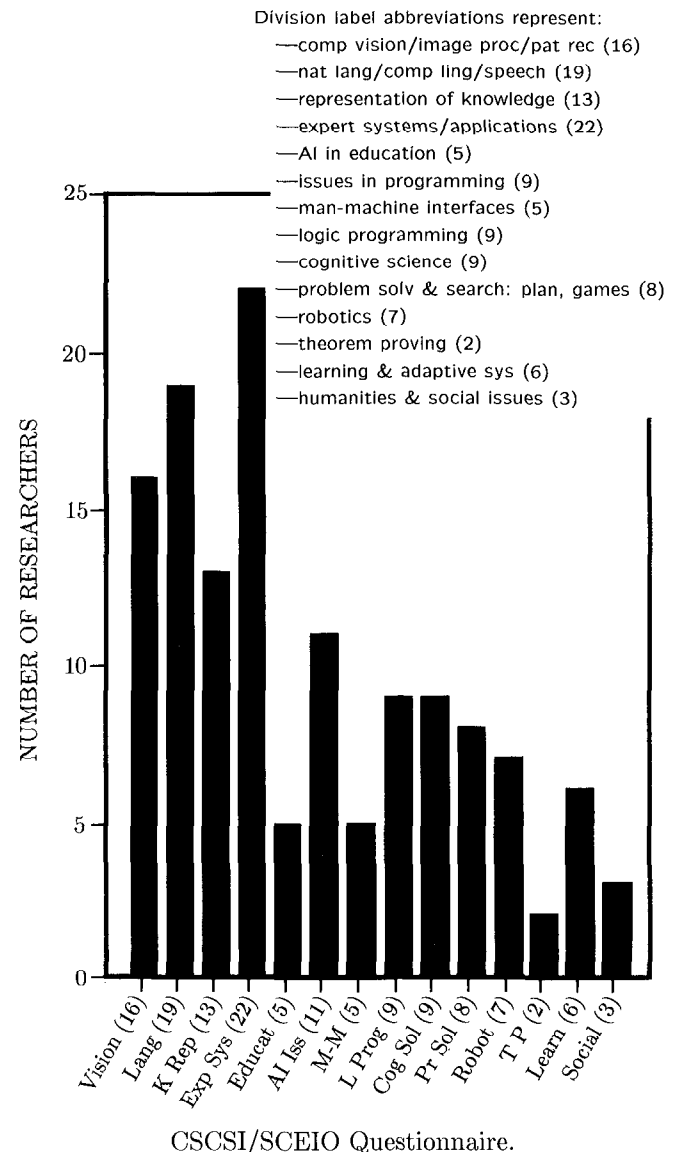
Other universities who haven't historically concentrated on AI are currently increasing their activity in AI. Many of these places will be discussed in the following descriptions of the different AI research areas investigated in Canada (see McCalla and Cercone (1984) for more detail). Graph 1 shows the relative concentrations on the various areas in Canada.

Summary of AI Research in Canada

Computer Vision and Image Processing

One of the most active areas of AI research in Canada is computer vision and its allied field of image processing. The UBC Laboratory for Computational Vision has two main research thrusts in this area. Alan Mackworth and Bill Havens are involved in the use of schema-based representation formalisms to interpret scenes, sketch map understanding (and the Mapsee2 program), constraint satisfaction in scenes, and applications in remote sensing (Havens and Mackworth, 1983). Bob Woodham is working on photometric methods for computational vision, intermediate scene representation, the exact representation and enhancement of color, and applications of remote sensing to forestry. There have been a number of graduate students and research assistants working on these projects over the years. Now at Queen's Roger Browse in his Ph.D thesis investigated knowledge based visual interpretation using declarative schemata. Jay Glicksman's thesis topic involved using output from Mapsee2 to advise an aerial image interpreter. Glicksman is now at Texas Instruments. Bill Havens in his Ph.D work devised the knowledge representation language MAYA and proposed a control structure that allowed top-down and bottom-up

GRAPH 1 — AREAS OF RESEARCH INTEREST

Division label abbreviations represent:
— comp vision/image proc/pat rec (16)
— nat lang/comp ling/speech (19)
— representation of knowledge (13)
— expert systems/applications (22)
— AI in education (5)
— issues in programming (9)
— man-machine interfaces (5)
— logic programming (9)
— cognitive science (9)
— problem solv & search: plan, games (8)
— robotics (7)
— theorem proving (2)
— learning & adaptive sys (6)
— humanities & social issues (3)

CSCSI/SCEIO Questionnaire.

knowledge to interact in the interpretation of scenes. Other students will soon finish, among them Jan Mulder, working on hierarchical constraint satisfaction applied to sketch map interpretation; Frank Wong, exploring the rectification of remotely sensed images using digital terrain models; and Jim Little who is investigating the reconstruction of objects from their extended Gaussian images. Jan Mulder will soon be joining the faculty at Dalhousie University in Halifax.

