Canadian Artificial Intelligence
Intelligence Artificielle au Canada

Summer 1992 No. 29 été 1992

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Canadian Society for the Computational Studies of Intelligence (CSCSI) held in conjunction with Graphics Interface (GI'92) and Vision Interface (VI'92)

société canadienne pour l'étude de l'intelligence par ordinateur (SCEIO) tenue en collaboration avec Graphics Interface (GI'92) et Vision Interface (VI'92)

Research in Natural Language Processing at Simon Fraser University

La Recherche en Traitement de Langage Naturel à l'Université Simon Fraser.

•

Report on the 4th UNB Artificial Intelligence Symposium

Compte rendu de 4e Symposium en Intelligence Artificielle à l'UNB

•

Dual Purpose Learning Environments

Environnements d'Apprentissage à Double Objectifs

Intelligent Micro-Robots
for ALife Experiments

The IS Robotics Intelligent Robots are based on the principles of Subsumption Architecture, developed by Professor Rodney Brooks, of the MIT Artificial Intelligence Labs. Currently at the forefront of applications being linked to Artificial Life or ALife R&D, the micro-robots are becoming a reality in labs, the defence sector, industry, classrooms and the home. These robots enable researchers to go beyond abstract workstation simulation studies to practical "real-world" experiments. Concentrate on high pay-off research and development, instead of time-consuming hardware creation, at a fraction of the cost.

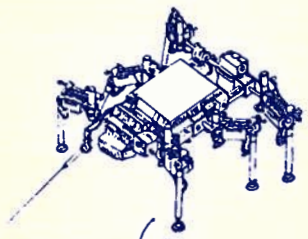
RESEARCH APPLICATIONS:

- Application-Specific Experiments
- Autonomous Agents
- Co-operative Systems
- Dynamic Environment Planning
- Exploration & Surveillance
- Find & Fetch Tasks
- Hardware Transport Platforms
- Predator-Prey Experiments
- Sensor Transport in Hazardous Environments

ROBOTS FEATURE:

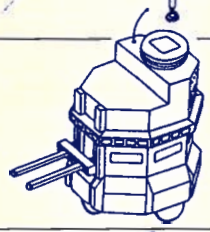
- Low Cost
- Small Size
- Easy Maintenance
- High Intelligence
- Flexible Mobility
- Open Bus Architecture
- Local Position Reference
- Optional Sofware & Sensors
- Inter-Robot Radio LAN Communication

Attila-IItm



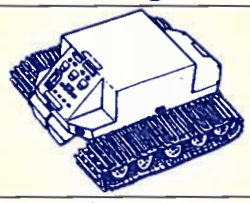
- Highly Dexterous Six-legged Micro-Robot
- Equipped with 150 High Performance Sensors
- Gyro Stabilized CCD Camera and Rangefinder
- High Performance Multi-Processor Network
- Capable of Determining Environmental Lay, Texture, Hardness and Colour
- Excels in "Find & Fetch" Tasks

R-2tm



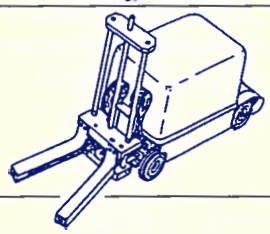
- Integrated, Wheeled Micro-Robot
- Vertical Direction Parallel Jaw Gripper
- Ring of Proximity & Bump Sensors
- Ideal for Autonomous Interaction Studies
- Cartesian Manipulator for Exploration

T-1tm



- Tracked Micro-Robot
- Highly Maneuverable
- Caterpillar Tracks for Rugged Terrain
- Low/High Gear Ratio Option
- Ideal for Mixed Terrain Co-operative Studies

R-1tm



- Wheeled Micro-Robot
- Equipped with Specialized Gripper
- Proportional Ackerman Steering
- Ideal for Co-operative and Autonomous Group Interaction Studies

For complete details on Intelligent Micro-Robot Technology, including the soon to be released product version of GENGHIStm ***and other new models please contact:***

Applied AI Systems, Inc.
Suite 500, Gateway Business Park
340 March Road
KANATA, Ontario, Canada K2K 2E4
Tel. (613) 592-3030
Fax. (613) 592-2333

Canadian Artificial Intelligence

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Canadian Artificial Intelligence welcomes submissions on any matter related to artificial intelligence. Please send you contribution, with an abstract, a photograph and a short bio to:

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Advertising rates are available upon request from the address above.

Book reviews and candidate books to review should be sent to:

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or — gh@ai.toronto.edu

COMMUNICATIONS

Dear CSCSI/SCEIO Member
and Computational Intelligence Subscriber,

As will soon be announced in the *Canadian Artificial Intelligence Magazine*, effective with our 1992 volume, Computational Intelligence will have a new publisher: Blackwell Publishers. This will result in a couple of changes for society subscribers. First, subscribers will have to deal directly with Blackwell, and no longer through CIPS. In particular, this means that you will have to renew CSCSI/SCEIO membership separately from your Computational Intelligence subscription. All you will need to do to keep getting Computational Intelligence at the society rate is to send your renewal request along with proof of membership in CSCSI/SCEIO to

Blackwell Publishers Three Cambridge Center Cambridge, MA 02142 U.S.A.
tel: (617) 225-0430 fax: (617) 621-9582

Unfortunately, although we were able to continue to get a reduced rate for society members, the society rate itself has been increased to $40 (U.S.) per year. Although the rate is higher, ultimately the renewal procedure should prove to be better than the former procedure since your request for subscription will no longer have to go through two different organizations. Moreover, it will be clear cut with whom to get in touch should you have questions as to the status of your subscription, and there will no longer be the confusing mis-match between the individualized monthly renewal scheme used by CIPS and the everybody-at-one-time-of-the-year scheme favoured by the journal.

During the current transition there may be some confusion. The sale of Computational Intelligence was finalized only very recently, and we haven't had time to provide "fair warning" to our subscribers. But, be assured that CIPS, Blackwell, and we as editors will do our best to work things out so that you can continue to receive Computational Intelligence without a hitch.

We are looking forward to a dynamic renewal of Computational Intelligence under its new ownership, and in fact already have most of an exciting Volume 8 planned. Nick and Gord have committed themselves to continue as editors for the next two years to try to ensure some continuity, but we have a new editorial assistant, Michelle. We will be happy to answer any questions you may have, so give us a call at (604) 291-3257 or e-mail us at ci@cs.sfu.ca.

Gord McCalla and Nick Cercone (co-editors)

WE'VE CHANGED!

The National Research Council's Division of Electrical Engineering (DEE) has been transformed into the Institute for Information Technology (IIT) and, in so doing, has undergone some shifts in its research programs.

We know that you have been in contact with us during the past three years and we need to know if you want to stay in touch. So, this letter is to bring you up to date on what has happened to the programs of DEE during the reorganization.

First of all, we must draw your attention to the fact that IIT is no longer involved in two former major DEE research areas. Though NRC continues to support inter-institute projects in Biomedical Technology, we have phased out the DEE research program in Biomedical Engineering. And the Power Engineering programs – Precision Electrical Measurements and Electrical Insulation – have moved to the Institute for National Measurements Standards. DEE's other projects have been reorganized somewhat and our current areas of research are:

• *diagnostic systems:* development of supporting tools and methodologies for design of knowledge based diagnostic, planning, and control systems, specifically for industrial process control and monitoring the condition of engines

• *electromagnetic (EM) protection:* development of state-of-the-art expertise in the areas of EM interference/compatibility, numeric modeling, testing, and a wide-band ultra-fast signal measurement

• *industrial and manufacturing systems:* development of computer based tools to support production planning, facility design and operation, and management and control of manufacturing operations as well as development of decision support systems for design, management, and supervision of industrial operation

• *information technology applications in resource and transportation industries:* application of information technology to decision support systems for planning, scheduling, monitoring, and control of industrial operation.

• *intelligent advisor systems:* identification and development of basic software that support creation and implementation of knowledge-based advisor systems in general, with applications for specific domains and in response to user requirements

• *machine learning:* development of computer-based knowledge acquisition tools, with emphasis on machine learning techniques and their application in manufacturing, resource, and service industries

• *photonic systems:* development of high-speed/image processing systems and sensor systems involving a combination of optical and electronic technology to achieve acquisition and processing of complex information in real time

• *sensor systems:* development and application of sensing techniques, specifically 3-D vision, for the automation of systems and processes

• *sensor-based robotics:* development and demonstration of sensor-based robotics for use in unstructured environments, specifically advanced robot control techniques for applications such as Space and self-navigating vehicles

• *software engineering:* development and application of tools and methodologies for realtime and embedded systems, mass market software, and large-scale systems, including work on issues such as reliability and configuration management

As part of the reorganization, NRC has developed a new standard for the annual reports issued by its institutes. Therefore, the Bulletin of the Division of Electrical Engineering is no more. Instead, we are working on the first Annual Report of the Institute for Information Technology. This report will concentrate less on detailed project updates and give a more complete report on the activities of the Institute in the past year.

Those of you in the Ottawa-Hull area may be familiar with the DEE Science Association lecture series. We are continuing to sponsor technical lectures, from September to June, on a variety of topics related to our research areas. These are now called the IIT Colloquium series.

A new venture for the Institute is the organization, in collaboration with the Ottawa-Carleton Research Institute (OCRI), of a formal seminar series. We will sponsor day long seminars, involving internationally recognized experts in chosen fields. We expect to hold about four seminars each year. The first, "Optically Enhanced Computing," was held on October 25, 1991.

Throughout NRC, the goal is to double the impact of our programs by the year 2000. We can only do this by building new and enhancing existing partnerships with industry, government, and universities. We now have more staff in the Institute's Industrial Liaison Office; these people are helping our researchers set up such collaborative arrangements.

S.A. Mayman
Director General

As of 1/Jan/92, Russell Greiner will be moving from Department of Computer Science, University of Toronto
to:
Siemens Corporate Research
755 College Road East
Princeton, NJ 08540 [greiner@learning.siemens.com,
(609) 734-6500]

CSCSI DISTINGUISHED SERVICE AWARD

This years recipient - John Mylopoulos

The executive of the Canadian Society for Computational Studies of Intelligence (CSCSI/SCEIO) is pleased to announce that John Mylopoulos of the University of Toronto will be presented with the inaugural CSCSI Distinguished Service Award. Henceforth, this prestigious award will be presented biennially to an individual who has made outstanding contributions to the Canadian AI community in one or more of the following areas: community service, research, training of students, and research/industry interaction. As discribed in the following biblographic sketch, John Mylopoulos' service record is exemplary in all of these areas.

John Mylopoulos can rightly be considered the "father of AL research in Canada. One of his most important accomplishments is the supervision of many of Canada's AI PhDs including (in chronological order with their last known affiliations):

George Tourlakis (York U)
Norman Badler (U of Pennsylvania)
Nicholas Roussopoulos (U of Maryland)
Doug Skuce (U of Ottawa)
Dick Peacocke (BNR)
Michael Bauer (U of Western Ontario)
John Tsotsos (U of Toronto)
Hector Levesque (U of Toronto)
Harry Wong (Ashton-Tate)
Michel Pilote (consultant, Toronto)
Sol Greenspan (GTE)
Jim Delgrande (Simon Fraser U)
Bryan Kramer (U of Toronto)

Several of these students have gone on to have significant careers and receive important accolades. John has also supervised the MSc theses for most of the above and other well-known individuals such as:

Phil Cohen (SRI)
James Allen (U of Rochester)
Alex Borgida (Rutgers U)
Peter Patel-Schneider (AT&T Bell Labs)
John Barron (U of Western Ontario)
Chrysanne DiMarco (U of Waterloo)

It must be stressed that it is not simply due to luck that John has supervised exceptionally good students, but rather that good students are naturally attracted to him because of his modest style, his solid knowledge of the field, his informed selection of interesting problems, and his natural leadership abilities. His care in the guidance of graduate students stands as an example to all.

John Mylopoulos is responsible for the birth, nurturing and adolescence of what is arguably one of the best and broadest AI groups in North America. Starting in 1970, he patiently waited out the lean years of AI funding and managed to still do amazing work with next to no support. Then, when AI funding began to finally appear in the early 1980s, he laid the groundwork for the rapid expansion and successes of the group we see today at the University of Toronto. Without his wisdom, patience, guidance and last but not least, his research record which formed the foundation of the group, none of this would have been possible.

John's public service accomplishments are a matter of record and include serving on the steering committee for the formation of CSCSI to more recently co-chairing the IJCAI'91 conference. He has served as secretary and president of CSCSI. He either is or has been an important member of virtually every AI-oriented

academic organization in Canada, including: Senior Fellow, CIAR; CIAR/PRECARN Associate; and Principal Investigator in ITRC, IRIS, and PRECARN's APACS project.

John has had two longstanding personal research activities, both of which he has instilled, through his team approach, to a wider set of people: knowledge representation systems per se, and their application to information system development. His research in knowledge representation systems involves formalisms for integrating concepts from semantic networks, logical and procedural representations. This work has resulted in two systems, PSN (Procedural Semantic Networks) and Telos and is seeing industrial application in systems for monitoring complex control processes. John's research in the application of knowledge representation systems to information system development has produced a series of requirements modelling and design languages culminating in Taxis, intended for the design of interactive information systems. A four year ESPRIT project, DAIDA, is based on this work.

The Distinguished Service Award, which will be officially announced at the AI '92 conference in Vancouver, provides an honorary lifetime membership in CSCSI, conference fees for AI '92 and a token gift. été

Intelligence
Artificielle
au Canada

CSCSI/SCEIO New Executive

Four new officers have been chosen to serve on the executive of
CSCSI/SCEIO for the next two years.
They are
President - Janice Glasgow
Secretary - Stan Matwin
Vice President - Peter Patel-Schneider
Treasurer - Eric Neufeld

We wish them luck in their new positions

Budget Report

- by Russ Thomas

From: 1/1/91 To: 12/8/91

Category Description	1/1/91 Actual
Advertising	10,113.66
AI-92 Sponsorship income	8,000.00
Conference Income	9,763.10
Credit Memo from Bank	13.87
GST collected	371.70
Refund of GST	510.93
Bank Certificate Interest	805.39
Signature account interest	421.95
Proceedings Sales (M.K.)	2,299.27
Total Income:	32,299.87
AI-92 Conference Expenses	2,678.99
Bank Service Charges	63.27
GST paid out	1,250.64
Mag. Production	26,538.18
Provincial Taxes	82.32
Total Expense:	30,613.40
Overall Total:	1,686.47

Firms learn to fly at SFU centre

Russ Francis
Sun Business Reporter

Bill Leiss has some tenants he hopes don't stay too long. They don't keep the neighbors awake with loud music and haven't missed a rent payment.

It's more a matter of principle - the companies renting space at the new Business Development Centre he administers at Simon Fraser University shouldn't stay any longer than 18 months, for fear they will become soft, he reckons.

Leiss, who is research vice-president at SFU, says the centre is intended only as a way station for companies spun off from research at the university, not as a source of long-term low rent office space.

"It's important they get into the real world," Leiss says. "The centre is for the very young (companies)."

Opened earlier this month, the centre, the first of its kind in B.C, provides more than the standard business centre facilities of phone, computer, fax and photocopier.

Academics sitting on hot discoveries typically have little expertise in running a business, and that's where the real benefits of being in the centre become apparent.

Patenting, legally incorporating and writing a business plan for the new companies costs from $10,000 to $50,000, and the centre has some money available to invest for this.

But the centre expects to get its money back, taking equity in the fledgling companies.

The centre is managed by SF Univentures, the corporate wing of the university.

So far four companies, MPR TelTech Ltd., Pacific Fluorotech Corp., Kinetic Effects Research Inc. and Echidna Research Corp., have taken up residence in the centre. There is room for two more.

It's important they get into the real world. The centre is for the very young (companies).

Bill Leiss

Reprinted with permission - The Vancouver Sun Dec.19/91

Research in Natural Language Processing at Simon Fraser University.

Dan Fass, and Nick Cercone

Résumé

Compte rendu de la recherche en traitement de langage naturel (NLP) à l'Université Simon Fraser (SFU) entre 1986-91.
La recherche est divisée en trois secteurs:

– Applications.
– Théorie.
– Systèmes intégrés.

Les trois principales applications en NLP poursuivies à SFU sont les interfaces de langage naturel, reconnaissance vocale et traduction par ordinateur.

Il y a un travail considérable théorique en ce qui concerne la syntaxe. Les théories grammaticales intensivement étudiées sont les théories de liaison-gouvernement, grammaire de discontinuité statique, grammaire de structure des phrases dirigeantes et grammaire d'arbre d'unification.

La recherche sur les systèmes intégrés comprend l'intégration des systèmes en NLP avec la programmation logique, les systèmes de base de données et systèmes experts, et conception d'outils pour développer la grammaire pour les systèmes en NLP.

Abstract

Research in natural language processing (NLP) at Simon Fraser University (SFU) during the period 1986-91 is described. The research is divided into applications, theory and integrated systems. The three main applications of NLP pursued at SFU are natural language interfaces, speech recognition, and machine translation. There is considerable theoretical work in syntax. Grammar theories studied intensively are government-binding theory, static discontinuity grammar, head-driven phrase structure grammar, and tree unification grammar. Integrated systems research includes integrating NLP systems with logic programming, database systems and expert systems, and designing tools for developing grammars for NLP systems.

1. Introduction

Writing a letter, reading a newspaper, watching the six o'clock news, having a conversation — the every-day written and spoken language of such activities is called natural language to distinguish it from artificial, made-up languages like programming languages. For over 30 years, researchers have studied how computers can be programmed to understand and generate written text and spoken utterances. The study area has been called natural language processing (NLP) or computational linguistics, though these terms tend to be associated with text processing rather than speech processing.

These days, NLP research is conducted at many universities and in the research laboratories of large companies, and there is a small but growing number of commercial NLP products (Obermeier, 1989). The commercial interest exists because the payoff for successful NLP systems is potentially enormous, particularly in applications like natural language interfaces, machine translation systems, and speech recognizers. Natural language interfaces allow people to communicate with machines in a natural language such as English. A particular application of natural language interfaces is to computer databases so that non-technical people can directly access the information in the databases. Machine translation systems automatically translate from one natural language (say French) into another (say Spanish or English). Speech recognizers understand the meaning of a speaker's utterance or, in the case of speech verification, infer the identity of a speaker or check a speaker's claimed identity.

The NLP group in the Centre for Systems Science (CSS) at Simon Fraser University (SFU) is perhaps the largest in Canada, and one of the larger groups in North America. NLP research at SFU can be divided into three broad categories: applications, theory, and integration with other computer systems.

- **Applications** (section 3). The three main NLP applications at SFU are natural language interfaces, speech recognition, and machine translation. The SFU group has extensive experience with these applications, especially natural language interfaces.
- **Theory** (section 4). Broadly interpreted, the theoretical NLP research at SFU is of two kinds. Some of the research is into detailed mechanisms for handling particular problems in natural language, e.g., Fred Popowich's work on reflexive pronouns. The remaining vesearch investigates the relationships between different NLP formalisms, e.g., T. Pattabhiraman's comparison of different approaches to generating text. Both kinds of research feed into the NLP applications described in section 3: several of the approaches developed by our researchers are being used in the applications, e.g., Veronica Dahl's static discontinuity grammar.
- **Integrated Systems** (section 5). A growing research topic in NLP is the integration of NLP systems with systems that offer other facilities and capabilities. Section 5 describes SFU research into integrating NLP systems and ideas with: logic programming, tools for developing grammars for NLP systems, general-purpose interfaces, database systems, and expert systems.

The appendices contain further information about NLP research at SFU. Appendix A lists the personnel involved, Appendix B lists the hardware and software used, and Appendix C describes the structure of the CSS.

2. Natural Language

This section introduces some of the major problems addressed in NLP. It can be skipped by those familiar with NLP.

The study of natural language is frequently decomposed into a number of smaller, partially overlapping study areas: phonology, morphology, syntax, semantics and pragmatics. The scope of each area is described below, together with problems that each area presents for NLP. The descriptions of areas are adapted from Crystal (1991).