Brian Funt, a Ph.D graduate of UBC now at Simon Fraser, specializes in computer vision. For some years he has been investigating how to use a parallel processing retina for perception and reasoning (see Funt, 1980). Early experiments involved use of the retina to predict configurations of falling blocks. He is currently looking at automatic wire

routing using diagrams in conjunction with this retina. Funt is also investigating the automatic interpretation of CT-scan images of sawlogs and the generalization of 2-D retinex color perception theory to 3-D.

John Tsotsos, a graduate of and professor at Toronto, is also interested in computer vision. He has been investigating the automatic interpretation of x-ray images of heart motion in order to recognize irregularities. The Alven expert system assesses performance of the human heart's left ventricle (see Mylopoulos et al., 1983). Knowledge representation techniques (borrowed in part from the Toronto "procedural semantic network" project) have been instrumental in his approach. More recently Tsotsos and his soon to be finished Ph.D student Tetsutaro Shibahara have been investigating a knowledge based approach to discovering arrythmias from electrocardiograms. The CAA system implements their approach. They are particularly interested in causality, event prediction, and projection as a transduction mechanism between two knowledge bases. Former Toronto graduate students interested in matters pertaining to computer vision are Dick Peacocke, now at Bell-Northern Research in Ottawa, who devised a picture processing formalism (a preliminary step en route to a picture processing programming language) for his Ph.D; and Norm Badler, now at the University of Pennsylvania, who studied motion understanding for his dissertation.

Another major effort in computer vision is underway at McGill, focussed in the electrical engineering department. Steve Zucker does highly regarded research into mechanisms for human visual perception (Zucker, 1981), and along with Martin Levine is exploring the use of robotics for inspection and repair of hybrid circuits. Zucker's relaxation labelling and theory of continuous relaxation are well entrenched in the computer vision area. In addition, Levine is undertaking research in computer vision and visual perception as applied to various biomedical applications. McGill's Computer Vision and Graphics Laboratory have V. Agarwal, H. Lee, and A. Malowany working with Zucker and Levine, and the lab provides the research facilities for a number of graduate students working under their supervision.

Roger Browse, Jeff Kulick and their colleagues at Queens University in Kingston, Ontario, are interested in computational models of visual attention, foveation, and reading; edge detection and grouping in image understanding; and medical imaging for 3-D tomography.

Image processing investigations at the National Research Council's Ottawa Laboratories include Tony Kasvand studying image processing as applied to the analysis of complex line structures; N. Abdelmalek studying restoration and compression of images; C. Merritt analyzing vegetable chromosomes; and S. Hueng studying binary lines. Visiting researchers also contribute to image processing at NRC.

Wayne Davis at Alberta is studying formats and storage techniques for spatial data and the analysis and enhancement of medical images. Larry Paul in the pathology department at UBC is working in biomedical applications of computer vision, in particular representing 2-D and 3-D properties of biological specimens. Morris Goldberg in the University of Ottawa's electrical engineering department is working with others to develop an expert system for analyzing remotely sensed images of forests. Tom Calvert, dean of interdisciplinary studies at Simon Fraser, in addition to his long term involvement in computer interpretation of Labanotation and animation of dance, has more recently become interested in aspects of computer vision for a mobile robot.

Natural Language Understanding and Computational Linguistics

Computational linguistics, particularly natural language understanding, is another area of longstanding Canadian expertise. In this field also, Toronto's contributions are substantial. John Mylopoulos supervised the initiation over ten years ago of the TORUS (TORonto Understanding System) project. This investigation into constructing a knowledge-based natural language front-end to a database of student records has since evolved into investigations into both natural language and knowledge representation. Working on the TORUS project initiated many graduate students into the study of natural language understanding. Most of the more recent Toronto efforts in computational linguistics have been oriented towards the semantics and pragmatics of natural language. Ray Perrault (now at SRI International) and his Ph.D students Phil Cohen (now also at SRI) and James Allen (now at the University of Rochester) and others formulated an approach to understanding natural language dialogue based on showing how the participants in a dialogue take into account each other's beliefs during a conversation (see Allen and Perrault, 1980). In particular this research illustrated how dialogue participants plan their own speech acts and recognize each other's plans in order to communicate with one another. Robin Cohen's recently completed Ph.D thesis continued the Toronto interest in natural language pragmatics, investigating how various structures give coherence to arguments. Cohen is now at the University of Waterloo. Graeme Hirst, a recent addition to Toronto's faculty from Brown University, is also involved with natural language, specifically knowledge representation techniques to help semantic interpretation and ambiguity resolution, and parsing. His M.Sc. thesis completed some time ago at UBC and now published as a Springer-Verlag book, is an entertaining and informative analysis of anaphora. One other Toronto computational linguistics effort was Alex Borgida's Ph.D research which involved the formalization of stratification grammar. Borgida is now at Rutgers University.

Alberta has also been involved in natural language understanding research. Starting a number of years ago under Jeff Sampson's tutelage, and more recently under Len Schubert's eagle-eyed direction, a number of natural language oriented research projects have evolved. One theme that runs through the research is the use of semantic network representations (see Schubert et al., 1979). Schubert's pioneering effort to extend the expressive power of semantic

networks were used by Nick Cercone during his Ph.D work to develop a state-based representation for factual knowledge. More recently, Schubert has renewed an interest in parsing. His projects include preference parsing of generalized phrase structure grammars and logical interpretation (with Jeff Pelletier; Schubert and Pelletier, 1982), general and special purpose inference for a question-answering system, and speech generation.

Involvement in natural language understanding is growing at Simon Fraser University. Nick Cercone has continued his interest in natural language and semantic networks first sparked as a Ph.D student at Albert (see Cercone, 1981). Working with a number of graduate students, he is also devising perfect hash functions which will improve access to large natural language lexicons. With Paul McFetridge and Tom Strzalkowski (Ph.D student), Cercone is parsing with extended cascaded augmented transition of networks. This is part of one competing prototype to construct a natural language interface to academic records for use in the "Automated Academic Advisor" [AAA] system. The AAA is a large ongoing project aimed at giving university administrators and others on-line access to appropriate academic data. The social and organizational impact of such information-communication systems is being investigated. Veronica Dahl, also at SFU, has devised the L3 parsing system to translate Spanish into logic (in Prolog) and continues active investigations into many areas of parsing (Dahl, 1981). Bob Hadley, a recent addition to SFU's faculty, is also interested in parsing using Prolog, specifically the interpretation of ambiguous quantified statements.

UBC has had an ongoing interest in natural language understanding for a number of years. Richard Rosenberg has been involved in a number of research efforts in the semantics and pragmatics of natural language, in particular work on case-based parsing, Hirst's anaphora investigations, and Gord McCalla's Ph.D research on representation techniques for natural language conversation. Recently Rosenberg and his soon to be finished Ph.D student Bob Mercer have been investigating the computation of presuppositions to natural language sentences. Rosenberg has now transferred his allegiance to Dalhousie University in Halifax; Mercer will soon join the University of Western Ontario in London, Ontario.

Another longstanding effort in computational linguistics is the machine translation project underway until recently in the Departmente de Linguistique at Universite de Montreal. Richard Kittredge and Igor Mel'cuk have been interested in translating between French and English, and achieved considerable success in the translation of weather reports. Now interested in generalizing beyond the weather report domain, Kittredge and Mel'cuk are currently investigating the tractability of various other sublanguages of English and French, and are also looking at the generation of text fragments from semantic networks in such narrow sublanguages (using Prolog).

Speech understanding, although not strictly part of computational linguistics, is being investigated by some research-ers, notably Renato de Mori at Concordia University. Ching Suen is interested in speech synthesis, in addition to his work on character recognition. Other people expressing an interest in aspects of computational linguistics are Ernie Chang (University of Victoria), David Curran (Vancouver), Renee Elio (Alberta Research Council in Edmonton), Wendy Moore (UBC), and Wilf Lalonde (Carleton University in Ottawa).

Representation of Knowledge

In the mid-seventies, Len Schubert and his Ph.D student Nick Cercone at Alberta led an effort to extend and formalize semantic networks. Subsequently, Schubert carried on this effort with the help of a number of graduate students at Alberta, and Cercone continued to collaborate from Simon Fraser. This project not only made many standard concepts (such as IS-A, type vs token, etc.) more precise, but also introduced quantifiers into semantic networks, precise concepts of scope, the idea of topic hierarchies to organize the information in the network, and a number of other enhancements.