• Phonology

Phonology is the study of the sound structure of language. Sounds are organized into a system of contrasts, and analyzed in terms of phonemes, distinctive features, or other such phonological units according to the theory used. A phoneme is the minimal unit of the sound system of a language. Some languages have as few as 15; others have as many as 80. No two languages have the same system of phonemes. Distinctive

features are used either to define phonemes or as an alternative to the notion of phoneme. Example pairs include +nasal and -nasal, and +voice (voiced) and -voice (voiceless). Nasal sounds are produced when there is complete closure in the mouth and all the air thus escapes through the nose, as in the 'n-' sound of 'nasal'. Voiced sounds are produced while the vocal cords are vibrating, e.g., the 'b-' sound in 'bin'; voiceless or unvoiced sounds are produced when there is no such vibration, as in the 'p-' sound of 'pin'.

Problems include the ratio of noise to data, the varying speech rates within and across individuals, and coarticulation. Coarticulation takes place when the articulation for two or more sounds takes place in the vocal tract, e.g., the 'sh-' in 'shoe' is normally pronounced with lip-rounding in anticipation of the '-oo' sound.

• **Morphology**

Morphology is the study of the structure of words, especially through use of morphemes. Morphemes are commonly divided into free forms (morphemes which can occur as separate words) and bound forms (morphemes which cannot occur in this way, e.g., 'unselfish' consists of three morphemes, 'self' which is a free form, and 'un-' and '-ish' which are bound forms.

A major morphological problem is ambiguity: the suffix 's', for example, can indicate the plural of a noun or the present tense of a verb. Another problem is exceptions, for example, the plural of the noun 'foot' is 'feet' (not 'foots').

• **Syntax**

Syntax is the study of how words are combined to form sentences in a language. Syntactic structures (or constructions) are analyzed into sequences of syntactic categories (or classes). The sequences are established on the basis of syntactic relationships that linguistic items have with each other in a construction, e.g., "tall people" is generally analyzed into a noun phrase consisting of an adjective 'tall' and a noun 'people'. Parsing refers to the assignment of syntactic categories and structures in single sentences. The following are some major problems for syntactic processing.

Structural ambiguity occurs when a sentence construction can be assigned several possible structures or combinations of elements, e.g. in "Jane saw the man in the park with the telescope" the prepositional phrase "with the telescope" could be attached to either "Jane saw" or "the man in the park."

Unbounded or **long distance dependency** is a relationship between two syntactic components of a sentence in which the related constituents are not required to be within some bounded distance of each other. The dependency, which may extend over one or more clause boundaries, usually involves an empty noun phrase constituent called a "trace" which is coindexed with another noun phrase appearing earlier, as in Show me the report$_{[i]}$ that Nick wanted Dan to write$_{[i]}$'' where, although report' is the object of the verb write', there is no explicit object following the verb.

• **Semantics**

Semantics is the study of meaning in language. It contains a number of branches including philosophical semantics and linguistic semantics, which have both been studied in NLP. Philosophical semantics studies relations between linguistic expressions (like sentences) and the entities in the world to which they refer, and the conditions under which such expressions can be said to be true or false. Analysis is performed with logical systems. Linguistic semantics studies the semantic properties of natural languages using a variety of linguistic constructs. Among the phenomena studied within semantics are the following.

Lexical ambiguity refers to a semantic property of words that they can have multiple senses or meanings, e.g., the word 'crook' has different senses: it can mean a thief, a bend, or a shepherd's stick. Resolution of lexical ambiguity is required for understanding sentences that contain ambiguous words like 'crook', e.g., in "The crook stole a diamond ring," the thief sense is meant.

Similarity or **paraphrase** refers to a property of sentences that different ones can have the same (or very similar) meanings, e.g.,
"Give me the Western region financial performance for July,"
"Give me the July financial performance for the Western region,"
"Give me the financial performance for July for the Western region" and
"Give me the July Western region financial performance" (cf. McFetridge, 1991).
The problem is recognizing when two sentence are paraphrases.

Reference is a relationship of identity between linguistic units, e.g., between a pronoun and a noun or noun phrase. Pronouns are of various kinds, including definite pronouns like 'it' and 'them', personal pronouns such as 'I' and 'you', reflexive pronouns like 'myself' and 'yourself', and relative pronouns such as 'who', 'whom' and 'that'. The problem is resolving reference, i.e., connecting a pronoun with the noun or noun phrase to which it refers.

Reference can occur across sentence boundaries, and can be backwards or forwards. Anaphora (or back-reference) is reference to an earlier part of a discourse. Cataphora (or forward reference) is reference to a later part of the discourse. The difference can be seen in a two different two-sentence discourses where the first sentence each time is "John is at home." There is an anaphoric reference to John when the second sentence is "If he is not drunk, Peter will be surprised" versus a cataphoric reference to Peter when the second sentence is "If he is not drunk, Peter will take me there" (Strzalkowski and Cercone, 1986, p. 159). Traditional syntactic solutions have been able to treat only simple classes of anaphora and only occasional inter-sentential references.

• **Pragmatics**

Pragmatics is the study of the communicative use of language, particularly the structure of conversations and dialogue: how participants take turns in conversations, how speakers use knowledge of communication (e.g., about the context in which language is used), and the effects their use of language has on other participants. Pragmatic problems include the following.

Presupposition is the information assumed by a person when using language and which is as the centre of a person's communicative interest, e.g., "There is unrest in Yugoslavia" assumes the existence of (a country called) Yugoslavia.

Conversational repair refers to "the attempt made by participants in a conversation to make good a real or imagined deficiency in the interaction (for example, a mishearing or misunderstanding)" (Crystal, 1991, p. 298). A major problem here is working out which participant is wrong or mistaken and hence should have their conversation (and understanding) repaired.

Indirect meaning refers to the communicative purpose of a piece of language which does not directly reflect its surface form. The true communicative purpose is understood from examining the context in which the piece of language was used, for example, +It's hot in here" looks like an assertion, but in the right context spoken to someone standing by a window might be a request to open the window. Likewise, "Can you pass the salt?" looks like a question, but can also be a request to pass the salt if said when sitting at a table and spoken to someone closer to the salt than you are!

3. Applications

• Natural language interfaces to databases

One of the most intensively studied areas of NLP is question-answering by natural language interfaces serving as "front ends" to databases. Such front ends help users in two main ways (McTear, 1987). First, they are relieved of the need to know the structure of the database. Second, the system is made more convenient and flexible for them. A particular application of natural language interfaces is executive information systems which allow management executives to access directly the information in the databases of their companies.

SystemX — *Nick Cercone, Paul McFetridge, Gary Hall, Wo-Shun Luk, Chris Groeneboer.*

SystemX turns ordinary English questions into database queries expressed in SQL (short for Structured Query Language), the standard computer language for manipulating relational databases (McFetridge et al, 1988a, 1988b; Cercone et al, 1989). SystemX has quite extensive coverage of English, and can handle passives, imperatives, possessives, relative clauses, prepositional phrases and quantification.

SystemX is of a modular design, containing a natural language understanding module and a database query module. The natural language understanding module has three components: a lexical analyzer (which analyzes words), parser (which does syntax processing), and semantic interpreter (which does semantic interpretation and produces canonical semantic representations).

The lexical analyzer contains two subsystems, TEMPLATE and MORPHOS, and accesses a syntactic lexicon. TEMPLATE uses the form of certain words to recognize that they belong to certain categories such as proper names, part numbers and report identity numbers. MORPHOS is a morphological analyzer which employs a set of rules to strip the endings off words and identify their roots. Words are looked up in the syntactic lexicon and the syntactic information retrieved is used by the parser.

The parser contains a set of grammar rules. The rules are applied to the syntactic information and a parse tree for the sentence is built. The parse tree is passed to the semantic interpreter.

The semantic interpreter contains a set of semantic rules and a semantic lexicon. Each entry in the lexicon is a frame containing a description of the database entity referred to by a particular word or expression. Information from the frames is attached to the parse tree and then the semantic rules are applied to build canonical semantic representations. When there is some ambiguity within an expression which the interpreter cannot resolve on its own, the names of the database entities contained within the canonical representation of the expression are passed to Pathfinder. Pathfinder uses the semantic information inherent in the database design to assist in the disambiguation of the expression. A database is a (restricted) conceptual model which represents the entities and relationships of the domain. English expressions correspond to substructures of the conceptual model. If an expression is ambiguous in some way, there will be multiple candidate substructures in the model. Pathfinder selects the correct one by analyzing the constraints inherent in the various relationship types used to structure the model, measuring for each candidate substructure the degree of semantic relatedness among the entities to which the expression refers, and selecting the candidate which exhibits the highest degree of semantic relatedness.

Often, however, Pathfinder cannot select a single best candidate structure and a user must be the final arbiter. In such situations, the candidates must be presented to the user in a manner s/he is capable of understanding. In SystemX, this is done by generating English sentences that correspond to each candidate structure. The sentences currently generated are somewhat rough and halting. Research is planned which will improve their quality.

The database query module contains a component that translates the canonical semantic representations into a logical form. A second component translates the logical form into SQL. Different versions of this component would translate the logical form into other database languages.

SX — *Nick Cercone, Paul McFetridge, Gary Hall, Dan Fass, Fred Popowich.*

The SX system, like SystemX, is a natural language interface to a relational database which turns ordinary English questions into requests in SQL. SX is being developed as an advanced prototype executive information system for Rogers Cablesystems, a major national Canadian cable company, through a grant from the Canadian Cable Labs Fund. The initial target is a statistical database describing the customer service operations of the company, which describes sets of entities such as service outages, telephone calls and customer service representatives, work orders, and payment methods.

Statistical databases are common in executive information systems, since executives are typically interested in summary information. Most conceptual modelling languages do not provide the facility to represent statistical concepts. Natural language queries to statistical databases often lack direct correspondence to database objects. Such queries often refer to the domain entities which are being summarized and these are only indirectly represented in the database via the statistics. This lack of correspondence means that the mediation of a conceptual model is even more necessary than in the general case. The SX group has focused on the proper representation of statistical concepts in such a model, and the use of such concepts in disambiguating natural language queries.

This extension into the domain of statistics is a major difference between SystemX and SX. The other major difference is that the natural language understanding module has been replaced in SX by one based on a more modern grammar formalism and a new semantics. The grammar formalism is head-driven phrase structure grammar (see section 4). Two parsers have been developed, one written in Lisp by McFetridge (McFetridge and Cercone, 1990), and the other written in Prolog by Popowich and Vogel (1990, 1991). The two parsers are used to test competing ideas, which are sometimes easier to implement and test in one language than another. The semantics, developed by McFetridge (1991), is modelled on the structure of the Rogers database. The parser produces logical forms which are then passed to an adapted version of the database query module from SystemX.

Natural language front ends to deductive databases — *Veronica Dahl.*

Dahl has developed language front ends to her own deductive database and expert systems, which first introduced logic programming into the database and expert systems fields (Dahl, 1979a). These interfaces translate sentences in French or Spanish into a specially tailored typed three-valued logic system with three-branched quantification (Dahl, 1979b) through which they can detect failed presuppositions, disambiguate sentences and reject semantically as well as syntactically anomalous ones with little computational effort, and distinguish collective from distributive plurals to provide appropriate answers in each case. Semantic agreement is equated with syntactic well-formedness, which evens the relative costs of doing semantic versus syntactic tests — both can be performed through unification. These front ends have been adapted to other languages, such as Portuguese (by H. Coelho and Luis Pereira) and English (by D. Warren and F. Pereira). The three-valued logic into which these parsers translate English serves directly as a query language to the associated data base or expert systems, so the resulting code is extremely concise.

Another front end developed by Dahl and McCord (1983) provides in particular a logic grammar treatment of coordination in English with reconstitution of elided phrases. A prototype English parser being developed by Dahl, Fred Popowich and Dr. Michael Rochemont from the Linguistics department at the University of British Columbia will be adapted in a second phase for use as a database front end.

• **Speech recognition**
Most speech recognition work in NLP has been concerned with analyzing isolated words and phrases of about 100 words, with training sessions required for each speaker. This is much easier than recognizing continuous speech. Speech recognizers are needed for future telephone answering machines that can understand spoken commands, computerized telephone operators, and talkwriters that print what you say. Speech verification may be a component of tomorrow's security systems and might be used in future telephone answering machines that will recognize voices and deliver messages to particular callers.

Recognition of rapid speech — *Tom Perry, Ross Saunders.*

Perry and Saunders, both from Linguistics, are seeking to use linguistic ideas about speech segmentation for automated speech recognition. Perry is developing an inventory of half-syllables. No natural language contains more than about one hundred of these half-syllables. The number may be small enough for the rapid recognition of fast speech.

Saunders is investigating a new method for getting more information out of fricatives by examining the gradient of onset of the sound of a fricative. Fricatives are sounds made when two parts of the vocal tract come so close together that the air between them produces audible friction, e.g., the 'f-' in 'fin', 'v-' in 'van', 'th-' in 'thin' and 'th-' in 'this'.

Automated speaker identification — *Binay Bhattacharya.*

Bhattacharya has recently been working with Bell Northern Research (BNR) Labs in Ottawa on a speaker identification/verification system that can be trained to identify/verify people based on their voice patterns. The BNR system takes 36 voice recordings of a person. Each voice recording is decomposed into values on 15 parameters which are then time normalized into 32 frames, resulting in 32 by 15 numbers.

Bhattacharya has applied computational geometry techniques to organize the data into a geometrically partitioned space-a-tree structure
and then has developed an efficient algorithm for traversing that tree, resulting in much faster speaker identification times than the methods BNR had been using (Bhattacharya et al, 1990).

• **Machine Translation**— *Veronica Dahl, Pierre Massicotte.*
CWARC (the Canadian Workplace Automation Research Centre) has been developing a system called CRITTER for translating agricultural reports from French to English, and vice versa. Dahl and Massicotte have collaborated with CWARC in extending CRITTER's semantic coverage by incorporating Dahl's methodologies for semantic verification which also provides better flexibility and better monitoring of operations. Under a research grant from IBM, Dahl studied the uses of static discontinuity grammars (see section 4) for generating conceptual graph representations of machine error messages (Brown, Pattabhiraman, et al, 1986), in view of their automatic translation. As outgrowths of this research, Brown completed a system for generating Spanish clitics using static discontinuity grammar (Brown, 1987) and Massicotte completed a linguistically principled system for generating conceptual graphs from functional structure representations (Massicotte, 1988).

4. Theory

This section is somewhat more technical than the preceding or following sections and can be skipped by the reader who is less interested in theoretical work. Section 5 does not assume knowledge of section 4. Some of the descriptions of theories presented below are adapted from Crystal (1991).

• **Morphology**
Pollard and Sag (1987) have proposed a program for organizing the lexicon hierarchically by lexical types. Lexical items inherit information which is not specific to them by according to their lexical type. In addition, relationships among words (for example, that between the 3rd person singular of the verb and its base) are expressed by lexical rules. Lexical rules may add information or transform information.

Paul McFetridge is initiating a project in information-based morphology to explore these proposals with particular focus on how lexical rules may be constrained and implementing a lexicon which is elaborated as needed rather than completely compiled when loaded.

• **Syntax**
Much of SFU's research in syntax aims to integrate computational and linguistic formalisms and ideas.

Static discontinuity grammar — *Veronica Dahl, Fred Popowich, Jamie Andrews, Susan Kindersley, Michael Rochemont.*
Dahl has developed static discontinuity grammar (Dahl, 1986a, 1989), which belongs to the family of discontinuous grammars also developed by Dahl, which are in turn a type of logic grammar. Logic grammars differ from traditional grammars in several respects including the form of their grammar symbols, which may include arguments representing trees or semantic interpretations, and the existence of processors based on specialized theorem-provers which give grammar rules a procedural aspect (Abramson and Dahl, 1989).

Discontinuous grammars can deal with many language phenomena involving discontinuity (i.e., the relating of constituents which may be widely separated in a sentence or phrase), for example unbounded dependency (see section 2) and free word order. Discontinuous grammars have provided the basis for related work in logic grammars (Matsumoto, 1988; Saint-Dizier, 1988; Sugimura et al, 1988) and in logic programming (Dahl et al, 1986; Saint-Dizier, 1990).

The significance of static discontinuity grammar is that it transparently turns high level linguistic specifications into executable code. Such specifications can include two of the major tenets of modern linguistics: discontinuity, and the modular constraining of discontinuous constituents through various linguistic principles and filters, as in government-binding theory. Popowich has developed a left-corner parser of static discontinuity grammar. Dahl and Popowich (1990) describes the parser, parsing efficiency, and the tree admissibility interpretation of static discontinuity grammars,

Abramson and Dahl (1991) are developing static discontinuity grammar methodologies for top-down parsing of immediate dominance and linear precedence (ID/LP) rules and free word order rules with discontinuous constituents. Their methods are analogues for logic grammars of Shieber's extension to Earley's algorithm which parses grammars with free word order and ID/LP rules "efficiently" in the sense that the object context free grammar is not generated. These methods permit in particular the treatment of scrambling and ellipsis in languages such as Japanese.

Andrews is developing a semantic characterization of static discontinuity grammars in terms of relevance logic, a particular form of logic which has been seen to have relationships to other grammar formalisms. This work will help researchers to explore the connection between static discontinuity grammars and these other formalisms. It may also result in

extensions which will help Dahl and Abramson's work in ID/LP parsing.

Government-binding theory — *Veronica Dahl, Fred Popowich, Michael Rochemont.*
Dahl has worked on merging government-binding theory into static discontinuity grammar (Dahl, 1988a). Government-binding theory is a model of grammar descended from extended standard theory (Chomsky, 1982, 1986). Most of the descriptive research into the formal syntax of the different languages of the world is within the government-binding formalism. The merging of one theory within the other is possible because the two have certain similarities: "both attempt to achieve maximal coverage with minimal expressive machinery, both can describe fairly free types of movement, both tend toward abstraction and generalization" (Abramson and Dahl, 1989, p. 153).

Static discontinuity grammars were successfully used for implementing government-binding theory in the system for machine error messages mentioned in section 3 (Brown, Dahl, et al, 1986). Dahl, Popowich and Rochemont (1991) are conducting further research into a static discontinuity grammar-based implementation of aspects of government-binding theory.

Unification-based grammars — *Fred Popowich, Paul McFetridge, Carl Vogel.*
Unification-based grammars are a family of grammars whose central operation is unification. Two descriptions can unify as long as they do not contain conflicting information. The result contains all the information that is in either description.

Unification-based grammars are declarative and lexical. Their declarative nature makes them relatively easy to understand and modify, since a grammar states relationships instead of giving procedures for their computation. Their lexical nature reduces grammar development to lexicon development because syntactic classes contain information about the classes with which they combine, which means that only a small number of grammar rules and principles are needed, and that those rules and principles are schematic and fixed. However the drawback is large lexicons with complex lexical entries. To avoid redundancy and to capture linguistic generalizations in such lexicons, lexical types and lexical rules have been introduced. Lexical types eliminate "vertical redundancy" by factoring out general information shared by whole syntactic classes, organizing lexical entries into multiple hierarchies based on the information they share, and inheriting down general information. Lexical rules eliminate "horizontal redundancy" by identifying lexical entries that have common, specific patterns which cannot be inherited via lexical types. In such cases, a lexical rule fills in the specific information.

Head-driven phrase structure grammar — *Paul McFetridge, Fred Popowich, Carl Vogel.*
Head-driven phrase structure grammar (Pollard and Sag, 1987) is one of the best known unification-based formalisms. A distinctive feature of the grammar is that attribute-value matrices are used to represent lexical entries and grammar rules and principles. A second distinctive feature is its head-driven nature: the head constituent of a phrase is a central notion. Otherwise, the grammar borrows freely from previous unification-based grammars. The treatment of syntactic categories, syntactic features, and some of the principles are from generalized phrase structure grammar (Gazdar et al, 1985). A number of the lexical rules are similar to those in lexical-functional grammar (Kaplan and Bresnan, 1982).

Chart parsing implementations of head-driven phrase structure grammar have been developed in Lisp by Paul McFetridge and in Prolog by Fred Popowich and Carl Vogel. Chart parsing is a type of parsing in which all syntactic structures which are built are placed on a single graph structure called a chart. A successful parse of a sentence is a list of edges and nodes that includes the start node of the chart, all the words in the sentence, and the end node.