A similar project got underway at Toronto in the mid-seventies as an outgrowth of lessons learned in the TORUS project. John Mylopoulos directed this effort to formulate precise procedural semantics for semantic networks. Eventually, the "procedural semantic network" (PSN) system was developed to, among other things, organize networks along several different hierarchies (I-SA, PART-OF, context); to define several different types of nodes including instances, classes, and meta-classes (dubbed an "instance" hierarchy); to introduce precise semantics into the process of inheritance; and to attach specific procedures to each class indicating how to insert, remove, fetch, and test (the existence of) instances of the class. More recently the representation effort has branched in a number of directions, including the creation of a layered PSN knowledge representation programming language, the use of PSN ideas in the medical systems being developed by Tsotsos et al, and the formulation of logical approaches to the representation of certain concepts which originally arose in PSN. A number of Ph.D students explored various of these directions, including Hector Levesque (who went to Fairchild Laboratory for AI Research but is returning to the University of Toronto faculty) who worked out a non-monotonic logic approach to incomplete knowledge; and two students who have nearly completed their theses: Jim Delgrande (soon to join Simon Fraser University) who is working out a logical approach to theory formation and conjecturing in knowledge bases; and Bryan Kramer who is examining reflection in knowledge bases and the representation of control knowledge. John Mylopoulos also heads up the TAXIS project which incorporates a number of AI representation ideas into the design of databases.

Ray Reiter at UBC is one of Canada's outstanding AI researchers and has made major contributions to knowledge representation over the past decade (see Reiter, 1980, Reiter and Criscuolo 1983). He was an early champion of logical formalisms for representation and was one of the pioneers of

what now has become known as non-monotonic logic. He has particularly been interested in the closed world assumption for the treatment of negation in knowledge bases (default logic) and in logical formalisms of database theory. He has had two Ph.D students interested in knowledge representation, including Brian Funt (now at SFU) who investigated non-propositional "analogical" representations (using a parallel processing retina), and Randy Goebel (now at Waterloo) who is almost finished his thesis on the representation and use of descriptions in knowledge bases. Also at UBC are Bill Havens and Alan Mackworth whose interest in knowledge representation for vision was discussed earlier.

Doug Skuce, currently at Ottawa, received his Ph.D from McGill for devising the general purpose knowledge representation language LESK ("Language for Exactly Stating Knowledge"). Skuce has more recently become interested in compiling LESK into another language of his design; the logical language KNOWLOG (based on Prolog). He is investigating the use of KNOWLOG in expert systems and natural language applications.

Expert Systems and Applications

Many researchers whose work we describe elsewhere are involved in developing practical applications. We will not re-iterate their names here. Instead we will concentrate on those whose major focus is the application itself or expert system technology.

Ernie Chang at the University of Victoria is developing LISP-based expert systems to interpret liver function tests and is using an ATN interpreter to structure man-machine dialogues occurring in several video disk applications in hematology. He is also interested in theoretical aspects of expert systems including using the utility function approach in selecting the next test and the compilation of production rules from descriptive knowledge bases.

Peter Rowat, a graduate from UBC's AI group now heading his own company Dogwood AI Research, has moved on from the problem solving and robotics foci of his Ph.D to the development of expert systems for forest management and avalanche control. He is particularly interested in how planning and reasoning about time can be usefully incorporated into these applications.

Alan Campbell, now in Smithers, B C , is elaborating on his Stanford work on PROSPECTOR (the expert system for seeking out mineral deposits). In the context of PROSPECTOR he is investigating general expert system frameworks that will work on micro-computers (particularly the IBM-PC).

John Tsotsos at Toronto has been involved in the CAA and Alven medical expert systems mentioned earlier and has also launched the HIPPOCRATES second generation medical consultant. Renee Elio at the Alberta Research Council has begun work on a meteorological expert system to help forecast storms. Others expressing an explicit interest in expert systems are Brian Unger (University of Calgary); Mike Bauer (University of Western Ontario); Michael Burke (AES

Data, Missisauga, Ontario); Janice Glasgow (Queens); Morris Goldberg (Ottawa); and Doug Skuce (Ottawa).

An application area of particular interest in Canada is the use of AI techniques and approaches in education. One focus of activity is at the University of Saskatchewan in Saskatoon. Gord McCalla has been experimenting (through the construction of a small LISP course) with the use of AND/OR graphs to structure courses, work that possibly has implications for the design of authoring languages (see McCalla et al., 1982). He is (with Darwyn Peachey) interested in how to automatically plan courses individualized for particular students and dynamically replan them to overcome misconceptions that arise. Dave Goforth, now at Science North in Sudbury, Ontario, has designed, has implemented and is experimenting with the programming language LEPUS created to allow students to participate in LOGO-style "student initiative learning" in non-mathematical domains, particularly domains involving the interaction of multiple entities in various environments. Marlene Colbourn, during her years at Saskatchewan before going to Waterloo, developed an expert system that helps to diagnose children's learning and reading disabilities.

Gerald Rambally has recently joined the faculty at University of Regina where he is pursuing computers and education interests developed as a graduate student at University of Oregon. There has been work at UBC on intelligent tutoring under the supervision of Richard Rosenberg and Alan Mackworth. Ivan Tomek at Acadia University in Wolfville, Nova Scotia, has developed Josef, an educational programming language similar in aim to Karel the Robot Simulator. There are computers in education interests at the University of Alberta, Ontario, Institute for Studies in Education in Toronto, and many, many other places. These efforts aren't particularly oriented towards AI

Issues in AI Programming, Man-Machine Interfaces, and Logic Programming

Canadian research is investigating programming languages and environments for AI. Wilf Lalonde at Carleton is developing an actor machine for use in AI. He is also looking at possible applications based on the actor paradigm.

At Western Ontario several people are interested in aspects of AI programming. Mike Bauer, for his Ph.D at Toronto, investigated how programs could be induced from traces of their output. Now at Western, he is exploring how to build software development experts to aid in the design, specification, and testing of software. He is particularly interested in the use of Prolog as a specification/prototyping language. Bauer is also involved in sophisticated interfaces for office systems. D. Julian M. Davies developed the POPLAR 1.5 AI programming language. His work at Western includes programming languages and networks. Ted Elcock, also at Western, is interested in the relationship between logic and computing, and in particular the potential role of logic in a good software methodology (see Elcock, 1983).

At Waterloo a significant effort is underway in logic pro-

gramming. Maarten van Emden has been involved for some time in logic programming (van Emden, 1977), and recently Randy Goebel joined the faculty with his interests in DLOG, a logic oriented representation language. David Poole is another faculty member with interests in logic programming among other things. One of the projects underway is the construction of Waterloo UNIX Prolog. Veronica Dahl pursues an interest in logic programming at Simon Fraser. She is constructing Prolog-based representations of grammars. Doug Skuce (Ottawa) in addition to developing his KNOWLOG language, is investigating intelligent backtracking in first order logic deduction. Stan Matwin collaborates with Skuce on some of his projects. Tomasz Pietrzkowski of the Technical University of Nova Scotia (TUNS) in Halifax is interested in logic programming, as well as architectures for computer graphics and AI.

A concentration of researchers interested in man-machine interfaces can be found at the University of Calgary in the Man-Machine Systems Laboratory. Brian Unger, director of project JADE, is investigating simulation and modelling, prototyping, and expert systems. John Cleary is working on distributed evaluation of logic programs based on message passing, and use of this to support intelligent understanding of simulation traces. Bob Bramwell is interested in LISP and other symbol manipulation languages as well as user interfaces (specifically on-line documentation systems). David Hill, Ian Witten, Brian Wyvill and others pursue interests in man-machine studies.

Bell-Northern Research in Ottawa is doing some work on software and man-machine interfaces. Dick Peacocke has recently been put in charge of a project involving AI applications in software engineering. James Bradford is working on ATN-based man-machine interfaces for various CAD/CAM applications.

Others having involvement with some aspects of AI programming or interfaces include Sol Greenspan whose Toronto Ph.D investigated a knowledge representation approach to requirements modelling. Greenspan has recently joined the Schlumberger-Doll AI laboratory in Connecticut. Michel Pilote's Toronto Ph.D thesis extended the TAXIS language so it could be used to describe the problem domain and the user interface. Tuncer Oren at Ottawa is involved in applications of AI software. Sharan Javey of York University is also interested in software design methods. Elio Renee at the Alberta Research Council is involved with intelligent interfaces.

Cognitive Science

A number of researchers have interests in cognitive science. Zenon Pylyshyn in the psychology department at Western Ontario has been a major player in Canadian AI for some years. His wide ranging cognitive science interests are now focussed in the Centre for Cognitive Science recently established at Western Ontario.

Julian Davies, also of Western, has been interested in the characteristics of emotional robots. George Baylor, Montreal, is trying to understand mechanisms underlying dreams. Roger Browse and a number of psychologists (Brian Bultler, Susan Lederman, Ian Morrison) at Queens are working in the area of cognitive modelling, including cognitive aspects of vision and perception. Kelly Wilson at Alberta has been interested in interactions between computing science and cognitive psychology for many years. Wilson has written a book, *From Association to Structure*, on this topic. Others expressing an interest in aspects of cognitive science are Brian Funt (Simon Fraser), John Cleary (Calgary), Gerald Rambally (Regina), Larry Rendell (University of Guelph), and James Bradford (Bell Northern Research). There are doubtless many more people involved in cognitive science, especially in psychology departments across the country. Unfortunately we have not heard from them.