Tree unification grammar — *Fred Popowich, Susan Kindersley.*
Tree unification grammar (Popowich, 1989a, 1989b) resembles head-driven phrase structure grammar in certain respects. Both formalisms use signs as information structures and provide facilities for establishing the relationships between signs. Tree unification grammar incorporates a greater degree of lexicalization, using one rule as opposed to the four or five rules described in Pollard and Sag (1987, forthcoming). Head-driven phrase structure grammar also relies on the use of universal grammar principles which apply in conjunction with the grammar rules. Many of these principles make use of functionally dependent values: they contain calls to relatively complex functions like *collect-indices, selectively-combine-semantics, order-constituents* and *bip* (application of the binding inheritance principle). In tree unification grammar, the relationships between the information contained in different signs is stated in terms of unification, or very simple list operations, within the lexical templates.

Tree unification grammar also differs from head-driven phrase structure grammar in the kind of derivational structures that it allows. In tree unification grammar the structures are binary, consisting of a specified functor and argument. For the structures used by head-driven phrase structure grammar, which are called phrasal signs, there is no theoretical limit on the branching factor. In the phrasal signs of head-driven phrase structure grammar, it is very awkward to describe specific relationships relevant to constraints on reflexive pronouns. Tree unification grammar specifies three different reflexive relationships contained in its *R-GPR, R-PR* and *R-NPR* lexical templates (Popowich, 1989a). The different relationships between semantic and reflexive information can be captured more elegantly in the formulation of head-driven phrase structure grammar introduced in Pollard (1989), but it is still not as concise as the tree unification grammar characterization that we have described.

A parser has been written that can use tree unification grammar in an NLP system (Popowich, 1989b). The prototype for this system will form the basis of a larger system for developing and testing natural language grammars that can be used in a natural language interfaces. The larger system is currently being developed by Susan Kindersley (Popowich and Kindersley, 1991).

Parsing as inheritance reasoning — *Carl Vogel, Fred Popowich, Nick Cercone.*
Vogel and Popowich (1990) have proposed that parsing with a unification-based grammar can be viewed as reasoning over an inheritance network. This research is of a system-building nature in comparison to the related research of Nebel and Smolka (1989) who explore the relationship between terminological reasoning systems and unification grammars with respect to the computational properties of computing subsumption in either system.

The aim of the research is to explore the extent of the relationship which begins with a number of similarities observed between unification-based grammar and inheritance reasoning. First, unification and inheritance reasoning are closely related: the monotonic unification operator can directly model strict inheritance, and extended unification algorithms can be used to describe defeasible or mixed strict and defeasible inheritance (Bouma, 1990).

Second, lexical types and inheritance reasoning are closely related: lexical types allow common information to be shared by lexical entries, while inheritance has frequently been used in NLP to allow the sharing of information in the lexicon (Flickinger et al, 1985; Evans and Gazdar, 1990). Lexical information is organized in an inheritance hierarchy and the information associated with a specific lexical entry is determined by

inheritance over this hierarchy. Information relating to grammar rules and principles can also be captured in a similar manner (Pollard, 1985; Fraser and Hudson, 1990). The construction of an inheritance hierarchy allows the concise statement of linguistic information, be it lexical, phonological, morphological, syntactic or semantic.

Third, inheritance need not be restricted to descriptive hierarchies such as a hierarchy of lexical types, but can also be used to establish relationships in derivational structures such as parse trees. Inheritance can thus be used in parsing and in generation.

The result of this research is a pedagogical tool for describing the structure and application of head-driven phrase structure grammar and, produced as an artifact, a cleanly specified if inefficient alternative parsing strategy.
More efficient parsers for head-driven phrase structure grammar do exist: Proudian and Pollard (1985) developed a chart parser for an early version of the formalism, and there are McFetridge's and Popowich's chart parsers too. A nice side effect of the inheritance reasoner is that it provides an elegant way to represent and process unknown words.

Grammar rule induction in connectionist networks — *Robert Hadley.*
A serious drawback of connectionist systems is that they do not permit the fast integration of new vocabulary and linguistic patterns which children exhibit once they have learned rudimentary syntax. The aim of this research to get a connectionist network to learn, on its own, some basic rules of syntax for natural language. These rules will be acquired as patterns by the connectionist network.

It is known that when semantic information is incorporated into the learning process, classical algorithmic methods for inducing syntactic patterns can be made significantly more efficient. Hadley is integrating the semantic acquisition process with the induction of syntactic patterns on a connectionist network, so that the acquisition of syntactic patterns will involve, as a sub-process, the acquisition of a small hierarchy of concepts, beginning with categories corresponding to objects, actions, and object-modifiers. Hadley has closely examined the problem of how primitive words (which denote objects, actions, and object-modifiers) become associated on a connectionist network with the real world objects they actually denote. There have been past designs of connectionist architectures for discovering this "denotation relationship" which obtains between particular words and particular aspects of a situation, but these designs have adopted the unrealistic assumption that the learnev (say, a child) already knows precisely what "state of affairs" a sentence is intended to describe.

In addition, Hadley's recent research has included a critical examination of connectionist systems which are purported to exhibit the compositionality and systematicity characteristic of natural language. He argues that many of these claims are seriously exaggerated (Hadley, 1990).

• Semantics

A representation for NLP using extended semantic networks
— *Nick Cercone.*
Cercone et al's extended semantic network representation (Cercone et al, to appear) can represent states, events, actions, logical and natural language quantifiers, expressible intentionality, modalities, adverbials, comparatives (explicit and implicit), and the meanings of complex concepts such as walking. The concept representation is hierarchical and recursive rather than dependent upon primitives. Formal methods for interpretation and manipulation of the network constructs have been developed and implemented. Complex concepts are efficiently processed. Lambda-abstracted predications are uniformly handled in the representation so that sentences such as "loving ones neighbours is a virtue" are understood.

Work has concentrated on two main problems: modifiers, and inferencing and reasoning strategies. Iterated modifier analysis is used advantageously to account for comparative and descriptive modifiers. In an implementation, we have refined our treatment of English modifiers.

A means of promoting inferences is being developed through the use of supra-organizations which will be imposed on the network database to allow rapid access to facts contextually pertinent to concepts.

A stratified meaning representation for natural language discourse
— *Tomek Strzalkowski, Nick Cercone.*
The stratified model, developed by Strzalkowski (1986) uses a lambda-categorial language for meaning representation. The model applies a series of disambiguating transformations to a discourse fragment before assigning it a final representation. The transformations include morphological analysis, lexical ambiguity resolution, syntactic parsing, computation of extra-sentential dependencies, and pragmatic evaluation in discourse context. The computation of extra-sentential dependencies is performed on an intermediate, formal representation of the discourse fragment. The transformations are done using Montague's (Thomason, 1974) style of coupling syntactic and semantic processing but not his use of an intensional logic - the intermediate representation used is a lambda-categorial language (a typed predicate calculus language with a lambda-operator). The final representation of discourse content, while not decided upon, will have a form resembling that of "abstract situation" from Barwise and Perry's (1983) situation semantics. The model has been used to investigate two discourse problems: first, the resolution of anaphoric and cataphoric reference across sentences (Strzalkowski and Cercone, 1986), and second, the representation and manipulation of non-singular concepts (Strzalkowski and Cercone, 1989). Presently, there is no implementation of the stratified model.

The resolution of cross-sentence anaphoric and cataphoric reference.
This work has so far been restricted to cases of anaphora in two sentence stories. In these stories, cases have been selected where a reference, if it can be computed at all, has a unique antecedent. A set of rules has been formalized for computing the references in these cases, and the transformation which encompasses these rules, and the rules themselves, have been related to the stratified model.

Cross-sentence cataphoric references have also been studied and some solutions specified for certain cases. Another discourse problem that has been studied using the same methods is repairing references in discourse. An example of reference repair is given in the following three sentence discourse: "I bought a black coffee in the pub. I brought it back to my office to drink. The cream in my office was off and it (the coffee) tasted bad."

The representation and manipulation of non-singular concepts.
This work (Strzalkowski and Cercone, 1989) generalizes the treatment of the concepts given in Strzalkowski and Cercone (1986). Non-singular concepts are abstract entities that embrace a variety of smaller or larger collections of instances. They are usually referred to using bare plural noun phrases (such as 'birds', 'alligators' and 'presidents'), definite singular noun phrases with a generic interpretation ("the alligator," "the president"), mass nouns ('water', 'gold'), and functional uses of definite descriptions ("the number of students," "the temperature").

Non-singular definite descriptions appear in a number of reasoning puzzles, for example, the following syllogism adapted from Partee (1972):

The president is elected every four years.

The president is Bush.

Thus, Bush is elected every four years.

This erroneous conclusion arises because we assign a non-singular interpretation to "The president" instead of a singular one.

Strzalkowski and Cercone's solution is a representation based on a partially ordered structure of levels in which the objects of the same relative singularity are assigned to the same level. Their choice of representation has been motivated by the following main concerns: (1) the representation should systematically distinguish between those language terms that are used to refer to objects of different singularity, that is, those classified within different but related levels of the model; (2) the representation should capture certain types of inter-sentential dependencies in discourse, most notably anaphoric-type cohesive links; (3) finally, the representation should serve as a basis for defining a formal semantics of discourse paragraphs that would allow for capturing the exact truth conditions of sentences involving non-singular terms, and for computing inter-level inferences. Some initial progress has been made on (1) and (2) but (3) is currently under investigation. Strzalkowski and Cercone believe that their approach promotes computational feasibility, because they avoid the identification of general terms like 'temperature', 'water', etc., with intensions, that is, functions over possible worlds. In their theory, the concept of non-singularity has a local (often subjective) character.

The met* method of metaphor and metonymy interpretation
— *Dan Fass.*
The met* method (Fass, 1988, 1991a, 1991b) distinguishes selected examples of metonymy from metaphor and from literalness and anomaly in short English sentences. Consider, for example, a waitress in a restaurant saying "The ham sandwich is waiting for his check." This sentence contains a metonymy while "The car drank gasoline" contains a metaphor. The difference between a metonymy and a metaphor, according to Lakoff and Johnson (1980), is that in metonymy one entity stands for another whereas in metaphor one entity is viewed as resembling another. This difference can be seen in the above sentences: "The ham sandwich" stands for the male person who ordered the ham sandwich, while "The car" is viewed as resembling an animate drinker in that both use up a liquid, take in the liquid through an aperture, etc.

In the met* method, literalness is distinguished because it satisfies contextual constraints that the non-literal others all violate. Metonymy is discriminated from metaphor and anomaly in a way that supports Lakoff and Johnson's (1980) view of metonymy and metaphor, permits chains of metonymies (Reddy, 1979), and allows metonymies to co-occur with instances of either literalness, metaphor, or anomaly. Metaphor is distinguished from anomaly because the former contains a relevant analogy, unlike the latter. The met* method is part of collative semantics (Fass, 1989, 1990), a semantics for natural language processing, and has been implemented in a computer program called meta5. Collative semantics is also concerned with the representation and resolution of lexical ambiguity. The meta5 program contains a lexicon of 500 word senses, a small grammar, and routines containing collative semantics.

Salience in language generation — *T. Pattabhiraman, Nick Cercone.*
The role of salience in decisions in natural language generation has been examined. The salience of an entity in natural language generation represents its prominence. It is therefore used in several decisions in natural language generation as a measure of preference that justifies the choices committed. Salience is a multi-aspect notion that includes vividness and topicality. The interactions among salience-influenced decisions can be characterized as synergistic, competitive, complementary, asynchronous, concurrent and weighted. The problems involved in making these interactions operational in natural language generation systems are being examined, in particular, from the viewpoint of efficient, maximally-deterministic generation. Computational mechanisms are being developed to capture the influences of salience in natural language generation decisions such as content selection, lexical selection, tactical linearization and the generation of pronouns (Pattabhiraman and Cercone, 1990a, 1991).

Pattabhiraman is also interested in the problem of evaluating theories and systems in natural language generation (Pattabhiraman and Cercone, 1990b) and is currently working on developing a coherent classification of natural language generation systems, and spelling out a set of evaluation criteria that are relevant to each kind. The classification of natural language generation systems is based on a number of dimensions such as objectives, stages of evolution and approaches to the modelling of linguistic knowledge.

• Pragmatics
SFU's work in pragmatics has been concerned with dialogue between a natural language interface and a user when one of them has faulty or missing information, specifically, how to keep the dialogue going and how to repair the dialogue. This work can also be viewed as introducing robustness into NLP systems because they attempt to keep a dialogue going in situations where it has broken down. The main problem in this work, which has been overlooked by many other researchers, is fault finding from the dialogue: is the faulty or missing information in the database of the natural language interface or with the user?

Predicting and explaining query failure
— *Stefan Joseph, Romas Aleliunas, Nick Cercone.*
Database systems don't contain all the information needed to model their target domain. Users' questions usually contain assumptions about the domain. A null answer arises when or more assumptions of a question are incorrect. For example, "which graduate students have taught CMPT681?" (example due to Bonnie Webber) assumes that graduate students can teach that course or "which text book is used for CMPT898?" assumes that CMPT898 is a course on which a text book is used. A null response — "no" — is not very helpful. What is needed is more informative responses.

Joseph has developed a way of predicting null responses to database queries in a way that avoids wasteful search of secondary memory and a way of generating meaningful explanations of why no result was found (Joseph and Aleliunas, 1991). A distinction is made between two main kinds of null value: "property is inapplicable" as in a male person's maiden name (which violates an obvious semantic constraint on male persons), and "value at present unknown." This research developed from Kao's work (Kao et al, 1988; Cercone et al, 1990) which analyzed the reasons for the null responses once the database access resulted in a no response.

Joseph uses an inference procedure to detect empty responses to queries and to give a reason why a response was empty. The inference procedure uses three sources of information: the query itself (an expression in relational calculus), the RM/T* catalogue which describes the structural and functional dependencies of the actual database, and a knowledge base whose rules are semantic constraints on the database. There is a general rule of inference for each operation of relational calculus (e.g., join, projection, selection). As soon as the inference procedure determines that one of the attribute-domain sets is empty, further database searching is unnecessary and the query must return an empty response. The inference procedure's actions are strictly controlled by the structure of the query.

A belief-based view of ill-formed input — *Dan Fass, Gary Hall, Nick Cercone, Chris Groeneboer, Paul McFetridge, Fred Popowich.*
Ill-formed input refers to "lexical problems such as misspelled words, sentential problems such as missing words or phrases and bad word

order, semantic problems such as anomalous or self contradictory sentences, and contextual problems such as incoherent requests or continuations" (Allen, 1983). Users of natural language interfaces produce ill-formed input which must be handled by the interfaces.

Perhaps the biggest problem with ill-formed input is locating it. We have tackled this problem by treating ill-formed input as a clash of beliefs between a user and an interface: the ill-formed input is then viewed as the false or incorrect beliefs of either the user or interface. To see how this works, consider what happens when a natural language interface parses a sentence containing the item 'recieve'. 'Recieve' is not in the interface's lexicon, hence there is a conflict of belief. There are two obvious causes of the conflict: first, 'recieve' is a spelling error by the user (i.e., the user has *false* beliefs about the spelling of 'receive'), and second, 'recieve' is an unknown word to the interface (i.e., the interface has *missing* beliefs about the word 'recieve').

This central idea about clashing beliefs has been incorporated into a framework we have developed for treating ill-formed input in which an interface and its users each has a "belief model" about itself and other participants with which it engages in dialogue (Fass et al, 1990; Fass and Hall, 1990). Each model contains beliefs of that participant about its language and its knowledge of the domain. The clashes of beliefs lead to a far more extensive classification of situation in which ill-formed input occurs than previous approaches to ill-formed input.

5. Integrated Systems

The aim in producing integrated systems is to combine natural language with logic programming, general-purpose interfaces, databases, and expert/reasoning systems.

Logic programming — *Veronica Dahl, Fred Popowich, Susan Kindersley, Greg Sidebottom, Joerg Ueberla.*

Veronica Dahl has been investigating the translation of high-level linguistic specifications in static discontinuity grammar into executable code in logic programming (Dahl et al, 1986). An approach to concept type hierarchies in logic programming has also been developed (Massicotte and Dahl, 1988) which, while reasonably efficient, is more portable than prior approaches. Together with Greg Sidebottom and Joerg Ueberla, Dahl is also developing constrained logic programming techniques which can provide a general, easy-to-use way of describing design worlds for efficient automatic problem-solving. These techniques combine a variation of Freuder's algorithm for synthesizing constraint expressions with a variation of Sidebottom's (1991) integer constraint satisfaction methods, and incorporates heuristic selection functions which are appropriate for design problems in general.

• **Grammar development tools**

The grammars used in NLP systems are becoming very sophisticated. Developing such grammars requires designing, testing and modifying grammar rules, principles and lexicons. Tools for developing such grammars are needed by system developers (and sophisticated users) of applications like natural language interfaces to databases, and by students and researchers for understanding existing grammars, for extending them, and for developing new grammars. Tools will make it easier to study how linguistic problems are handled by different grammars, to import ideas from one grammar into another, and to describe fresh linguistic problems within an existing grammar.

TREETOOL, a tool for displaying tree structures — *Fred Popowich, Sue Baker, Rob Hamm.*

A graphics module for displaying the tree structures associated with tree unification grammar has been developed on SUN workstations (Baker et al, 1990), and is being ported to X-Windows. The module has also been incorporated into a government-binding theory parser and Lisp-based and Prolog-based head-driven phrase structure grammar parsers. The module is a useful tool for any NLP system for displaying complete parse trees and partial analyses.

Toolkit for developing unification-based grammars — *Fred Popowich, Susan Kindersley.*

Development tools exist for many general purpose unification-based grammar formalisms like PATR-II (Shieber et al, 1983), D-PATR (Kartunen, 1986), and STUF (Uszkoreit, 1986; Bouma et al, 1988). Popowich and Kindersley are interested in providing a system for implementing particular unification-based grammars like tree unification grammar and head-driven phrase structure grammar which have specific development problems not found in the more general grammars. For instance, head-driven phrase structure grammar allows functions to appear as feature values, and tree unification grammar possesses relations requiring an element to be an arbitrary element of a list. These operations are not available in PATR or in STUF.

The toolkit will make it easier to compare particular grammars. For example, the toolkit will facilitate the examination of recent proposals for the treatment of anaphora, coordination, comparatives and adjuncts in head-driven phrase structure grammar (Popowich, 1989a, 1989b) and the consideration of alternatives.

The grammar development tools will be developed by Susan Kindersley within the ProWindows environment of Quintus Prolog. Since unification is a primitive operation in logic programming frameworks, it is appropriate to adopt a logic programming language like Prolog to implement the system.

The LINGKIT system for developing government-binding theory grammars — *Veronica Dahl, Fred Popowich, Michael Rochemont.*

Many of the world's languages have been described within government-binding theory. Since the theory is still evolving, it is important for linguists to be able to design grammars and principles and to examine the correlation between their hypotheses and the natural language data. The LINGKIT system will allow linguists to focus on the treatment of unbounded dependency constructions. The system is based on a declarative high level logic grammar formalism in which unbounded movement can be easily described, namely static discontinuity grammar (see section 4).

• **General-purpose interfaces** — *Chris Groeneboer, Nick Cercone.*

Users prefer different modalities at different stages of learning to use a system and for different applications. Naive users learn to use new systems faster with natural language, while experienced users prefer control keys because they are faster (Napier et al, 1989). Graphical displays may be preferred for certain tasks, e.g., clicking on a region of a map to get information about that region. What is needed are user interfaces that can handle different modalities and different applications.

Chris Groeneboer and Nick Cercone (1991) have developed a modular architecture for a multi-modal, multi-application user interface. The architecture has five layers consisting of: user, modalities, the interface itself, applications, and the underlying operating system. Requests and responses undergo transformations as they pass through the layers. User requests pass down through the layers to the appropriate application. System responses pass up through the layers to the user in an appropriate modality for presentation. The layered architecture is designed to make changes easy, for example, adding a new modality, application or user. Control resides with the interface itself which contains a set of experts: a modality expert, an applications expert, a representation expert, an interaction expert, and a coordinator which organizes the other experts. Each expert has access to two knowledge bases specific to its expertise,

one that contains general domain-independent information, and another that contains specific domain-dependent information. For example, the interaction expert has a domain-independent knowledge base about human-computer interaction in general while the domain-dependent knowledge base contains user models which in turn contain information about specific users.