Problem Solving and Search: Planning, Robotics, Theorem Proving, Game Playing

There is surprisingly little Canadian work in the general area of problem solving and search in AI Planning was a major component of the Perrault-Cohen-Allen natural language effort at Toronto. Gord McCalla, in a project started at Toronto and continued at Saskatchewan, has investigated plan creation, plan execution, knowledge acquisition, and error recovery in a dynamic geographic microworld, work which may prove relevant in the course planning project mentioned earlier. Peter Rowat (Dogwood AI) worked on robot problem solving for his Ph.D research at UBC. Bob Hadley (Simon Fraser) is interested in very general problem solving. Reid Smith (formerly of Defence Research Establishment Atlantic now at Schlumberger-Doll Research in Connecticut) developed during his Stanford Ph.D the contract net formalism for distributed problem solving. Larry Rendell has investigated adaptive planning for state space problems (see Rendell, 1983).

In the area of robotics, Richard Gordon (University of Manitoba) is investigating automated robotics techniques for early detection of melanoma and controlling an x-ray microbeam. Susan Lederman and others at Queens are working on robot perception (visual, tactile, kinesthetic), especially using parallel processors. James Bradford (at Bell Northern Research) is interested in robot sensors. Martin Levine and Steve Zucker at McGill are exploring the use of robotics for inspection and repair of hybrid circuits. Tom Calvert's work at Simon Fraser on the kinesthetics of dance has implications in robotics as his recent involvement with computer vision for mobile robots indicates. Len Schubert at Alberta is working with a Heathkit robot trying to equip it with touch sensors and use their improved range finder to enhance its planning capabilities. There is other "mainstream" robotics work which is being carried on in engineering departments, government research laboratories, and the private sector, but these seem to make little use of AI techniques.

Another area with Canadian expertise is theorem proving. Ted Elcock and Donald Keuhner at Western Ontario have been interested in theorem proving for some time as has Tomasz Pietrzkowski at TUNS and formerly at Water-

loo. Waterloo has also produced a number of Ph.D graduates in this area, including Phil Cox (now also at TUNS) and Lew Baxter who went on to York before joining Logicware, a Toronto-based AI company. Many people whose early interests were in theorem proving are now also interested in logic programming (including Ted Elcock, Tomasz Pietrzkowski, Ray Reiter, and others).

Game playing research is also carried out in several places in Canada. Two of the more prominent names in this area are Tony Marsland at Alberta (see Marsland and Campbell, 1982) and Monroe Newborn at McGill. Both have created chess playing programs which play with considerable skill. Julian Davies at Western also expresses an interest in game playing, and Maarten van Emden at Waterloo has used Prolog in implementing strategies for chess endgames.

Learning and Adaptive Systems

An area of growing interest in AI is learning. In Canada, Larry Rendell of Guelph is perhaps most prominent in this area. Since completing his Ph.D at Waterloo, he has been very active in exploring a number of topics, including inductive inference, particularly from elementary data in search; genetic systems; and the unification of various approaches to generalization. Rendell has recently taken up an appointment at University of Illinois in Urbana-Champaign. Gord McCalla at Saskatchewan has supervised work in learning procedures and data structures, and has investigated the automatic acquisition of episodic knowledge in dialogue systems as well as acquisition of route information in the geographic planning system. Wilf Lalonde at Carleton is interested in the learning of natural language. Two nearly completed Ph.D theses also are investigating topics in learning; Jim Delgrande's work on automatic theory construction, and expatriate Canadian Bob Holte's work on constructing machines to be able to keep up with changing facts and demands. Holte is currently a Ph.D student at Brunel.

Adaptive systems is related to learning, but has different theoretical underpinnings. Several Canadian professors have trained in this area at the University of Michigan under John Holland's supervision, but have since strayed from the adaptive systems path. One that hasn't is Jeff Sampson at Alberta who is still helping to elaborate the theory of adaptive systems and has written a widely read book on the subject. Jeff Sampson supervised Anne Brindle's Ph.D thesis. She is now in California. John Cleary at Calgary is aiming to achieve a VLSI realization of parallel adaptive systems.

It is highly probable that there will be increased Canadian interest in the problem of learning as it becomes a more prominent AI issue.

Computers and the Humanities—Social Issues

There is some interest in Canada in the relationship of AI to other areas and to society. Nick Cercone and Carol Murchison at Simon Fraser have been compiling an annotated bibliography of computer-based literary and linguistic studies. Richard Rosenberg of UBC and Dalhousie has had longstanding concern for the social implications of AI, and has recently written a book on the social issues of computing with many aspects pertinent to AI Needless to say, many scientists, both within AI and elsewhere, feel that it is important to be aware of the social implications of their work.

The CSCSI/SCEIO

The Canadian Society for Computational Studies of Intelligence/Societé Canadienne pour l'étude de l'intelligence par ordinateur began unobtrusively in 1973 with an informal "get together" at the University of Western Ontario. This was followed by an Ottawa "workshop" in 1975. The First National Conference of the CSCSI/SCEIO was held in 1976 at the University of British Columbia. Every two years since 1976 a national conference has been held and refereed Proceedings produced. In 1978 the second conference was held in Toronto, followed in 1980 by the third conference at the University of Victoria and the fourth conference in 1982 at the University of Saskatchewan. The Fifth National Conference was held at the University of Western Ontario in May, 1984. The Sixth National Conference will be held in Montreal in May of 1986, with Renato de Mori acting as general chairman and Bill Havens as program Chairman. Next May, a natural language workshop, "Theoretical Approaches to Natural Language", sponsored by the CSCSI/SCEIO will take place in Halifax.

The CSCSI/SCEIO became a special interest group of the Canadian Information Processing Society [CIPS] in the late 1970s. Formal accreditation came to the CSCSI/SCEIO in 1980 in the form of a constitution and an Ontario letters patent which were filed that year. Its purpose, according to the constitution, is to "promote the interests of professionals by setting up study groups to investigate and report on relevant major issues, to organize seminar and tutorial meetings, publish the CSCSI/SCEIO newsletter for the membership, forge and maintain informed links with Government, Industry and other societies with similar goals, and other items of interest to the society. The CSCSI/SCEIO is organized and operated exclusively for educational and research purposes in the interest area of computational studies of intelligence."

The CSCSI/SCEIO can report considerable success in meeting its objectives. The newsletter, which came out annually in the early years, one being produced at UBC, Western Ontario, Toronto, Alberta, and Ottawa, is now more frequently distributed. Since these early "one-shot" newsletters, the CSCSI/SCEIO has co-operated with two other CIPS special interest groups, CIPPRS and CMCCS, producing a jointly written newsletter, thanks mainly to the efforts of Wayne Davis and University of Alberta facilities. Recently, the CSCSI/SCEIO Newsletter re-established independence and will be appearing quarterly under the able guidance of its new editor, Graeme Hirst. Alan Mackworth announced last year that NET CAN.AI and NET CAN AI CSCSI were created for users of the UNIX UUCP mail facility as another vehicle for dissemination of information about Cana-

dian AI activities. Present and past executive members of the CSCSI/SCEIO (see Appendix 2) have written timely and concerned letters to industry, private foundations, and government officials (particularly NSERC and Science Council) putting forth concerns of the CSCSI/SCEIO.

The CSCSI/SCEIO co-sponsored the 7th IJCAI which was held in Vancouver in 1981. In addition the October, 1983 issue of IEEE Computer was solicited by the IEEE and was based, in part, on the papers presented at the CSCSI/SCEIO 4th National Conference in Saskatoon. The CSCSI/SCEIO has successfully negotiated with the National Research Council of Canada (NRC) over the past few months to begin publishing a new journal—*Computational Intelligence* (CI). A recent survey of artificial intelligence researchers worldwide was conducted by the CSCSI/SCEIO which showed overwhelming support for such a journal. The Executive is confident that the CSCSI/SCEIO can sponsor and maintain a high-quality journal like CI. It will be up to the co-editors, Nick Cercone and Gord McCalla, to achieve this goal. CI begins publishing in the first quarter of 1985.

Concluding Remarks

Before concluding this article, several other recent endeavors of relevance to Canadian AI should be mentioned. The first is a project sponsored by the Canadian Institute for Advanced Research that is funding three centers of excellence (UBC, Toronto, and McGill) to carry out long term fundamental research into "AI, Robotics and Society" [AIRS]. The initial time frame for the AIRS project is five years. A second recent initiative is the formation of a Canadian Institute for Fifth Generation Research which is in the process of identifying Canadian Fifth Generation expertise and lobbying for funds to support Fifth Generation research. Currently, most funding for AI in Canada comes in the form of individual grants from the National Sciences and Engineering Research Council (NSERC). Fifth generation money would augment these funds and would encourage more widespread collaboration. Finally, it should be noted that there are a number of companies now doing AI in Canada, although these are not as numerous as in the United States. Among them are Dogwood AI in Vancouver, specializing in expert systems for resource management; Logicware in Toronto, promoting PROLOG; and Cognicom, a consortium of academic AI researchers. There are other companies already in existence and more seem to be forming all the time.

In conclusion, it is our hope that this article will engender interest in Canadian artificial intelligence. We recognize that it is impossible to attempt to survey the entire country without some error and misrepresentation; we apologize if we have misrepresented anyone. We welcome any feedback from both Canadian and other readers of AI Magazine.