Groeneboer and Cercone have also developed an underlying philosophy of interface design based on the constructivist paradigm. Within this paradigm, knowledge is viewed as constructed by a user to fit with the user's experiences of the world. Attention is paid to the processes by which users organize their experience. The significance of this paradigm for interface design is that attention is paid to how users construct the interface environments they want.

Other researchers at SFU whose work is helping is Tom Calvert's Graphics Lab, the Intelligent Graphic Interface (IGI) Group, and Gerri Sinclair's EXCITE Lab.

• **Database systems** — *Veronica Dahl, Jai-Wei Han, Gary Hall, Ranabir Gupta.*
Dahl has worked on integrating NLP, database and logic programming techniques (Dahl, 1982, 1990; Dahl, Sidebottom et al, 1991). She has developed a typing system that reduces many type checking operations to unification and which have found applications in deductive databases (Dahl, 1991). The distinctive feature in Dahl's work on deductive relational database systems is the use of logic as a single tool for formalizing and implementing different aspects of database systems in a uniform manner. The use of logic throughout allows for a uniform representation of programs, parser, data, inference, semantic interpretation and query evaluation. Its use both as the theoretical framework and as the implementation means allows for a great degree of data-independence and non-procedurality. Dahl has developed a single logical formalism, serving both as a meaning representation language and a query language (see section 3), which contains features of logic programming database querying and defining and features of representations of natural language.

Han has been working on constraint-based reasoning in deductive databases (Han, 1991). Constraint-based reasoning has been studied extensively in logic programming and artificial intelligence, for example, the Echidna reasoning system described below. Han has developed a constraint-based reasoning technique for deductive databases involving functional linear recursions. The application studied is booking air flight tickets.

Hall and Gupta (1991; Gupta and Hall, 1991) have been studying how to integrate the representation of the static and dynamic aspects of a domain into a single conceptual model. Hall is looking to extend Pathfinder (used in SystemX and SX) to measure semantic relatedness in models which include relationship types that Pathfinder cannot presently manage.

Generating a conceptual model is a major phase of customizing a natural language interface to a database. Hall has been looking into means to automate this phase as much as possible. A related problem is how to update changes which occur in the domain of the database to a natural language interface. Successful automatic generation techniques should ease this problem because the techniques should be able to deduce changes in the domain which are prompting changes to the logical model and to the patterns of data in the database itself.

• **Expert systems** — *Veronica Dahl, Fred Popowich, Paul McFetridge, CSS Expert Systems Laboratory, Joerg Ueberla.*
Veronica Dahl (1986b, 1990) has proposed an integrating framework for the development of expert systems that either have linguistic knowledge as their domain of expertise, or use it in their interfaces. Also, as mentioned earlier in section 5, she is presently working on an expert system for automatic design problems, which provides in particular some built-in heuristics that are applicable to all automatic design domains, plus modular definition facilities for completing the heuristic information with problem specific data for each application. A prototype is being developed with Greg Sidebottom and Joerg Ueberla for the specific problem of designing computer configurations satisfying a user's particular needs (Dahl, Sidebottom et al, 1991).

Some NLP researchers are using an expert system reasoning engine for NLP applications. The reasoning engine is called Echidna developed by Bill Havens, Director of the CSS Expert Systems Laboratory, and his research team. Fred Popowich and Bill Havens are writing a natural language parser in Echidna, and Paul McFetridge is using Echidna to develop a decomposition of task verbs for a robot assembly system.

Echidna is a constraint logic programming system for model-based expert systems applications. It improves on existing expert systems by combining aspects of predicate schema-based object-oriented knowledge representations, dataflow dependency backtracking, and constraint logic programming (Havens et al, 1990a). It includes a justification-based clausal reasoning maintenance system. Echidna is the first logic programming language that integrates active constraint reasoning techniques to detect failure in search sooner and dependency backtracking to avoid unnecessary computation when failure is detected (Havens, 1990).

A prototype, Echidna version 0, has been in use internally since April 1990 (Havens et al, 1990b). Testing began on an internal release of Echidna version 1 in February 1991. This version is implemented in C++, has an interface in X-windows and runs on Sun and NeXT computers. In the future, it is planned to provide Echidna on other platforms with support for distributed systems and hypothetical reasoning. Echidna will be made available commercially in the future.

Prototype knowledge bases are being implemented in the area of mechanical and architectural design. Also being implemented is further support for problems in diagnosis and problems in operations research (such as graph colouring and scheduling). Echidna version 0 is also being evaluated on a number of applications, including an intelligent computer-aided design system called intelCAD, an intelligent graphics interface project for supervisory control called IGI, and an automotive diagnosis project for engine computer control systems called SuperEAS.

Acknowledgements
Some of the material in sections 3-5 and appendices A and B is adapted from material in the CSS Update, CSS Research Review and CSS Natural Language Laboratories leaflet, all edited by Barry Shell. The interested reader is encouraged to look at these. Carolyn Seely-Morrison, Administrative Assistant of the CSS, was of great assistance in preparing Appendix D.

Appendices

A. Personnel

• Faculty

Principal researchers — text processing

Nick Cercone — Computing Science; Director, Centre for Systems Science

Veronica Dahl — Computing Science; Director, Logic Programming Laboratory

Paul McFetridge — Linguistics; Director, Natural Language Laboratory

Fred Popowich — Computing Science
Principal researchers — speech processing
Binay Bhattacharya — Computing Science

Tom Perry — Linguistics

Ross Saunders — Linguistics

Associate researchers
Robert Hadley — Computing Science

Jai-Wei Han — Computing Science

Bill Havens — Computing Science; Director, Expert Systems Laboratory

Wo-Shun Luk — Computing Science

Michael Rochemont — Linguistics, University of British Columbia

• Staff
Post-Doctoral Fellows
Jamie Andrews

Research Scientists
Dan Fass

Chris Groeneboer

Gary Hall

Susan Kindersley

• Students
Present graduate students
Ranabir Gupta — PhD in Computing Science (a framework to support object-oriented views of dynamic database domains)

Chantal Lunardi — PhD under Special Arrangement (multi-ethnic characteristics of computer enrichment)

T. Pattabhiraman — PhD in Computing Science (salience in natural language generation)

Allan Bennett-Brown — MSc in Computing Science (neural network model of early speech perception)

Xiobing Chen — MSc in Computing Science (extracting functional dependencies and finding synonyms)

Alison Marchant — MA in Linguistics (to be decided)

Michael McGuire — MSc in Engineering (speech recognition using neural networks)

Joerg Ueberla — PhD in Computing Science (neural networks applied to speech recognition and natural language understanding)

Bruce Wiebe — MSc in Computing Science (computational phonology)

Recent graduate students
Eric Wu — (1991) MSc in Computing Science (a benchmark method for SQL query performance)

Yandong Cai (1990) — MSc in Computing Science (attribute oriented induction in relational databases)

Carl Vogel (1990) — MSc in Computing Science (inheritance reasoning and head driven phrase structure parsing)

Mimi Kao (1988) — MSc in Computing Science (generating quality responses from null answers to queries)

Stefan Joseph (1988) — MSc in Computing Science (eliminating unnecessary database accesses with natural language interfaces)

Pierre Massicotte (1988) — MSc in Computing Science (generating conceptual graphs from functional structures)

Charles Brown (1987) — PhD in Computing Science (generating Spanish clitics using static discontinuity grammar)

• Academic grants

Amount	Period	Source	Recipient(s)	Notes
141,000	93-94	IRIS B-4 node	Cercone et al	Design and human interfaces (4 years)
139,000	92-93	IRIS B-4 node	Cercone et al	
146,000	91-92	IRIS B-4 node	Cercone et al	
132,000	90-91	IRIS B-4 node	Cercone et al	
36,611	91-92	NSERC operating award	Cercone	Knowledge representation and natural
36,611	90-91	NSERC operating award	Cercone	language understanding (6 years)
36,611	89-90	NSERC operating award	Cercone	
34,300	88-89	NSERC operating award	Cercone	
34,300	87-88	NSERC operating award	Cercone	
28,480	86-87	NSERC operating award	Cercone	
12,500	91-92	CIAR, IRIS	Cercone	CIAR Associate
12,500	91-92	PRECARN	Cercone	IRIS Area Coordinator (for teaching release)
175,000	84-91	NRCC	Cercone	Computational Intelligence journal
30,000	90-91	CSS matching	Cercone	
107,880	88-89	NSERC strategic grant	Cercone, Luk	Accessing information through
110,380	87-88	NSERC strategic grant	Cercone, Luk	ordinary language (3 years)
107,880	86-87	NSERC strategic grant	Cercone, Luk	
21,000	86-87	CSS research grant	Cercone, Luk	SystemX
36,500	86-87	UVIC President's research grant	Cercone	Canadian 5th Generation Research Society
33,490	89-90	CWARC collaboration	Dahl	Automatic translation of agricultural reports
11,845	88-89	CWARC	Dahl	Automatic translation of agricultural reports
25,187	91-93	NSERC operating award	Dahl	Logic applied to natural language processing
25,187	90-91	NSERC operating award	Dahl	and expert database systems
25,187	89-90	NSERC operating award	Dahl	
25,187	88-89	NSERC operating award	Dahl	
25,187	87-88	NSERC operating award	Dahl	
25,187	86-87	NSERC operating award	Dahl	
5,000	88-89	CSS research grant	Dahl	automatic translation of agricultural reports
36,000	91-94	NSERC operating award	Popowich	unification-based grammars
30,000	89-91	NSERC operating award	Popowich	unification-based grammars
105,000	89-92	ASI fellowship	Popowich	unification-based grammars
10,000	91-92	Bridge/CSS strategic	Perry	speech recognition
5,000	88-89	CSS research grant	Perry	speech recognition
3,000	87-88	CSS research grant	Perry	speech recognition

• Industrial contracts

Amount	Period	Source	Recipient(s)	Notes
20,000	91-92	BNR	Bhattacharya	Speaker identification/verification
20,000	90-91	BNR	Bhattacharya	Speaker identification/verification
100,000	92-93	Rogers Cablevision	Cercone et al	Expert information management (3 years)
100,000	91-92	Rogers Cablevision	Cercone et al	
83,640	90-91	Rogers Cablevision	Cercone et al	
18,000	90-91	BCSC MART grant	Cercone	Market assessment of SystemX competition
187,000	86-87	IBM SUR grant	Dahl	machine translation
??	91-92	International Sub-Engineering	McFetridge	Task verbs for robot control marine

• Infrastructure and equipment grants

Amount	Period	Source	Recipient(s)	Notes
75,000	93-94	NSERC infrastructure	Cercone, Kameda, Hafer	
75,000	92-93	NSERC infrastructure	Cercone, Kameda, Hafer	
75,000	91-92	NSERC infrastructure	Cercone, Kameda, Hafer	
45,055	93-94	Ministry of Advanced	Cercone	For IRIS B-4 "Design and human
45,055	92-93	Education & Job Training	Cercone	interfaces" 90-94 (4 years)
45,055	91-92	provincial match	Cercone	
10,000	90-91		Cercone	
86,000	90-91	NSERC infrastructure	Cercone, Kameda, Hafer	
86,000	89-90	NSERC infrastructure	Cercone, Kameda, Hafer	
86,000	88-89	NSERC infrastructure	Cercone, Kameda, Hafer	
60,480	87-88	NSERC infrastructure	Cercone, Kameda, Hafer	
60,480	86-87	NSERC infrastructure	Cercone, Kameda, Hafer	
41,557	89-90	NSERC equipment	Cercone et al	
13,852	89-90	CSS matching	Cercone et al	For NSERC equipment 89-90
83,700	87-88	SUN Microsystems	Cercone	Support of NSERC strategic grant 86-89 equipment grant
69,768	87-88	NSERC equipment	Cercone, Kameda, et al	

B. Hardware and Software

The following is developed from Barry Shell's leaflet *CSS Natural Language Laboratories*. The Natural Language Interface Laboratory and Logic Programming Laboratory are equipped with Macintoshes, NeXTs, PCs and SPARCstation 1 workstations. Software available includes the Oracle Database, the G2 expert system shell, Common Lisp, Quintus Prolog, ALS Prolog, Sicstus Prolog, Arity Prolog, and LPA Prolog.

C. The Centre for Systems Science

The CSS was established at SFU in 1987 as a provincial Centre of Excellence to foster basic cooperative research and education in advanced systems including artificial intelligence, robotics, computing science, and microelectronics. The Director of the CSS from its inception has been Nick Cercone. The CSS supports three broad research groups in: intelligent systems, computer & communication systems, and microelectronics. These research groups involve approximately 84 faculty, drawn principally from the Schools of Computing Science and Engineering Science, but also including faculty from Linguistics, Mathematics, Physics, Geography, Philosophy, Psychology, Communication, Education, Kinesiology, and Business Administration.

Several research laboratories have been established within the CSS, including the Natural Language Laboratory (Director: Paul McFetridge), the Logic Programming Laboratory (Director: Veronica Dahl), and the Expert Systems Laboratory (Director: Bill Havens). Work from all three of these laboratories has been described in this report.

The CSS has established a research support computing network which currently serves over 400 users in twelve departments. The network consists of over 400 computers, and growing. Computers and related equipment have come from a variety of sources, the major ones being faculty research grants, the CSS, and SFU.

The CSS has engaged in numerous other activities, including a University/ Industry joint appointments option for hiring faculty, and several research support programs, including the research grants competition and support for research groups competition. These programs have been replaced by two newer programs, the matching grants policy and strategic initiatives program. Matching grants are designed to provide a four or five to one pay back to SFU for funds invested. The next appendix lists the major grants won by the main researchers in NLP at SFU.

D. Grants of Principal Researchers in Natural Language Processing (1986 on)

As many acronyms are used in the tables that follow, a key is supplied.

Key: AGAR = Assistance Grants for Applied Research (program of BCSC).
ASI = Advanced Systems Institute of British Columbia, Burnaby, BC.
BCSC = British Columbia Science Council, Metrotown, Burnaby, BC.
BNR = Bell Northern Research, Ottawa. ON.
CCLF = Canadian Cable Labs Fund, Metrotown, Burnaby, BC.
CIAR = Canadian Institute of Advanced Research, Toronto, ON.
CSS = Centre for Systems Science (part of SFU).
CWARC = Canadian Workplace Automation Research Centre, Montreal, PQ.
IBM = International Business Machines, Toronto, ON.
IRIS = Institute of Robotics and Intelligent Systems, Ottawa, ON
ISE = International Submarine Engineering, Port Coquitlam, BC.
MART = Market Assessment (program of BCSC).
NCE = National Centres of Excellence (with NSERC), Ottawa, ON.
NRCC = National Research Council of Canada, Ottawa, ON.
NSERC = National Science and Engineering Research Council, Ottawa, ON.
PRECARN = Precompetitive and Applied Research Network, Ottawa, ON.
SFU = Simon Fraser University, Burnaby, BC.
STDF = Science and Technology Development Fund (program of BCSC).
STF = Science and Technology Fund (program of BCSC, replaces STDF and AGAR).
SUR = Shared University Research (program of IBM).
UVIC = University of Victoria, Victoria, BC.

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Fuzzy Logic: A Basic Phenomena

Mir F. Ali, I.S.P.

In order to demonstrate intelligence in the computer programs, there are some fundamental issues needed to be addressed. These issues deal with the questions of how knowledge should be acquired, what should be the source, how should it be defined, what should be the structure for representing knowledge in these programs, what should be the ways or algorithms to retrieve knowledge efficiently once a knowledge base is built, how the user interface will be designed to establish a meaningful communication link between a computer (program) and human (user), and what will be the best strategies to ascertain answers to the questions posed by the user. The answers to these questions define the technique to build an expert system. Expert systems are a part of Artificial Intelligence discipline and a home for *Fuzzy Logic*.

An expert system, in a broad sense, is defined as a computer system used to distribute the expertise of a human or group of humans on useable form throughout a group of users to make the expertise conveniently available. There are three subsystems as a part of an expert system which includes: the *knowledge base*, the *inference engine*, and the *user interface*. An expert system will be capable of explaining its reasoning process, ask the questions that are most pertinent given the information received from the end user, and accept data through interactive sessions. Another desirable characteristic of an expert system is the capability to "learn" from its interactions or otherwise expand its knowledge base in a dynamic manner. James F. Brule defined expert systems as programs that mimic the advise-giving capabilities of human experts.

There are nine rules of inference in classic logic together with three "Laws of Thought" make up procedures which are included in some form or another, in every computer system. In view of these procedures, *propositions* could be either true or false and *propositions* can be grouped together to form an *argument*. Every *argument* has at least one *premise* and has exactly one *conclusion*. For example:

1. All babies have no teeth
2. Jacob is a baby

Therefore:

3. Jacob has no teeth

A combination ofthree *propositions* stated above makes an *argument*, the first two are *premise*, and the last of which is the *conclusion*. The process of determining true or false is called inferencing.

Designing strategies to compose accurate and intelligent answers based on classic logic or "Laws of Thought" is the most challenging part of the development of an expert system. Perhaps the best way to introduce the topic of Fuzzy Logic is to talk about the Laws of Thought. There are three specific laws involved in this dilemma which could be explained by demonstrating the following statements:

1. A cat is a cat (The Law of Identity):
2. A cat is not a cat or a full jar is not empty (The Law of Contradiction): and
3. It is either raining or it is not (The Law of the Excluded Middle).

The Law of the Excluded Middle states that everything either be true or false and there is no room for any values in between. This law was publicized for the first time in 999 B.C. by Heraclitus and since then it was criticized and challenged by numerous mathematicians and philosophers. It is the challenge to this law which gives rise to Fuzzy Logic.

In 1965 Lotfi A Zadeh, a Professor of engineering in the University of Southern California developed a new approach to represent intermediate values between true and false which is known as a Fuzzy Logic or Imprecise Reasoning. Fuzzy Logic is a generalization of the mathematical notion of set membership, in which an element may have partial membership in a set. For example, in classical set theory, if 40 degree celsius is defined as a HOT day, then any day with the temperature of 40 degree celsius or over is a HOT day, and consequently any day with 39 degree celsius is NOT HOT day. Fuzzy Logic presents an interesting perspective to look at the degree of "heat". For example, the day with a temperature of 30 degree celsius will indicate that it has some degree of "heat" whereas the day with a temperature of 70 degree celsius will give an impression that it has a much more greater degree of "heat". Similarly, if the age 65 is accepted as OLD, there will be some degree of "oldness" at the age of 50 and much more greater degree of "oldness" at 80. In other words, if it is concluded based on certain argument that it is not raining, it does not necessarily mean that it is not misting, sprinkling or drizzling.

Realizing the fact that logic is the foundation of mathematics, and any new logic that was proposed had to be able to

generate the same sort of mathematics that everyone was used to, Zadeh allowed for an infinite range of values between 0 and 1 whereas the classic logic allowed 0 for false and any value greater than 1 converted to 1 for true. He also suggested two sightly different operations to replace the addition and multiplication in the traditional sense. In place of addition (OR), he used the MAX function or maximum and instead of using multiplication (AND), he used MIN for minimum. For example, we assign the statement "Mathew is tall" to A, and "Mathew is smart" to B. Furthermore, let us assume that Mathew is very tall which will define A = 0.9, to reflect "very tall", and Mathew is very smart which will define B = 0.9, to reflect "very smart". The following statements demonstrate the difference between Classic Logic and Fuzzy Logic:

Statement: Mathew is very tall and Mathew is very smart.

Mathew is very tall = A = 0.9
Mathew is very smart = B = 0.9

1. Classic Logic: A AND B
Translation: 0.9 * 0.9 = 0.81
Fuzzy Logic: MIN [0.9,0.9] = 0.9

Statement: Mathew is very tall or Mathew is very smart.

2. Classic Logic: A OR B
Translation: 0.9 + 0.9 = 1.8 Converted to 1
Fuzzy Logic: MAX [0.9,0.9] = 0.9

The result produced in the first classic case is lower than the MIN function under Fuzzy Logic as 0.9 is greater than 0.81. If we assume that 0.81 only represents "Quite" tall whereas 0.9 represents "very" tall, then the classic result could be translated into:

If Mathew is very tall, and Mathew is very smart
Then he is a quite tall, smart person

Whereas Fuzzy Logic would determine:

If Mathew is very tall, and Mathew is very smart
Then he is a very tall, smart person

One of the attributes of Fuzzy Logic is that it leaves mathematics essentially intact. This also can be tested by *Bayesian inference*. Bayesian inference is a mathematical method for processing a probability factor that is consistent with reality. In probability theory there is no question as to being "somewhat" tall, "very" tall, or anything similar and we translate the result of the first classic logic case:

Probability: There is an 81 percent chance that Mathew is both smart and tall.

It is very important to realize that Fuzzy Logic is based on possibilities, not probabilities and this gives it the capability to "think" in terms that people can understand. Another attribute of Fuzzy Logic is to provide a capability of subjective measurement. It has personal semantics along with a way to map the intuitive measure of how we look at the different concepts.

There is no doubt that Fuzzy Logic will enhance and improve the scope of conventional expert systems by allowing them to emulate the way in which people actually make decisions. It helps evaluating the grey areas more accurately and reducing the size of the rule set. Fuzzy Logic will make it possible to build applications that can be matched with any level of expertise. Fuzzy reasoning dynamically adapts to what users know or don't know. However, it is critical to understand that Fuzzy Logic offers a unique capability for specific applications and the purpose of Fuzzy Logic was to improve the effectiveness of the laws (Law of Excluded Middle) but not to replace it. Therefore the selection of domain for Fuzzy Logic must be done carefully.

Fuzzy Logic has for years been well accepted in Europe and Japan but the United States just started to become acquainted with this technology. NASA has recognized the value of this technology and initiated projects to take advantage in the areas where higher degree of accuracy is desirable. Also this technology has been used commercially in a limited way to help design TV sets, air conditioners and automatic transmissions, however, the software developers at large have not recognized its potential for opening up entirely new approaches to application development for expert systems.

It is predicted that during this decade Fuzzy Logic will not only change the way in which we have approached existing expert systems, it will also allow for the automation of functions that have never before been addressed by experts.

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Evan W. Steeg

Report on the 4th UNB Artificial Intelligence Symposium

The 4th University of New Brunswick Artificial Intelligence Symposium (4th UNB AI Symposium) was held from Sept. 19 through Sept. 21, 1991 in Fredericton, N.B. Sponsorship for the Symposium was received from Bell-Northern Research, the Canadian Society for Computational Studies of Intelligence and the UNB Faculty of Computer Science. With 103 registered participants, this was the largest of the AI Symposia yet held at UNB. Registrants hailed from six different countries (Canada, U.S.A., India, Japan, Sweden and England), and were principally associated with universities. Affiliation statistics were 76 from university, 17 from industry and 10 from government organizations. A proceedings [Goldfarb and Nickerson, 1991] containing the 56 papers of the Symposium (including the three invited papers) was prepublished and available at the registration desk.

Two half-day tutorials entitled "Expert Systems" (instructor Brad Nickerson) and "Computer Vision" (instructors Bernd Kutz and Przemyslaw Pochec) were held in the afternoon of Sept. 19 before the "ice-breaker" reception held in the evening. Prepublished tutorial notes of the same title were available for the tutorial participants.

The International Association of Knowledge Engineers (IAKE) held their all-day Certified Knowledge Engineer (CKE™) examination on Sept. 19 also. This was the first time that the IAKE has held this exam outside the U.S.A. Based in Rockville, Maryland, U.S.A., IAKE is a non-profit organization which seeks to ensure professional standards for knowledge engineers. They also sponsored the publication of the 665 page Standards and Review Manual for Certification in Knowledge Engineering, which documents the knowledge engineering field.

The invited speakers gave very interesting and informative talks. A brief synopsis of each talk is given below in the order in which they were presented.

Dr. Reid Simmons of the Carnegie Mellon School of Computer Science gave a very interesting talk on the six-legged walking robot known as the Ambler Rover. Dr. Simmon's talk addressed the issue of building a highly reliable autonomous robot suitable for exploration of Mars. A video was also shown which clearly illustrated the walking motion of the unique circulating gait motion of the 12 foot high Ambler. Video Clips of less successful attempts at walking robots and R2D2 of Star Wars fame provided comic relief along with illustrating that robotics research has much room for improvement.

Dr. Linda Smith (Dept. of Psychology, Indiana University) gave an interesting talk on the dynamics of similarity during human development. Dr. Smith reported on studies comparing young children's perception of how objects are similar to those of older children and adults. Young children tend to identify two objects as similar which have roughly the same characteristics overall (e.g. a green square and a blue-green rectangle), whereas adults tend to choose those objects having exactly the same characteristic in one dimension (e.g. a green triangle is considered the same as a green circle).

Dr. Ranan Banerji of the Center for Machine Learning, Dept. of Mathematics and Computer Science, Saint Joseph's University, Philadelphia, reviewed some recent work in computational learning theory. The seminal paper of Valiant [1984] was used as a starting point. He then gave a very interesting overview of what makes certain set of classes learnable and others not. Algorithms for determining if certain sets are learnable or not were also discussed.

The last Symposium event was a panel discussion on "The role of machine learning in artificial intelligence". Panel members included the three invited speakers noted above, Dr. C.L. Giles of the NEC Research Institute in Princeton, NJ and the moderator, Dr. Lev Goldfarb, of UNB. The discussion was introduced by Dr. Goldfarb who suggested that the structure of an intelligent machine is the mathematical model representing how it learns. Dr. Giles said that learning was a mute point; computer programs which do work similar to that of intelligent humans are useful entities, and one should concentrate on how to make these programs more useful. Dr. Smith and Dr. Banerji were more strongly in agreement with Dr. Goldfarb that a machine must be able to learn or adapt to its surroundings before it could be considered to have intelligence. Dr. Simmons took the opposite view that no automated learning is required for machines to be considered to be intelligent. As an illustration, he compared the Brooks robot, which automatically "learns" how to walk, to the Ambler Rover. The Brooks robot would succeed in crossing a boulder field approximately 80% of the time, whereas the Ambler Rover, having no learning mode in the automated sense, would be able to cross the same field successfully approximately 99% of the time. Which robot is more intelligent?

As anyone who has organized a Symposium will know, this one would not have been possible without the concerted efforts of a large number of people. These include the many reviewers who read submitted papers (almost all papers were reviewed by three reviewers, many of them from the Canadian AI community), the staff of the UNB Faculty of Computer Science, members of the UNB AI Group, and the sponsors/co-sponsors of this event. Thanks are due to everyone who participated in making this a professional and enjoyable Symposium.

Submitted by
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Dual Purpose Learning Environments

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1. Introduction

Feurzeig (1987) described his view of "intelligent microworlds" as permitting the mode of interaction between the user and system to be switched (by the user) from exploratory to tutorial to evaluative. The view offered here derives from Feurzeig's suggestion but moves in a different direction, to focus more on the purposes of the parties involved — instructor and student — than on the performance mode of the system. Consider the following as an example of a system that will permit dual usage.

When engaging in explanation of grammar, a teacher wants to offer his students a lucid and well-articulated description of the principles which govern the forms of a language in use, along with succinct examples illustrating those principles. If an intelligent system supports such use, one can have instructional use of the system. Students often prefer a more exploratory approach to learning. One might say, for example, "Let me try to do something novel to find out what I can do with this language" or "Let me probe what the system can do, beyond requiring me to generate a sentence it will accept. Can I determine what the limitations of the system are ? Can I improve the system's grammar in such a way that it will be more nearly perfect ?" Pursuing such questions puts a student in a very active mode, one in which some students will learn much better than most other ways regardless of the domain or language focus.

A system with such flexibility in use would be a dual purpose learning environment, one in which the instructor can have his way, provide his best guidance, but hopefully one in which the student can also act in a powerful and positive way to correct and augment the system itself and through doing so develop his own knowledge as much as he cares to.

2. Project Objectives

Observing that people in Europe have been more sensitive than Americans to the need for learning multiple languages and to second language instruction, we tried to take advantage of their expertise. A primary objective of this project was to port a European PC - based instructional system, LINGER 1, for use on Macintosh computers in the USA. LINGER (Yazdani, 1990) is an application package directed to instruction in several foreign languages. It's a Prolog-based intelligent tutoring system. The original version of LINGER was a research vehicle. We tried to scale up that system for wider use. Adapting LINGER for the Macintosh had two dimensions. First was the issue of the Macintosh port. We chose LPA Prolog as the implementation language, expecting little trouble in converting the source code. So we found the case. Some low level routines, primarily based on I/O calls had to be re-written. Interface improvements, especially when set up to take advantage of Macintosh features, required additional coding.

The second dimension of the project revolved around scaling up the size of the dictionaries and grammars used with LINGER. Although this sort of activity is commonly undervalued, it often reveals problems not apparent with small-scale prototypes. LINGER has three main components: a dictionary representing the words of the language, a data base of rules which amount to the grammar specified for that language, and an inference engine which uses the dictionary and the rules to test the grammaticality of strings of words submitted to the program.

3. LINGER as an ITS

LINGER was initially designed as a grammar checker for novices at a second language. Artificial Intelligence (AI) techniques were needed in LINGER because novice text production typically deviates considevably from the standard of the target language. We use ITS (for "Intelligent Tutoring System") here in a loose sense to mean that LINGER uses AI programming technology for instructional purposes. In effect, LINGER was designed to guess the user's intended text from the input, then judge the closeness of fit of the entered text to a correct expression of the inferred intended text. LINGER is in character more analytic than didactic.

When LINGER receives a string of text, it returns to the user a parse of the string with comments and suggestions about the string's validity. It also attempts to compose its own version of what the string should have been had the user produced a grammatically correct version. This may seem an audacious goal — unless one considers the limitations of the original context of use. LINGER was created originally for a foreign language instructor who was tired of correcting novice-students' obvious errors. He hoped that his students could improve their assigned essays by typing sentences into LINGER and receiving grammar criticism at a fairly low level of sophistication. LINGER was intended to be used as a kind of "language calculator" to catch obvious errors. It was necessary for the system to deal with unrecognized words because one could not count on students typing correctly.

4. Grammar and LINGER's Architecture

The prototype grammar of LINGER is a set of Prolog rules. The prototype grammars of the three ported LINGER systems (Spanish, English, and French) are largely similar within the limited domain of the grammars' coverage of the languages. The prototype grammars were intended as examples to be changed and developed by the final user. Even given such an intention, one needs to describe the starting point to see what progress is possible. The character of the grammar can be judged from its depth, size, breadth, and modifiability. Consider the English grammar as typical of the other LINGER prototypes. It is five levels deep. The English grammar has four levels of structural rules (a fifth set, "checks", verify grammaticality after structure has been determined). There are sentence to clause rules (2 in number); clause to phrase rules (4); phrase to phrase rules (23); and word-lookup rules by part of speech (17). The number of checks is 28. The size of the grammar, in total number of rules then, is 74.

Simple dictionaries require complex processing rules, and vice versa. Decisions about grammar rules and their coding interact with the knowledge representation used in the dictionary. In LINGER, for example, non-standard plural inflections are coded directly into the dictionary. So also are bound comparative forms of adjectives. This representation decision has two primary consequences. First, multiple dictionary entries are needed for those words which can serve as different parts of speech. Second, one should expect a persistent trade-off in the implementation between extending the dictionary (and thus parsing time of entered strings) and extended parsing times through increased complexity of processing.

The issue of breadth is complex, since it measures the extent to which the rule set covers the grammar of the language. The LINGER grammar prototypes are narrow in some ways which can be easily modified and in other ways which require a major redesign of the system. Consider the easily modifiable cases first. In English, the passive is formed with a past participle and an auxiliary verb. LINGER's prototype dictionary recognized only forms of the verb "be" as a passive-forming auxiliary. English permits the use of two other auxiliaries, "get" and "become" to form either action-oriented or developmentally focussed passives; for example, "the thief got caught and in due time and with due process became imprisoned". Such

omissions can be simply corrected at need by adding definitions of the two auxiliaries to the dictionary. The more complex limitations of LINGER derive from interactions of the dictionary, grammar, and the inference engine.

5. Macintosh LINGER Dictionaries

At the conclusion of this project, dictionaries available for use with Macintosh LINGER in three languages have been scaled up by a factor of twenty. Original LINGER prototype dictionaries were a mix of parts of speech totaling between fifty and seventy words. The new LINGER English dictionary is approximately 1200 words and is implemented as three separately loadable Prolog files, of approximately 200, 500, and 500 words each. The new LINGER Spanish dictionary is 1300 words long. It is implemented as eight separately loadable files. The French dictionary, of approximately 1000 words, is implemented as a single large file. It is a word collection typical of those used for vocabulary review in US high school French courses. It is not partitioned because the source vocabulary did not include any principles justifying grouping of the words in a usage-based, meaningful way.

The Spanish dictionary is based on Heywood Keniston's (1920) collection of "Common Words in Spanish". The list derives from dialogue appearing within plays and novels. It was an early attempt at representing real conversational vocabulary and a reasonable one given the absence of recording equipment. The words are grouped in eight levels of use by frequency. The source frequency partition explains why one could break-up that list into groups which might be of a manageable size for study and/or instruction. One reason for choosing that list was that for more than fifty years the Keniston word list has been used by text book publishers of commercially available textbooks in Spanish; in this specific sense it is still "state of the art". Some more recent frequency counts have been based on interviewing people (this has a natural appeal as far as realism goes), but they are not vastly different from the Keniston list.

The English dictionary is derived from frequency counts of words appearing in a collection of stories told by children. It is based upon a study of childrens' story telling by Moe, Hopkins, and Rush (1982). They asked children to tell their favourite stories, then counted the frequency of occurrences of all the words. We took that study as a basic source, then deleted references to individuals (Spiderman, Superman, Goldilocks, etc.) to create our own list of 1200 frequently used words. Since the words were produced by young children, this list might be especially suitable as a list of very common words in English. The original collection of words has been somewhat compressed by removal of duplications based on inflections and contractions.

6. The Use of Polylingual ITS with other media

How should we think of a long-term sequence of language learning activities in which such interactive teaching systems and tools could play a productive role? We need a practical view with at least one component that takes full advantage of the technology and yet also respects the limitations of expense and cost that technology involves. How could future LINGER-like systems fit in with less expensive, more traditional educational technologies and practice?

Let's suppose a language training program involves an immersion experience at a hypermedia-capable language training center. Such could be a place for total immersion in the second language, where people would speak and listen to the second language as well as working with systems for second language instruction. Before people attend such a center, it would be important for them to be familiar with the kinds of systems they would work with, what such a systems could do and what such a systems' goals were. It would be efficient if future center students could be introduced to the training system through remote site viewing of videotapes about them. The optimal way to do so would be to strip from the interactive system introductory demonstrations made in the native language of the future student , so that when at the training center the student could concentrate on use of the system with the target language of instruction.

When people leave the training center and return to their normal positions, they might then find a LINGER-like facility useful primarily in the mode of a linguistic calculator. A LINGER-like system with a nearly complete grammar — designed for maximum processing efficiency and NOT using any hypermedia training materials — would be most cost effective. At this time, an interactive teaching system fits a niche within a larger language training and learning program.

7. LINGER Usability for Future Instruction

The LINGER system we have discussed is not usable in classrooms today, but it serves as an interesting and promising research tool. What sorts of utility might it have after a significant redesign and further development ? The target audience for LINGER is one of people who are learning a second language. One may think grammar is important as a crutch for learning second languages — not necessarily because of the good fit of grammatical rules to what is in the mind but primarily because such systems of rules have been of proven value to people in making judgments about how writing and talking should proceed. Grammar will continue to be a subject of instruction while second languages are taught.

One strength of LINGER is its ability to continue processing even when it encounters words not encoded in its dictionary, using the structural rules to guess at the type of unknown words. Such flexibility is essential for educational applications. A major new objective for future LINGER systems should be extension of this capability to permit the addition of user-defined rules to the grammar. Such a capability will not be easy, but it should be possible through fusion of techniques based on programming by example and through definition of erroneous variations of new structures as "near misses" at the time of grammar rule extension. There are three broad categories of application we can foresee now for such systems as LINGER or its descendants: - traditional instruction, - student guided discovery, - instructor experimentation,

7.a Traditional Instruction

One can imagine LINGER systems as linguistic calculators, with which a student might verify that his composed sentences are correct before commiting them to paper in an essay. Such could increase the feasibility of writing assignments in second languages (and thus enjoyability for both student and instructor). By itself, this would be a significant enhancement for many language instruction programs.

7.b Student Guided Discovery:

One of the key questions in education is the extent to which students are actually active in learning what they are studying. We believe this approach to the use of educational technology holds the most promise for individual students through engaging them actively in their studies, but making this approach effective will require redesign of LINGER systems. In self-guided discovery mode, the student would use a LINGER-like system as a modifiable grammar, one whose operations and performance he could explore and change.

7.c Instructor Experimentation:

Experienced instructors try to diagnose the errors their students make so that they may offer them effective advice on how to improve their grasp of the language. One approach in current use is to develop lists of common errors and offer them to students as warnings of what they should avoid. Lists such as that of Tables II and III might serve future

ITS as bug catalogues. LINGER could enhance an instructor's ability at diagnosis in a way that goes beyond lists of errors or bug catalogues by providing a developing language modelling capability. This could enhance the development of teachers' intuition and their explicit knowledge of the roots of errors manifest in speech production.

Even now, in LINGER's early state of development, one can load with the shell the grammar of one language with the dictionary of another, since the dictionaries and grammars are modules. One may ask then what sort of performance would come out a system with a "native" grammar of one language and the beginnings of a vocabulary in another language? What would be the results, in terms of the performance of the system, if one began to add to the native language a rule representing a specific grammatical construct of the grammar in the second language?

But how does that relate to what students and teachers actually do and learn ? "*Me llamo es," says one of the thousands of beginning Spanish students that pass through one's class — and it appears that there are two approaches to understanding this common pattern (with an eye towards its easy eradication). We can use a list of commonly found incorrect patterns, such as that of Table II, to locate an explanation of precisely what the error is then correct the student with a lecture on the need to use a reflexive verb construction to identify oneself in Spanish. Any experience as a language teacher will convince you that this is almost useless. Clearly, some other approach is needed and perhaps a better understanding of the nature of the error would help.

One road to that understanding is to be seen in the three kinds of analyses identified by James(1990) as "learner language." These are contrastive analyses (comparisons of native language to target language), error analyses, (comparisons of what Selinker, (1980) called interlanguage to a specific target language), and transfer analyses (comparisons of interlanguage to the learner's native language made in an effort to find evidence of inappropriate transfers from the native language to the interlanguage). Certain of these analyses have had important effects on language teaching practices. For example, contrastive analyses have, in the past thirty years, had their effects on the ways some language teachers generalize about such items as aspect of verb tense in Romance Languages; and error analyses have revolutionized the ways some language teachers respond to error. There may be the possibility for using LINGER-like systems to effect another analytical approach which may have a similarly beneficial effect. LINGER now accommodates more kinds of grammatical structures in more languages that it used to. Further development will lead to improvement and, perhaps, a new outlook on the analyses mentioned above.

The capabilities of LINGER-like systems include developing parallel implementations in different languages, even of mixing and intermingling different grammars and vocabularies, to create a kind of exploratory learning environment for foreign languages. The new outlook could be effected by these capabilities deriving from LINGER's language independence. Contrastive analysis emphasizes the ways language differ from one another. But LINGER-like systems can be developed multi-lingually and function in a language-independent manner within the context of the Romance Languages. Thus the architecture of LINGER-like systems might one day enable applied linguists to examine the similarities among languages and thus explore new ways of thinking about error. Given the flexibility and polylingual commitments of LINGER, future LINGER-like systems may be the first kind of ITS that are naturally congenial to such a view of language and language learning.

If the instructor has a facility with which he can model the language learning process, it should enhance his ability to diagnose student errors and to refine his suggestions of how the student could avoid them. LINGER-like systems could become an AI-based workbench for the diagnosis of error as a language independent phenomenon — or as a tool to help in accounting for the differences in particular errors made while learning a target language given a specific native language as the student's starting point. For the teachers, working with language-learning modelling systems would provide an experience which would improve their diagnostic capability. This specific area of application, teacher skill-enhancement through student cognitive modelling, could be a significant new research area for future language instruction.