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APPENDIX I: Cross Reference List

Area of Interest ⟺ Researcher

Computational Vision/Image Processing/
Pattern Recognition

J. Paul (UBC), W Havens (UBC), A Mackworth (UBC), R Woodham (UBC), B Funt (SFU), T. Calvert (SFU), W. Davis (Alberta), J Tsotsos (Toronto), R. Browse (Queens), J Kulick (Queens), M. Goldberg (Ottawa), T. Kasvand (NRC), C Suen (Concordia), S Zucker (McGill), M Levine (McGill), J. Glicksman (Texas Inst)

Natural Language/Computational Linguistics/Speech

E Chang (Victoria), D Curran (Vanc), R Rosenberg (UBC-Dalhousie), W. Moore (UBC), N. Cercone (SFU), V Dahl (SFU), R Hadley (SFU), E. Renee (Alta RC), L Schubert (Alberta), G. McCalla (Sask), G. Hirst (Toronto), R. Perrault (SRI), R. Cohen (Toronto), W LaLonde (Carleton), C. Suen (Concordia), R deMori (Concordia), R. Kittredge (Montreal), B. Webber (Penn), C Koniklipsis (NYU)

Representation of Knowledge

W Havens (UBC), A Mackworth (UBC), R Reiter (UBC), B Funt (SFU), N Cercone (SFU), L Schubert (Alberta), R Goebel (Waterloo), T. Shibahara (Toronto), G Hirst (Toronto), J. Mylopoulos (Toronto), D Skuce (Ottawa), R Smith (Schlumberger), H Lévesque (Fairchild - Toronto)

Expert Systems / Applications

E. Chang (Victoria), J. Paul (UBC), P. Rowat (Dogwood), N Cercone (SFU), A Campbell (Smithers), E Renee (Alta RC), T Marsland (Alberta), B. Unger (Calgary), M Colbourn (Sask-Waterloo), M. Bauer (UWO), M Burke (AES), T Shibahara (Toronto), J. Mylopoulos (Toronto), J Tsotsos (Toronto), R Browse (Queens), M Goldberg (Ottawa), D. Skuce (Ottawa), T Oren (Ottawa), T. Kasvand (NRC), M. Levine (McGill), J Glicksman (Texas Inst), R. Smith (Schlumberger)

AI in Education

G McCalla (Sask), D. Goforth (Sask), M Colbourn (Sask-Waterloo), G. Rambally (Regina), I. Tomek (Acadia)

Issues in AI Programming

G Turnquist (Cooperators), R Bramwell (Calgary), B. Unger (Calgary), M Bauer (UWO), J Davies (UWO), S Jarvey (York), T Oren (Ottawa), W LaLonde (Carleton), R Peacocke (BNR), T Pietrzkowski (TUNS), I Tomek (Queens)

Man-Machine Interfaces

E. Renee (Alta RC), R Bramwell (Calgary), M. Bauer (UWO), J Bradford (BNR), T Pietrzkowski (TUNS)

Logic Programming

P Rowat (Dogwood), R Reiter (UBC), V Dahl (SFU), J Cleary (Calgary), T Elcock (UWO), R Goebel (Waterloo), M van Emden (Waterloo), D. Skuce (Ottawa), T. Pietrzkowski (TUNS)

This list is based on responses to our questionaires Some non-Canadians are included since the questionaires were distributed to all CSCSI/SCEIO members, some of whom are not resident in Canada

Cognitive Science

B Funt (SFU), K Wilson (Alberta), J. Cleary (Calgary), G Rambally (Regina), Z Pylyshyn (UWO), L. Rendell (Guelph-Illinois), R. Browse (Queens), J. Bradford (BNR), G Baylor (Montreal)

Problem Solving and Search: Planning, Games

P Rowat (Dogwood), R. Hadley (SFU), T Marsland (Alberta), G. Mc-Calla (Sask), J Davies (UWO), R. Perrault (SRI), M Newborn (McGill), R Smith (Schlumberger)

Robotics

T Calvert (SFU), R. Gordon (Manitoba), T Shibahara (Toronto), R. Browse (Queens), J Bradford (BNR), S. Zucker (McGill), M. Levine (McGill)

Theorem Proving

T Elcock (UWO), T. Pietrzkowski (TUNS)

Learning and Adaptive Systems

E. Renee (Alta RC), J Sampson (Alberta), J. Cleary (Calgary), L. Rendell (Guelph - Illinois), W. LaLonde (Carleton), R. Holte (Brunel)

Humanities and Social Issues

D. Curran (Vancouver), R Rosenberg (UBC - Dalhousie), N Cercone (SFU)

Appendix II: CSCSI/SCEIO

Officers of the CSCSI/SCEIO

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