In conclusion, three answers are available to the question of how one might use future LINGER-like systems: as a linguistic calculator; as an environment for student discovery of new grammatical knowledge; and as a kind of an experimental workbench for teachers to explore the nature of language and the nature of language learning.

Acknowledgments

The LINGER system was developed by Masoud Yazdani and others at Exeter University in England. We are grateful to these colleagues for making available their system, including prototype dictionaries and grammars, and for providing help and guidance throughout this project. Alan Garfinkel has made significant contributions to this paper and the LINGER project at Purdue. The project was supported through an SBIR grant from the US Army to the Learning Environments Inc.

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PRECARN UPDATE
NOUVELLES DE PRECARN

February 1992

Jean-Claude Gavrel

The Institute for Robotics and Intelligent Systems (IRIS)

First a test for all the loyal readers of *Canadian Artificial Intelligence*! In which issue did our first article of IRIS appear? Correct! — It was the November, 1990 issue. At that time the IRIS Network of Centres of Excellence was just over four months old; the "start-up" concerns of hiring, finding laboratory space and purchasing equipment were still the paramount concerns of the people involved although, as we later discovered, the research was also up and running with incredible speed as well. In our November 1990 column we provided the reader with a summary description of the Network, its primary objectives and the content of its research Program. For those of you who missed that issue or cannot find you copy, we will provide a brief recap.

IRIS - What is it?

The Institute for Robotics and Intelligent Systems (IRIS) is one of the fifteen Research Networks selected by the Federal Government under the Networks of Centres of Excellence Program. It brings together, in one nation-wide network, the best academic talent in this field. It is founded on the network of excellence established by the Canadian Institute for Advanced Research (CIAR) some six years ago and includes all of the Fellows of that network. IRIS is an essential element of a major nation-side effort to develop and harness these enabling technologies and to train Canada's future leaders in the field.

The research program of IRIS includes 22 projects at 18 Canadian universities. The work comprises three areas of enquiry: Computational Perception (Area A); Knowledge-Based Systems (Area B); and, Intelligent Robotic Devices (Area C) - three essential elements of a system's ability to perceive, to reason, to plan and to act. The Network will invest $23.8 million over a four-year period. PRECARN Associates Inc. manages the IRIS Network and, in doing so, harmonizes it with PRECARN's own national, industry-based research program. Most of the "artificial intelligence"work is carried out in the Area B sub-network. The main research topic are the following:

• Knowledge-Base Management: How to construct, access and maintain a large knowledge base, how to optimize queries, how to offer the knowledge base to concurrent users. (Project B3)

• Reasoning: Studies of different types of reasoning, such as nonmonotonic, probabilistic and abductive reasoning. Also, the development of efficient implementations of inference mechanisms for logic programming and constraint logic programming. (Projects B5 and B6)

• Human Interfaces: How to build various types of interfaces between a knowledge base and its human users, including natural language front ends, speech and text processing interfaces and graphical interfaces. (Projects B2 and B4)

• Applications of Knowledge Bases to the Design of Intelligent Information Systems: This project will explore how to facilitate the development of information systems and how to build more effective systems by using knowledge representation (new design languages), knowledge bases (expert systems for design), and also by viewing an information system as a knowledge-based system that reasons with respect to what it "knows" in accepting new information and in responding to questions. (Project B1)

An Update - Eighteen Months In

The first eighteen months of the research have been completed. Reports of the progress are positive. All significant start-up activity has been completed. These activities include the hiring of personnel, the acquisition of equipment and, in many cases, the transition into new or augmented laboratory space. The research program is now fully underway.

In summing up the progress of their Areas, the three Area Coordinators reported on progress at the twelve-month point. Dr. Denis Poussart, of Université Laval, reported for Area A: "All projects report that the work has essentially proceeded as scheduled and that, for the most, the Year 1 milestones have been achieved. In several instances, they have been somewhat exceeded..." Dr. Nick Cercone, Simon Fraser University, on Area B progress: "Initial plans and objectives have, at this point in time, been met, exceeded or, in some cases, revised to reflect directions which appear most promising to the principal investigators after initial research and analysis." And, Dr. Yury Stepanenko, University of Victoria, noted on behalf of Area C: "The first year performance of Area C projects can be evaluated as successful. The research has been conducted strictly in accordance with the plans and milestones. Moreover, after the first year, almost all projects have reported results which surpass expectations."

All Area Coordinators noted, in some form or other, that the influx of IRIS funds into the universities has acted as a catalyst for the application of other funding support to the research program. This leverage is most noteworthy in the personnel area, where the establishment of an IRIS project at a university has, in many cases, attracted other graduate students or post-doctoral fellows to interesting and productive work, while their funding may come, in whole or in part, from other sources. In addition, as with all of the Networks of Centres of Excellence, the federal fund have in some cases prompted provinces to provide further support for "infrastructure" costs.

One significant development occurred across the Network during the second half of the year. While the focus of this new development

was the first annual IRIS•PRECARN Conference, it is more broadly described as an increasing awareness of the importance of "networking" and, in fact, increased activity in this area. Networking is now recognized as an important and valuable component of the program, with the Conference contributing to this perception. All Areas are developing specific plans for improving their "networking" performance. Success in this area will be essential to the ultimate success of the Network.

The above article was prepared by Paul Johnston, a Senior Advisor from the Canadian Space Agency, currently on Executive Interchange at PRECARN where he is responsible for the smooth running of the administration of IRIS. Thank you Paul.

And now some PRECARN News:

The Board of Directors of PRECARN, at its meeting of September 19, has approved funding of two new feasibility studies.

The first, headed by Inco Limited, will explore the prospects of building on existing underground communications systems to develop fully autonomous equipment for underground mines using artificial intelligence and robotics technologies. Other participants in the Feasibility study include Falconbridge Limited, the Canadian Centre for Automation and Robotics in Mining (CCARM) and the McGill Research Centre for Intelligent Machines (McRCIM).

The second feasibility study, headed by Spar Aerospace, is for a proposed five-year research program to develop technologies to overcome the limitations of today's robots. Specifically, the research will seek to understand and solve some of the serious control problems that are foreseen in future applications of advanced robotics. New opportunities for robotic applications will be developed, not only in the space and nuclear sectors, but also in such important areas as manufacturing and environmental clean-up. Other participants in the feasibility study include the Canadian Fusion Fuels Technology Program and the universities of Toronto and McGill.

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BOOK REVIEWS
CRITIQUES DE LIVRES

Edited by Graeme Hirst

VISION AND PLANNING FOR MOBILE ROBOTS
Artificial vision for mobile robots: Stereo vision and multisensory perception Nicholas Ayache (INRIA) Cambridge, MA: The MIT Press (Artificial Intelligence series), 1991, xiii+342 pp, hardbound, ISBN 0-262-01124-7, US$45.00 (Originally published as *Vision stéréoscopique et perception multisensorielle*, InterEditions, Paris, 1989; translated by Peter T. Sander)

Reviewed by
Michael Jenkin
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Ayache's book describes recent research in visually guided mobile robotics carried out at INRIA with the Esprit Depth and Motion Analysis Project. The robot developed under this project uses trinocular stereo vision to guide a robot through its environment and to build up depth information concerning the environmental layout. The book is divided into two main sections: passive stereo vision and multisensory perception.

In the first section (chapters 3 to 9), Ayache introduces the classical problem of two camera binocular stereopsis. This section presents the development of an algorithm based on matching segments of edge contours extracted using a classical difference-of-Gaussian zero-crossing technique. The contour matching process is based on local constraints to disallow matches that are impossible given the geometry of the viewing parameters, and on global heuristic constraints of uniqueness and continuity.

Chapter 3 describes the geometry of binocular vision and how these constraints can be exploited when considering interocular matches. It also discusses the problems of calibration and how image rectification can be used to reduce the stereo matching problem to a one-dimensional search.

Chapter 4 argues for the use of a symbolic image representation based on contours of edges identified by a difference-of-Gaussians filtering operation. The resulting contours are approximated by chains of straight lines, which are then converted to a neighbourhood graph representation to explicitly represent adjacency information.

Chapters 5 and 6 describe the basic binocular correspondence algorithm. Chapter 5 deals with the problem of determining the correspondence between straight-line segments; how orientation, length, and intensity gradients can be used to reduce the possible number of matches. Global heuristics such as uniqueness, match ordering, and continuity are also identified. Chapter 6 describes how the binocular constraints discussed in Chapter 5 can be used, given the chosen representation of the monocular images to produce a final disparity image based on matching left and right image chains.

Chapter 7 presents some results obtained when the algorithm is applied to binocular images. Tests include both robotic indoor scenes as well as more-general stereo scenes.

Chapter 8 extends the algorithm from two to three cameras and presents some experimental results with three cameras. The resulting algorithm is much simpler, and the results appear more robust. A comparison of the stereopsis algorithm presented here with a number

of other stereopsis algorithms that have appeared in the literature is given in chapter 9.

The second section (chapters 10 to 17) deals with the task of recovering environmental layout from the output of successive depth measurements and from a knowledge of the relative motion between them. As both the depth measurements and the robot motions are noisy processes, this task is very complex. The author presents a solution based on optimal estimation (Kalman filtering) to combine the noisy measurements. The environment is modelled as a collection of geometric primitives and motion is encoded as geometric displacements.

Chapter 10 describes the basic problems involved in recovering environmental layout from successive sensor readings in a static environment from a noisy sensor; what primitives should be used to represent the environment, and how can the noisy data be integrated given the uncertainty in the measurement?

Chapter 11 introduces an extension of Kalman filtering to take noisy measurements and to refine these measurements in an optimal (least-squares) way.

Chapter 12 considers the problem of representing objects and motions of those objects. A representation based on the parameterization of points, lines, and planes is described, and the effects of rotations and translations on these representations.

Chapter 13 puts together a number of earlier results. It shows how different objects; monocular points, matched points, lines, etc, can be integrated to form more complex objects, and that the collection of these more complex objects can be used as a visual map of the environment.

Chapter 14 considers the problem of integrating visual maps from different positions. Some results are shown in chapters 15 and 16. Finally, chapter 17 relates the algorithms given in the second half of the book to other techniques. In addition, some of the limitations of the approach are discussed; such as the assumption of a globally static environment.

As a description of a particular research endeavour, the book is informative and concise. The algorithms are presented in enough detail to allow them to be implemented by other researchers. The book is not a general description of binocularly (or trinocularly) guided mobile robotics. It describes a single approach to the problem and does not present alternative approaches to the problems considered in any detail. This focus makes the book more suitable as research tool than as a text in a course in mobile robotics. The lack of a critical comparison with other approaches makes it difficult to determine how the approach presented here compares with other systems. It is, however, interesting to see the flavour and philosophy of a particular approach in this detail. Coincidentally, the book *3D model recognition from stereoscopic cues*, edited by Mayhew and Frisby, was also published by MIT Press in 1991. Together, these two books give an inside look into stereoptically guided robotics as seen by two different labs.

Michael Jenkin is an Assistant Professor of Computer Science at York University. He is a member of the Federal Networks of Centres of Excellence and of the Precarn Project in Autonomous Robotics. His main research interests are in the areas of stereo vision and visually guided mobile robotics.

Robot motion planning

Jean-Claude Latombe (Stanford University)
Boston: Kluwer Academic Publishers (The Kluwer international series in engineering and computer science; Robotics: Vision, manipulation and sensors), 1991, xviii+651 pp, hardbound, ISBN 0-7923-9129-2, US$95.00

Reviewed by
Evangelos E. Milios
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Latombe's book is a well-organized and timely survey of a substantial volume of current research results in robot motion planning, and definitely fills a vacuum in the literature. The main theme of the book is the problem of planning a collision-free path of a robot from a start to a goal configuration among known obstacles. The book reviews the considerable body of research that has accumulated in this area primarily over the last decade, and it does a very good job of providing a meaningful and coherent organization of this material, with emphasis on complexity results and sound mathematical definitions, rigour and generality. Difficult mathematics is explained with simple examples first, and with suitable figures. Four appendices provide a summary of the mathematical definitions used throughout the book, and make the study of the book considerably easier. Proper study of this book requires background not only in algorithms, but also in geometry, topology and algebra.

Chapter 1 is an overview of the motion planning problem, and of the contents of the rest of the book. The configuration space is defined, and a classification of motion planning approaches into roadmap, cell decomposition, potential field, and local versus global methods is presented. Extensions to the basic problem include moving obstacles, multiple robots, articulated robots, two different types of kinematic constraints, holonomic constraints (involving equality constraints on the configuration parameters), non-holonomic constraints (involving the configuration constraints and their derivatives), and movable obstacles. Different ways of reducing the complexity of the motion planning problem are projection in configuration space, slicing of configuration space, simplification of the shape of objects, and focusing attention on a subset of the workspace.

Chapter 2 deals with the configuration space of a rigid robot and its various parameterizations. Chapter 3 deals with the representation of various types of obstacles in configuration space and the associated computational geometric problems. The focus is on polyhedral objects, and the chapter concludes with a brief discussion of the more-general case of semi-algebraic workspaces (defined by polynomial inequality constraints on the configuration parameters).

Chapter 4 covers roadmap methods, namely methods that represent the connectivity of free space via a network of one-dimensional routes. Visibility graph, retraction, the heuristic freeway method of Brooks, and Canny's silhouette method applicable to a semi-algebraic workspace are presented. Chapter 5 covers exact cell decomposition methods of theoretical interest, and concludes with

a practical method in which both the robot and the obstacles are polygons in two dimensions and the robot can translate and rotate freely. Chapter 6 covers approximate cell decomposition methods, which require cells of a simple prespecified shape, and are typically incomplete, i.e., they may fail to find a path, even if one exists. However, their advantages are that they are simpler to implement and less sensitive to numerical errors than exact cell decomposition methods. Chapter 7 talks about potential field methods, typically defined as the superposition of an attractive potential, which pulls the robot toward the goal configuration, and a repulsive potential, which pushes the robot away from the obstacles. Different types of potential functions are presented and various ways of dealing with the local minima problem inherent in such methods.

Chapter 8 involves multiple moving obstacles, where the solution is not a geometric path, but rather the configuration of the robot as a continuous function of time. Several techniques for this class of problem are presented as extensions of the methods for solving the basic problem that were presented in the previous chapters. Chapter 9 deals with kinematic constraints, with primary emphasis on non-holonomic constraints, i.e., constraints on the robot motion that do not reduce the dimensionality of the configuration space but that of the robot's velocity space (one example of a non-holonomic device is the usual automobile). Chapter 10 is concerned with the presence of uncertainty in motion planning. The concept of preimage backchaining, assuming that the robot is equipped with position and force sensors, is defined, and various techniques based on it are reviewed. The preimage can be regarded as the weakest precondition whose satisfaction before executing an action guarantees that some postcondition will be satisfied after the action is executed. Chapter 11 deals with movable objects and reviews a variety of results. One of them involves the motion planning of a robot that can move objects, in which case the goal configuration specifies not only the configuration of the robot, but also the positions and orientations of the movable objects, which may be different from the initial configuration. Another problem dealt with in this chapter is grasp planning, whose goal is to ensure force closure (i.e., the grasping fingers can exert arbitrary force and torque on the grasped object) or stability in the presence of flexible fingers, or minimization of gripping forces. These studies have implications in the design of gripping devices with multiple fingers. The chapter concludes with a section on assembly planning, treated as a problem of constructing and searching an AND/OR graph.

The conclusion points out that future research directions are motion planning under uncertainty, under dynamic constraints, with flexible objects, and integration with perception. A transition is predicted from algebraic representations of geometry to distributed representations such as grids or bitmaps, and the need is pointed out for a comprehensive computational theory of spatial reasoning. The book is suitable as a reference for researchers in the field and as a textbook for advanced graduate courses in the field of robot motion planning. Exercises after each chapter are included to facilitate its use in course work.

Evangelos Milios is associate professor with the Department of Computer Science at York University. He is currently working on sensor-based mobile robot navigation and exploration.

COMPUTERS AND CHESS

Computers, chess, and cognition
T. Anthony Marsland and Jonathan Schaeffer (editors)
(University of Alberta)
NY: Springer-Verlag, 1990, xii+323 pp Hardbound,
ISBN 0-387-97415-6 and 3-540-97415-6, US $35.00

Reviewed by
David W. Erbach
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Imagine that the following dialogue occurs at t = 0 (years) between a Quite Skeptical Observer and an Optimistic Graduate Student of computer science.

QSO: I know computers can do a lot, but they'll never be able to do X. [The reader is invited to substitute any favorite unsolved problem in artificial intelligence for X.]

OGS: That problem will take five years, maybe ten. But someday we'll be able to do X with a computer, for sure.

QSO: I doubt it. Definitely not in ten years. Maybe never.

At t = 15 the dialogue is resumed, the OGS having since become a Professor of Computer Science, and the observer, a Professor of Philosophy:

PCS: See, we did it. I told you we could.

PP: Tell me exactly what you did here, please.

PCS: It works like this...

PP: Oh, is that all you did? If that's all it takes to do a task like X, then obviously intelligence isn't really involved. This kind of research shouldn't be counted as progress in artificial intelligence. What computers will really never be able to do is Y.

Computers, chess, and cognition collects the papers presented at the 1989 workshop on New Directions in Game-Tree Search. The workshop was held in conjunction with the 6th World Computer Chess Championship, at the University of Alberta.

As the whimsical dialogue above suggests, despite the extraordinary progress that computer science has made in both hardware and software over the last few decades, computer game research has never quite achieved intellectual respectability. It suffers endlessly from the "is-that-all-it-takes?" syndrome.

Computer chess is the principle archetype of this. In the early 1950s, Claude Shannon published his famous article in *Scientific American*. The article outlined strategies that a chess program might eventually employ to become the world's champion.

It took some 15 years for computers to make noticeable progress in any real games. Perhaps the first milestone was reached in the early 1960s, by Arthur Samuel, of IBM's T.J. Watson Research Center. He developed a checker program that eventually played a stronger game than its author, and was able to improve its play through practice.

But the QSO's weren't very convinced by progress in checkers. So in 1968, International Master David Levy made his famous bet that machines weren't going to beat him at chess, at least for some time. At that time, no one quibbled about the techniques which might eventually be employed. Chess was chess.

It took another dozen years before chess programs broke through to compete in open tournaments, and reach a strength where, if ratings were to be believed, Levy started to be in some danger.

Now, at a distance of 40 years, Shannon's predictions at last seem near to coming true. In 1988, Brent Larsen became the first grandmaster to fall under tournament conditions. A year later, David Levy finally lost a match, to Carnegie Mellon's Deep Thought program. Gary Kasparov, the current world chess champion, had little trouble dispatching Deep Thought in a recent two-game challenge. Yet, he seems to have taken the match seriously.

The papers presented at the workshop, then, form a composition in computer game research involving several themes. They begin with a description of the history of computer chess. The exposition takes up the state of the currently strongest programs. A speculative theme develops the question of whether, and how, a computer might eventually become the world chess champion. The coda takes two directions. One explores whether, in fact, computer chess research has really accomplished much, or whether it too will fall victim to the is-that-all-it-takes? syndrome. The other asks whether the oriental game of go is in fact a better locus than chess for game-oriented research in artificial intelligence.

To return to the beginning, Part I of *Computers, chess, and cognition* is titled "Man and machine". Chapters by Marsland and Kopec provide a general history of computer chess. Schaeffer brings the story up to date with a description of the 6th World Computer Chess Championship. Finally, David Levy speculates about how programs might make the last step, from beating the occasional grandmaster, to beating the world champion.

Part II provides an up-to-date summary devoted to each of the three currently strongest programs: Deep Thought, Hitech, and Cray Blitz. The direction is clear: there is overwhelming emphasis on getting as deeply into the move tree as possible. This is done partly by employing faster and more parallel hardware, partly by finding ways to exclude unimportant parts of the tree, and partly by doing any possible calculations in advance. It has turned out that there is little need, and consequently, little effort, to simulate a human's approach. Doubling the number of nodes searched pushes the USCF rating up by about 100 points. Another 300 or so points, and Kasparov has to watch out. Q.E.D.

Part III is devoted to techniques. Kaindl opens with a good general survey of tree-searching techniques, beginning at the beginning, with alpha-beta searching, and continuing through a variety of extensions and refinements. Geotsch and Campbell give a survey of the effect of the "null-move" heuristic added to the Hitech algorithms. Their best version seems to result in a reduction of the opening and middle game search of around 25%.

Two succeeding articles renew the theme of whether computer and human techniques have anything to offer each other. Jansen deals with the question of problematic positions and speculative play. If, in a given position, two moves are equally strong theoretically, but one involves more chances than the other for the opponent to blunder, it is natural, against a human, to play the latter. Their question is how a program might be made to behave similarly.

Herschberg, van den Herik, and Schoo's article "Verifying and codifying strategies in a chess endgame" describes their studies of a number of specialized endgame positions. They are interested in whether machine analysis might be reduced to heuristics that could improve upon such traditional ones as "in sparse positions, don't separate your king and other pieces". In particular, they are interested in the so-called Troitzky endgame KNNKP(h).

Part IV takes up the matter of computer chess and AI. The experts all seem to be agreed that chess can be played at grandmaster level as simply a tactical game. Make no errors out to a horizon of 15 half-moves, and you will beat almost everyone. But doing that is, in theory, not very complicated. You just need fast hardware. If it isn't quite fast enough for you yet, you can advance a few years by some judicious tree-pruning. The quibbling about technique has definitely begun.

For those who are not specialists in computer chess, Donskoy and Schaeffer's essay "Perspectives on falling from grace" is perhaps the most interesting of the book. They take up the question of why computer chess has not really succeeded in winning academic respectability, even as it approaches the possibility of winning the world championship. The essay is a thoughtful one, and many of the points made are palpable hits in more than just computer chess.

Part V turns to the problem of computer go. For many years, go has been considered the main challenger to chess's status as the premier intellectual game. As it's turning out, in terms of relevance to AI research, it may be game, set, and match to go.

Though they are both board games, in many respects, go is a quite different affair from chess. For starters, the search tree is much larger, and neither the opening nor the endgame is nearly as stereotyped as in chess. If you deprived chess programs of both their opening books and endgame tablebases they would be a lot weaker.

But the main difference is that go is a game of market share. In the end, all parts of the board will count equally. So at any time, it is natural that there will be a number of board locations all of approximately equal value. A program's attempt to judge among competing needs that are qualitatively different leads directly to questions of planning and consistency, two of the most notable areas of weakness in software theory.

Kiyoshi Shirayanagi is a researcher at NTT's software labs. His "Knowledge representation and its refinement in go programs" represents one of half a dozen approaches that go programmers have tried. The program he describes, YUGO, is not particularly strong, but it attempts to deal head-on with the fundamental problem of designing structures that correctly represent the underlying structure of go.

No one knows how far go programs would have progressed had work on them equalled the efforts devoted to chess. But we may have the chance to find out. At the end of the workshop, the audience was asked what chess researchers would be concentrating on in 10 or 15 years. The spontaneous answer from the floor was "go"!

David Erbach is a professor of mathematics and Director of the programmes in Business Computing and Administrative studies at the University of Winnipeg. He is editor of the international newsletter *Computer Go*.

NEURAL NETWORKS

Neurocomputing 2: Directions for research
James A. Anderson, Andras Pellionisz, and Edward Rosenfeld (editors) (Brown University, New York University, and *Intelligence*
Cambridge, MA: The MIT Press, 1990, xxviii+727 pp, hardbound, ISBN 0-262-01119-0, US $60.00

Reviewed by
Sue Becker
University of Toronto

Neurocomputing 2: Directions for research is a collection of 41 reprinted papers on computational models of neural networks, both biological and artificial. The first in this two volume series, *Neurocomputing: Foundations of research* (MIT Press, 1989), was a collection of classic papers in the field, covering fundamental topics such as McCulloch and Pitts's computational model of a neuron, Hebb's original learning rule, and the first model neural networks, Rosenblatt's perceptrons. *Neurocomputing 2* includes some more recent classics that have provided the impetus for several major "sub-movements" in the field, including Linsker's Infomax learning principle and Carpenter and Grossberg's ART2 cluster formation model. It also includes a sampling of papers on neurobiology, as well as some applications of connectionist models which show promise for future research. I would have liked to see a section on theoretical aspects of neural networks, such as learnability, generalization, complexity, and storage capacity, but apart from this, the collection provides a good survey of the field. Overall, it should be a useful collection to both newcomers to the field and established researchers.

Neurocomputing 2 has the same format as the first volume, each reprint being prefaced by a two-to-three page introduction by the editors. These introductions make the collection infinitely more valuable than a mere collection of photocopied papers to a neophyte in the field of neural networks. They give the reader insight into the significance of each paper in relation to the rest of the field, and in some cases provide additional background material explain some of the more difficult concepts in the papers.

The collection has four sections. The first, Network Architecture, is a rather eclectic mix of papers ranging from Aristotle to Kanerva (in chronological order of publication), and well illustrates the diversity in memory models proposed through the ages. The second, Computation and Neurobiology, is an excellent collection of some of the most interesting biological and biologically motivated network models in the literature, such as Edelman's model of neuronal group selection, and Suga's fascinating work on the auditory cortex of the bat. The third section, Statistics and Pattern Classification, is a mixture of some lesser-known work and some extremely influential work (such as that of Linkser and Kohonen); the papers on clustering models from section 1 might more appropriately have been placed in this section, and it's a shame there are no papers on neural networks for function approximation included here. Finally, section 4, Current Applications and Future Problems, is a very well-chosen collection of papers highlighting the successes and most promising directions of neural network research, including speech and handwritten digit recognition and prediction of stock markets and protein sequences. And so as not to leave the reader feeling too optimistic, the last section also includes the famous Fodor and Pylyshyn paper critiquing connectionism.

Sus Becker is a senior PhD student in the connectionist group at the University of Toronto. Her research deals with computational models of unsupervised learning in neural networks.

BRIEFLY NOTED

A practical guide to knowledge acquisition
A. Carlisle Scott, Jan E. Clayton, and Elizabeth L. Gibson
Reading, MA: Addison-Wesley, 1991, xv+509 pp,
hardbound, ISBN 0-201-14597-9

Knowledge acquisition is well-known as a major bottleneck impeding the development of expert systems in new domains. This new book presents a detailed account of interviewing techniques and the organization of the resultant knowledge into a form suitable for input to an expert system shell. It does not deal with automatic techniques, or any computer-based tools whatsoever. The book is divided into two main sections: Knowledge-Engineering Activities and Interviewing Activities; the two parts present parallel views of the knowledge acquisition process. No other part of the development of an expert system is covered, but there is a short, annotated list of additional readings at the back of the book. Except for this section, there are no references to other work.

A case study is used throughout of the diagnosis and repair of a toaster. This is enhanced with over 50 sections of dialog concerning details of the problem. The book also has a large number of tables and figures, and a summary at the end of each chapter.

This is not a book of great interest to academics, researchers or people in AI, but is an excellent and readable introduction to knowledge acquisition for beginning expert-systems builders in industry.

Mildred Shaw, University of Calgary

The artificial intelligence dictionary
Ellen Thro San Marcos, CA: Microtrend Books (The Lance A. Leventhal Microtrend Series, edited by Lance A. Leventhal), 1991, xiii+407 pp; paperbound, ISBN 0-915391-36-8, cdn $32.95

Yet another dictionary of AI, but not a bad one. Useful extra features include a list of "landmark expert systems" and of prominent AI institutions and researchers. (Interestingly, some prominent institutions have no prominent researchers, and some institutions are not prominent despite the presence of two prominent researchers.) The definitions themselves are a mixed bunch, and are broad enough to include concepts on the fringe of AI, such as Montague grammar. *Naive physics* is nicely described, but the definition of *functional language* is a "programming language that describes functional relationships". *G.H.*

Research directions in computer science:
An MIT perspective *Albert R. Meyer, John V. Guttag, Roland L. Rivest, and Peter Szolovits* (editors) (MIT)
Cambridge, MA: The MIT Press, 1991, xxiv+490 pp,
hardbound, ISBN 0-262-13257-5, US $40.00

MIT's Project MAC, which began in 1963, produced some of the most important research in computer science, such as time sharing. Its two descendents, the MIT AI Laboratory and the Laboratory for Computer Science, still dominate their fields. This book is based on a 1988 symposium to celebrate the 25th anniversary of the founding of Project MAC, but it mostly covers present-day projects, not history. The AI section contains the following papers:

"Intelligence without representation" by Rodney Brooks;
"Parallel networks for machine vision" by Berthold K.P. Horn;
"Knowledge-based systems" by Peter Szolovits;
"Legged robots" by Marc H. Raibert;
"Intelligence in scientific computing" by Harold Abelson and others.

The cybernetics group
Steve J. Heims Cambridge, MA:
The MIT Press, 1991, xii+334 pp, hardbound, ISBN 0-262-08200-4, US $25.00

Before there was AI there was cybernetics. From 1946 to 1953, the Macy Conference on Cybernetics met to discuss interdisciplinary ties between information theory, computer theory, and cybernetics, laying many of the foundations for the subsequent development of AI. Norbert Wiener, John Von Neumann, and Margaret Mead were among the many participants. Heims's book chronicles this group and its effect on science and society.

BOOKS RECEIVED

Books listed below that are marked with a + will be reviewed in a future issue. Reviewers are still sought for those marked with a *. Authors and publishers who wish their books to be considered for review in *Canadian Artificial Intelligence* should send a copy to the book review editor at the address below. All books received will be listed, but not all can be reviewed.

Readers who wish to review books for *Canadian Artificial Intelligence* should write, outlining their qualifications, to the book review editor, Graeme Hirst, Department of Computer Science, University of Toronto, Toronto, Canada M5S 1A4, or send electronic mail to gh@cs.toronto.edu. Obviously, we cannot promise the availability of books in anyone's exact area of interest.

Proceedings, Ninth National Conference on Artificial Intelligence
(AAAI-91) (Anaheim, CA, July 1991)Menlo Park, CA: AAAI Press and Cambridge, MA: The MIT Press, 1991, xviii+937 pp, paperbound, ISBN 0-262-51059-6, US $75.00

A theory of computer semiotics: Semiotic approaches to construction and assessment of computer systems
P.B. Andersen (University of Aarhus) Cambridge, England: Cambridge University Press (Cambridge series on human—computer interaction 3), 1990, vii+416 pp, hardbound, ISBN 0-521-39366-1, US $59.50

Technobabble
John A. Barry Cambridge, MA: The MIT Press, 1991, xv+268; hardbound, ISBN 0-262-02333-4, US $22.50

Principle-based parsing: Computation and psycholinguistics *Robert C. Berwick, Steven P. Abney, and Carol Tenny* (editors) (MIT, Bell Communications Research, and University of Pittsburgh)Dordrecht: Kluwer Academic Publishers, 1991, vii + 408 pp (Studies in linguistics and philosophy 44) Hardbound, ISBN 0-7923-1173-6, US $89.00

***Automated reasoning: Essays in honor of Woody Bledsoe** *Robert S. Boyer* (editor)(University of Texas at Austin) Dordrecht: Kluwer Academic Publishers (Automated reasoning series 1, edited by William Pase), 1991, xi+365 pp, hardbound, ISBN 0-7923-1409-3, US $89.00

Grammaire de Montague: Langage, traduction, interpretation *Michel Chambreuil* (Université Blaise-Pascal, Clermont-Ferrand) Clermont-Ferrand, France: Éditions Adosa (Langues naturel et traitement de l'information 1), 1989, 248 pp, livre broché,
ISBN 2-86639-008-3, FF 360

Vision, instruction, and action
David Chapman (Teleos Research)
Cambridge, MA: The MIT Press (Artificial intelligence series), 1991, xiii+295 pp, hardbound, ISBN 0-262-03181-7, US $35.00

+Computers and musical style
David Cope (University of California, Santa Cruz) Madison, Wisconsin: A-R Editions Inc (The computer music and digital audio series, edited by John Strawn, volume 6), 1991, xvii+246 pp; hardbound, ISBN 0-89579-256-7, no price listed

+Philosophy and AI: Essays at the interface
Robert Cummins and John Pollock (editors) (University of Arizona) Cambridge, MA: The MIT Press, 1991, xi+304 pp, hardbound, ISBN 0-262-03180-9, US $29.95

Origins of the modern mind: Three stages in the evolution of culture and cognition
Merlin Donald (Queen's University) Cambridge, MA: Harvard University Press, 1991, viii+413 pp, hardbound, ISBN 0-674-64483-2, US $27.95

The transparent Prolog machine: Visualizing logic programs
Marc Eisenstadt, Mike Brayshaw, and Jocelyn Paine (Open University and University of Oxford) Oxford: Intellect and Dordrecht: Kluwer Academic Publishers, 1991, vii+176~pp, hardbound, ISBN 0-7923-1447-6, US $59.00

Principles and parameters in comparative grammar
Robert Freidin (editor) (Princeton University) Cambridge, MA: The MIT Press (Current studies in linguistics 20), 1991, xii+464 pp, hardbound, ISBN 0-262-06140-6, US $50.00

Prolog for natural language processing
Annie Gal, Guy Lapalme, Patrick Saint-Dizier, and Harold Somers (SYSECA S.A., Université de Montréal, Université Paul Sabatier, and UMIST) Chichester, England: John Wiley (Wiley professional computing series), 1991, xiii+306 pp; paperbound, ISBN 0-471-93012-1, US $47.95. Program diskette, 5.25-inch IBM compatible, ISBN 0-471-93089-X, US $26.60,

The KBMT Project: A case study in knowledge-based machine translation *Kenneth Goodman and Sergei Nirenburg* (editors) (Carnegie Mellon University) San Mateo, CA: Morgan Kaufmann, 1991, xvi+331 pp, paperbound, ISBN 1-55860-129-5, US $34.95

Connectionist symbol processing
Geoffrey Hinton (editor) (University of Toronto)
First published as a special issue of *Artificial Intelligence*, 46, (1-2), 1990. Cambridge, MA: The MIT Press, 1991, 262 pp; paperbound, ISBN 0-262-58106-X, US $22.50

Foundations of artificial intelligence
David Kirsh (editor) (University of California, San Diego)
First published as a special issue of *Artificial Intelligence*, 47, (1-3), 1991. Cambridge, MA: The MIT Press, 1992, 358 pp;

paperbound, ISBN 0-262-61075-2, U $25.00

Prolog from the beginning
Henry K. Konigsberger and Frank W.G.M. de Bruyn London: McGraw-Hill, 1990, viii + 363 pp. Paperbound,
ISBN 0-07-707216-2 Kasusrelationen und semantische Emphase [Case relations and semantic emphasis] Jürgen Kunze (Zentralinstitut für Sprachwissenschaft, Berlin) Berlin: Akademie Verlag (Studia grammatica 32), 1991, 225 pp, paperbound, ISBN 3-05-001771-6

The humanities computing yearbook 1989—90
Ian Lancashire (editor) (University of Toronto) Oxford: Clarendon Press, 1991, xviii+701 pp, hardbound, ISBN 0-19-824253, cdn $141.00

Understanding CLOS, the Common Lisp Object System
Jo A. Lawless and Molly M. Miller (Lucid, Inc. and Ascend Communications, Inc.) Bedford, MA: Digital Press, 1991, ix+192 pp Paperbound, ISBN 1-55558-064-5, US $26.95

Conceptual information retrieval: A case study in adaptive partial parsing
Michael L. Mauldin (Carnegie Mellon University) Boston: Kluwer Academic Publishers (The Kluwer international series in engineering and computer science: Natural language processing and machine translation, edited by Jaime Carbonell), 1991, xx+215 pp, hardbound, ISBN 0-7923-9214-0, US $62.50

The perception of multiple objects: A connectionist approach
Michael C. Mozer (University of Colorado, Boulder) Cambridge, MA: The MIT Press (Neural network modeling and connectionism series), 1991, xi+217 pp, hardbound, ISBN 0-262-13270-2, US $27.50

Logic programming and non-monotonic reasoning: Proceedings of the first international workshop (Washington, DC, June 1991) *Anil Nerode, Wiktor Marek, and V.S. Subrahmanian* (editors) (Cornell University, University of Kentucky, and University of Maryland) Cambridge, MA: The MIT Press, 1991, xi+289 pp, paperbound, ISBN 0-262-64027-9, US $32.50

Machine translation:A knowledge-based approach
Sergei Nirenburg, Jaime Carbonell, Masaru Tomita, and Kenneth Goodman (Carnegie Mellon University) San Mateo, CA: Morgan Kaufmann Publishers, 1992, xiv+258 pp; hardbound, ISBN 1-55860-128-7, US $39.95

Sémantique et recherches cognitives
Francois Rastier (Centre National de la Recherche Scientifique) Paris: Presses Universitaires de France, 1991, 262 pages (Formes sémiotiques) Livre broché, ISBN 2-13-043825

The new hacker's dictionary *Eric Raymond* (editor) Cambridge, MA: The MIT Press, 1991, xx+433 pp; paperbound, ISBN 0-262-68069-6, US $10.95

Artificial intelligence (second edition) *Elaine Rich and Kevin Knight* (MCC and Carnegie Mellon University) New York: McGraw-Hill, 1991, xvii+621 pp. Hardbound, ISBN 0-07-052263-4

Computational morphology: Practical mechanisms for the English lexicon *Graeme D. Ritchie, Graham J. Russell, Alan W. Black, and Stephen G. Pulman* (University of Edinburgh, University of Geneva, University of Edinburgh, and University of Cambridge and SRI International, Cambridge) Cambridge, MA: The MIT Press (ACL—MIT Press series in natural language processing, edited by Aravind K. Joshi, Karen Sparck Jones, and Mark Y. Liberman), 1992, x+291 pp, hardbound, ISBN 0-262-18146-0, US $32.50

+Do the right thing:Studies in limited rationality *Stuart Russell and Eric Wefald* (University of California, Berkeley) Cambridge, MA: The MIT Press (Artificial intelligence series), 1991, xx+200 pp, hardbound, ISBN 0-262-18144-4, US $27.50

Programming paradigms in Lisp
Rajeev Sangal (Indian Institute of Technology, Kanpur)
New York: McGraw-Hill, 1991, xv+292 pp (McGraw-Hill series in artificial intelligence) Paperbound, ISBN 0-07-054666-5

Foundational issues in natural language processing
Peter Sells, Stuart M. Shieber, and Thomas Wasow (editors) (Stanford University, Harvard University, and Stanford University) Cambridge, MA: The MIT Press (System Development Foundation benchmark series), 1991, vii+232 pp; hardbound, ISBN 0-262-19303-5, US$32.50

The bounds of logic: A generalized viewpoint *Gila Sher* (University of California, San Diego) Cambridge, MA: The MIT Press, 1991, xv+178 pp; hardbound, ISBN 0-262-19311-6, US $27.50

Principles of semantic networks: Explorations in the representation of knowledge
John F. Sowa (editor) (IBM Systems Research) San Mateo, CA: Morgan Kaufmann (The Morgan Kaufmann series in representation and reasoning, edited by Ronald J. Brachman), 1991, xi+582 pp; hardbound, ISBN 1-55860-088-4

Intelligent user interfaces
Joseph W. Sullivan and Sherman W. Tyler (editors) (Lockheed Artificial Intelligence Center) New York: ACM Press and Reading, MA: Addison-Wesley (ACM Press frontier series), 1991, xv+472 pp, hardbound, ISBN 0-201-50305-0

Generalized LR parsing
Masaru Tomita (editor) (Carnegie Mellon University) Boston: Kluwer Academic Publishers, 1991, xii+166~pp, hardbound, ISBN 0-7923-9201-9, US $59.95

Connectionist approaches to language learning *David Touretzky* (editor) (Carnegie Mellon University) First published as a special issue of *Machine Learning*, (2—3), September 1991. Boston: Kluwer Academic Publishers (The Kluwer series in engineering and computer science: Knowledge representation, learning and expert systems), 1991, 149 pp; hardbound, ISBN 0-7923-9216-7, US $65.00

Meaning and speech acts.
Volume I: Principles of language use. Volume II: Formal semantics of success and satisfaction *Daniel Vanderveken* (Université du Québec á Trois-Riviéres) Cambridge, England: Cambridge University Press. Volume I: 1990, x+244 pp; hardbound, ISBN 0-521-37415-4, Volume II: 1991, x+196 pp; hardbound, ISBN 0-521-38216-5

Knowledge representation and metaphor
Eileen Cornell Way (State University of New York, Binghamton) Dordrecht: Kluwer Academic Publishers, 1991, xx + 271 pp (Studies in cognitive systems 7) Hardbound, ISBN 0-7923-1005-5, US$98.00

Computer supported cooperative work: An introduction
Paul Wilson (CSC Europe) Oxford: Intellect and Dordrecht: Kluwer Academic Publishers, 1991, iv+124~pp, hardbound, ISBN 0-7923-1446-2, US $57.00

CONFERENCE ANNOUNCEMENT

Artificial Intelligence '92 • Graphics Interface '92 • Vision Interface '92

May 11-15, 1992 - Vancouver, British Columbia, Canada

AI/GI/VI '92 is a unique event combining three Canadian research conferences that present the latest results in artificial intelligence, computer graphics, and computer vision. Each conference offers a three-day track of invited and submitted papers. Conference participants can attend presentations in all three tracks for a single registration fee, promoting the exchange of knowledge among these three important disciplines. A salmon barbecue and an electronic theatre provide additional opportunities to meet speakers and other attendees for informal discussions in a social setting. The conference is preceded by two days of tutorials and workshops, on selected topics of particular interest to researchers and practitioners in all three disciplines.
Sponsored by the Canadian Information Processing Society, through its three special interest groups: the Canadian Society for the Computational Studies of Intelligence, the Canadian Human-Computer Communications Society, and the Canadian Image Processing and Pattern Recognition Society in cooperation with ACM SIGGRAPH and the Vancouver Local ACM SIGGRAPH.
AI/GI/VI '92 will be held at the University of British Columbia, located on Point Grey, at the west end of Vancouver, Canada's third largest city. Vancouver is easy to reach by major airlines, with the University about twenty minutes from the airport. In addition to the scenic campus, the city is noted for the beauty of its setting on the Pacific Ocean, surrounded by mountains and parks. Renowned for its casual lifestyles, cosmopolitan atmosphere and spectacular scenevy, Vancouver offers entertainment, dining and shopping experiences for every budget.

Tutorials
Attendees can register for one or more tutorials that will be presented on Monday and Tuesday, May 11-12. The tutorials are presented by experts in the field and are designed for attendees wishing to gain deeper knowledge of the specialized topics being offered. Most of the material is at the introductory or intermediate level.

Workshops
Also offered on Monday and Tuesday, May 11-12, are four workshops. Each workshop has limited attendance by invitation only. Attendees wishing to register for one or more workshops are invited to contact the organizer for each workshop directly for additional information about the workshop and invitations.

Technical Program
Wednesday through Friday, May 13-15, will be devoted to over one hundved technical papers, covering current research and applications in the fields of artificial intelligence, computer vision, and computer graphics. All sessions will be held on campus at UBC.

Electronic Theatre
On the evening of Wednesday, May 13, an electronic theatre will feature recent videos of computer-generated animation and scientific visualization. A retrospective of Canadian computer animation will highlight the show.

Banquet
On the evening of Thursday, May 14, a salmon barbecue will be held at the Faculty Club of the University of British Columbia. All attendees receive one complimentary invitation to this event as part of the conference registration fee. Guests and others may attend the banquet by buying tickets in advance or on-site.

TECHNICAL PROGRAM

Monday, May 11, 1992
Full Day Invited Workshop
09-00-16:30. Workshop on the Commercialization of AI Technology in Canada
The objective of this workshop is to provide a forum for those who are developing AI related applications, including applications in engineering, science and business. Presentations will be on successfully completed systems as well as general issues that relate to system development. The workshop will also consist of an open discussion on the current state of applied AI in Canada.

Monday, May 11, 1992
Full Day Invited Workshop
09:00 - 16:30. Problems and Solutions for Local Illumination
As the problems of global illumination jumped to the forefront of research in rendering in Computer Graphics, the problems of local illumination and light source modelling have been somewhat left behind. The goal of this workshop is to bring together researchers who think differently, and are involved in active investigation of the problems of local illumination and light source modelling. Some of the issues discussed will be better illuminations models, measurements of surface reflectance, efficient implementation of models, hardware assist and dynamic models.

Monday, May 11, 1992
Full Day Tutorial
09:00 - 16:30. Interactive Three Dimensional Graphics and Virtual Reality, Mark Green and Chris Shaw (U. Alberta)
Over the past several years the cost of high performance three dimensional graphics workstations has dropped tremendously, and many new three dimensional input and output devices are now widely available. These events have resulted in considerable interest in three dimensional interaction and a new style of user interface called Virtual Reality. In a virtual reality user interface, the user is placed in the same three dimensional environment that the data occupies. This allows the user to interact directly, in 3D, with the data. In this course we present the basic ideas behind interactive three dimensional computer graphics, survey the existing hardware (such as head-mounted displays and DataGloves), and discuss software structures and architectures. Examples drawn from the work done at the University of Alberta and other well known research groups will augment the concepts in this course. A case study based on the system we have constructed at the University of Alberta will also be presented.
A basic understanding of three dimensional graphics and user interfaces is required for this course. This course is aimed at programmers and researchers in computer graphics, but most of the material will be accessible to managers and others with a good technical background.

Monday, May 11, 1992
Full Day Tutorial 09:00 - 16:30. Input and Interaction: Theories, Techniques and Technologies, Bill Buxton (U. Toronto/Xerox PARC)
Interactive systems are typically weighted on the display side, when compared to input. Nevertheless, input is central to achieving fluid and effective interaction. Therefore, the objective of this tutorial is to provide the basis for balancing the scales.
We look at input from three perspectives: technologies, techniques and theories. Technologies are discussed in the context of new taxonomies that are more meaningful than the mouse, joystick, trackball categories that are all too typical. The techniques discussed include stylus-based pencentric interaction, character and gesture recognition, two-handed input, and interacting with 3D objects. Throughout, the approach to design is founded on a theory of the phrasing of human-computer dialogues with pressure and motion. The tutorial is highly illustrated, with video examples and live demonstrations. The materials provided are intended to support practitioners and teachers.

Monday, May 11, 1992
Full Day Tutorial
09:00 - 16:30. Neuronal Morphology of Biological Vision and Machine Vision (Neuro-Vision) Systems, Madan M. Gupta (U. of Saskatchewan)
This is a short course introducing the basis of biological vision and the foundation for machine vision (neuro-vision) systems. In this course, we will introduce the morphology of biological vision and characteristics of biological neurons. Neuronal morphology and receptive fields of the biological channels (retinal, LGN, and visual cortex) will be examined in detail.
We will examine, in detail, the mathematical morphology of visual receptive fields, its generalizations, Gabor functions, and discriminant operators. We will describe the architecture of the dynamic positive-negative neural processor for the extraction of information from visual images, and for creating some visual functions like visual memory, spatio-temporal filtering and coding of visual information. We will give some examples of the use of these dynamic neural layers for the detection of motion. We will also present the basic concepts of fuzzy neural networks and its applications in visual perception and control. This description will help to design a generalized form of a neuro-vision system.
This course is directed toward engineers working in the area of vision systems, and to others interested in machine vision, as well as mathematicians interested in the new mathematics of biological vision. A basic degree in engineering or mathematics with some familiarity of transform theory and signal analysis would be helpful.

Tuesday, May 12, 1992
Full Day Invited Workshop
09:00 - 16:30. Uncertainty Management: Theory and Practise
This workshop will explore issues involving the management of uncertainty in knowledge-based systems. Almost every aspect of human behavior involves uncertainty in some way and this impacts on the practical development of expert systems and the formal modeling of human reasoning and cognition. Many methodologies exist for handling these problems. However, much work remains to be done to successfully solve the complicated issues involved. Presentations relating theoretical ideas to practical applications are particularly welcome.

Tuesday, May 12, 1992
Full Day Invited Workshop 09:00 - 16:30. Machine Learning
The purpose of this workshop is to bring together people who are active in the applications or (theoretical or experimental) studies of machine learning. Participants in related fields such as genetic algorithms and neural nets are also welcome. The emphasis of the workshop will be on informal communication and exchange of ideas.

Tuesday, May 12, 1992

TECHNICAL PROGRAM cont...

Full Day Tutorial

09:00 - 16:30. CAVECAT and Telepresence: A Case Study In Video Enhanced CSCW, Bill Buxton (U. Toronto/Xerox PARC), Marilyn Mantei (U. Toronto), and Ron Baecker (U. Toronto)

CAVECAT is a project at the University of Toronto that has been investigating the use of audio, video, LAN, computer and telecommunications technologies to support collaborative work. The focus is very much on integrating the technology into the workplace, such that it supports the day-to-day activities of its user community. The point of departure for the work was the Mediaspace project at Xerox PARC, and the RAVE system at Rank Xerox EuroPARC (which one of the instructors was instrumental in designing). From this, CAVECAT has evolved to the point where it is now the springboard for a larger initiative, The Ontario Telepresence Project.

This tutorial is intended to serve two main purposes. First, it is intended to use the case study of CAVECAT and Telepresence as the basis for an introduction to what might be called computer enhanced video conferencing, or video enhanced CSCW. In this capacity, it is hoped that the course will be of interest both to those interested in learning about the field and those active in it. We address questions such as what we did right, what failed, what we would do differently, and what would we do now if we were just starting out?

The second objective is to use the tutorial as an opportunity to provide a detailed status report on the project. Our hope is that through this our results in this fast-moving area will be disseminated in a timely and effective manner.

Tuesday, May 12, 1992

Full Day Tutorial

09:00 - 16:30. Volume Visualization, Arie E. Kaufman (SUNY), William E. Lovensen (General Electric), and Roni Yagel (Ohio State U.)

Volume visualization is emerging in the nineties as a key field of visualization, computer graphics, and computer imaging. It encompasses an array of techniques, a technology, and a nomenclature, and it holds substantial challenges. The techniques provide the mechanisms that make it possible to reveal and explore the inner or unseen structures of volumetric data and allow visual insight into opaque or complex datasets. Volume visualization, as a technology, brings a revolution to computer graphics and promises important breakthroughs in numerous applications.

Volume visualization is concerned with the tasks of representing, manipulating, and rendering volumetric data. This course provides an overview of the technology, the nomenclature, and the techniques for these tasks, emphasizing algorithms,architectures and applications. The course covers and compares different approaches in volume representation, volume synthesis, volume and surface viewing, volume shading, special-purpose architectures, and applications of volume visualization.

The tutorial is designed for scientists, engineers, computer graphics specialists, and medical researchers, who are new to the field of volume visualization or interested in expanding their knowledge in that field. This tutorial is based upon a recently published IEEE Tutorial on Volume Visualization by A. Kaufman.

Tuesday, May 12, 1992

Full Day Tutorial

09:00 - 16:30. Computer Architecture for Computational Vision, James J. Little (U. of British Columbia)

Recent developments, new architectures for vision machines, respond to the increasing demands that vision systems make on machines. New machines enlarge the range of vision tasks, and change the role of vision systems. Fast vision means that complex visual tasks can be performed by active robotic systems. Machine vision has been a forcing function for new development of technology, primarily because it is computationally intensive. Like most scientific computing, machine vision requires an enormous amount of computational resources unlike most scientific computing, it also requires high bandwidth input and output. To face the challenge of interpreting and utilizing images rapidly, machine vision turns to novel machine architectures to provide the necessary computation and communication.

The workshop will include the following topics:

1) structure of vision computational processes
2) structure of machines that implement vision processes.
3) new architectures (distributed, concurrent, parallel)
4) specialized architectures

Wednesday, May 13, 1992

Artificial Intelligence '92 Technical Papers

08:30-09:30. SESSION: Planning.

Chair: David Poole (UBC)

Generating Object Descriptions: Integrating Examples with Text, Vibhu O. Mittal and Cecile L. Paris (USC)

Formalizing Plan Justifications, Eugene Fink and Qiang Yang (U. Waterloo)

Building Macros in Deterministic and Non-deterministic Domains, Bertrand Pelletier and Stan Matwin (U. Ottawa)

09:30-10:30. SESSION: Invited Speaker.

Using Constraints, Alan Mackworth (UBC)

10:50-11:50. SESSION: Philosophical Issues/Data Classification.

Chair: Russell Greiner (Siemens Corporate Research)

Artificial Intelligence in the Real World: A Critical Perspective, Richard S. Rosenberg (UBC)

Visual Thinking in the Development of Daltons Atomic Theory, Paul Thagard and Susan Hardy (Princeton U.)

Efficient Algorithms for Identifying Relevant Features, Hussein Almuallim and Thomas G. Dietterich (Oregon State U.)

13:30-14:30. SESSION: Search.

Chair: Richard S. Rosenberg (UBC)

Explicitly Schema-Based Genetic Algorithms, Dwight Deugo and Franz Oppacher (Carleton U.)

Binary Iterative-Deepening-A*: An Admissible Generalization of IDA* Search, Brian G. Patrick (College Militaire Royal)

Probabilistic Hill-Climbing: Theory and Applications, Russell Greiner (Siemens Corporate Research)

14:30-15:30. SESSION: Invited Speaker.

How to Prove Theorems by Induction, Alan Bundy (U. Edinburgh)

15:50-17:10. SESSION: Applications.

Chair: Bob Mercer (U. Western Ontario)

Synthesis of System Configurations Based on Desired Behavior, Michel Benaroch and Vasant Dhar (U. New York)

An Interactive Constraint-Based Expert Assistant for Music Composition, Russell Ovans and Rod Davison (SFU)

A Customization Environment for the Expert Advisor Network Management System, Tony White and Andrzej Bieszczad (Carleton U.)

Metaknowledge in the LOUTI Development System, Gilbert Paquette (U. Quebec)

17:20-18:30. CSCSI Meeting. 20:00-21:45. Electronic Theatre.

Thursday, May 14, 1992

TECHNICAL PROGRAM cont...

Artificial Intelligence '92 Technical Papers

08:50-10:30. SESSION: Reasoning With Uncertainty.
Chair: Mary Deutsch-McLeish
(U. of Guelph)
Computing the Lower Bounded Composite Hypothesis By Belief Updating, Yang Xiang (SFU)
A Rational Agent Can be Surprised No Matter What, Yen-Teh Hsia (IRIDIA)
A Continuous Belief Function Model for Evidential Reasoning, Chua-Chin Wang and Hon-Son Don (SUNY)
An Efficient Approach to Probabilistic Inference in Belief Nets, Zhaoyu Li (Oregon State U.)
Definite Integral Information, Scott D. Goodwin (U. Regina), Eric Neufeld (U. Sask.), and Andre Trudel (Acadia U.)
10:50-11:50. SESSION: Invited speaker.
Memory, Mind, and Models of Self, Donald Perlis (U. Maryland)
13:30-14:30. SESSION: Default Reasoning.
Chair: Randy Goebel (U. Alberta)
A Characterization of Extensions of Geneval Default Theory, Zhang Mingyi (Guizhou Academy of Sciences)
What is Default Priority?, Craig Boutilier (UBC)
Possible Worlds Semantics for Default Logics Philippe Besnard (IRISA) and Torsten Schaub (FG Intellektik)
14:30-15:30. SESSION: Invited Speaker.
What Linguistics Can Contribute to AI, Veronica Dahl (SFU)
15:50-17:30. SESSION: Constraint-Based Reasoning.
Chair: Bill Havens (SFU)
Fast Solution of Large Interval Constraint Networks, Alexander Reinefeld (U. Hamburg) and Peter Ladkin (U.Bern)
Ordering Heuristics for ARC Consistency Algorithms, Richard J Wallace and Eugene C. Freuder (U. New Hampshire)
Extending PATR with Path Patterns and Constraints, Greg Sidebottom and Fred Popowich (SFU)
Structure Identification in Relational Data, Rina Dechter and Judea Pearl (UC Irvine)
Inference in Inheritance Networks, Using Propositional Logic and Constraint Networks Techniques, Rachel Ben-Eliyahu and Rina Dechter (UCLA)
18:30- Banquet.

Friday, May 15, 1992

Artificial Intelligence '92 Technical Papers

08:50-10:30. SESSION: Knowledge Representation.
Chair: Jim Delgrande (SFU)
Decision-Theoretic Defaults David Poole (UBC)
Hierarchical Meta-Logics for Belief and Provability: How We Can Do Without Modal Logics, Fausto Giunchiglia and Luciano Serafini (U. Genoa)
Tractable Approximate Deduction Using Limited Vocabularies, Mukesh Dalal (Rutgers U.) and David W. Etherington (AT & T Bell Labs)
A Formal Analysis of Solution Caching, Vinay K. Chaudhri (U. Toronto) and Russell Greiner (Siemens Corporate Research)
Reasoning About Action in First-Order Logic, Charles Elkan (UCSD)
10:50-11:50. SESSION: Invited Speaker.
AI and Massive Parallelism, David L. Waltz (Thinking Machines)
13:30-14:50. SESSION: Learning.
Chair: Rob Holte (U. Ottawa)
Case-based Meta Learning: Using a Dynamically Biased Version Space in Sustained Learning, Jacky Baltes and Bruce MacDonald (U. Calgary)
Learning Expertise from the Opposition: The Role of the Trainer in a Competitive Environment, Susan L. Epstein (CUNY)
Training Networks of Value Units, Michael R. W. Dawson, Don P. Schopflocher, James Kidd, and Kevin Shamanski (U. Alberta)
Relevancy Knowledge in Analogical Reasoning, Ye Huang and Alison E. Adam (U. Manchester)
15:10-16:40. SESSION: Panel: An Interdisciplinary View of Constraint Reasoning.
Chair: Veronica Dahl (SFU)
Participants: Veronica Dahl (SFU), Bill Havens (SFU), Maartin van Emden (U. Vic.), Pascal van Henternyck (Brown), Alan Mackworth (UBC), Greg Sidebottom (SFU)

Wednesday, May 13, 1992

Graphics Interface '92 Technical Papers

08:30-10:10. SESSION: Modelling And Rendering I.
Chair: John Amanatides (York U.)
An implementation of multivariate B-spline surfaces over arbitrary triangulations, Philip Fong and Hans-Peter Seidel (U. Waterloo)
Interactive solid modeling using partitioning trees, Bruce Naylor (AT&T Bell Labs)
Fast algorithms for rendering cubic curves, Benjamin Watson and Larry F. Hodges (Georgia Inst. of Tech.)
Parameterization in finite precision, Chanderjit L. Bajaj and Andrew V. Royappa (Purdue U.)
10:40-11:55. SESSION: Program And Document Presentation.
Chair: John Amanatides (York U.)
Hyper-rendering, Jergen Emhardt and Thomas Strothotte (Free U. of Berlin)
Program auralization: Sound enhancements to the programming environment, Christopher J. DiGiano and Ronald M. Baecker (U. Toronto)
Viz: A framework for describing and implementing software visualization systems, John Domingue, Blaine Price, and Marc Eisenstadt (Open University)
13:30-14:30. SESSION: Invited Speaker.
Volume rendering using the Fourier projection-slice theorem R., Marc Levoy (Stanford)
14:30-15:20. SESSION: Visualisation.
Chair: Mikio Shinya (NTT)
An extended cuberille model for identification and display of 3D objects from 3D gray value data, Xiaoqing Qu and Wayne Davis (U. Alberta)
Annotating the real world with knowledge-based graphics on a see-through head-mounted display, Steven Feiner, Blair MacIntyre and Doree Seligmann (Columbia U.)
15:50-17:05. SESSION: Anti-Aliasing, Sampling, And Images.
Chair: Mikio Shinya (NTT)
Algorithms for the detection and elimination of specular aliasing, John Amanatides (York U.)
Hierarchical Poisson disk sampling distributions, Michael McCool and Eugene Fiume
(U. Toronto)
Performing in-place affine transformations in constant space, Ken Fishkin (Xerox PARC)
17:20-18:30. CHCCS Meeting.
20:00-21:45. Electronic Theatre.

Thursday, May 14, 1992

Graphics Interface '92 Technical Papers

08:30-09:20. SESSION: Computer Supported Co-operative Work.
Chair: Mark Green (U. Alberta)

TECHNICAL PROGRAM cont...

Working together, virtually, Jin Li and Marilyn Mantei (U. Toronto)
Telepresence: Integrating shared task and personal spaces, Bill Buxton (U. Toronto/Xerox PARC)
9:20-10:20. SESSION: Invited Speaker.
CSCW - WCSC: Computer Supported Cooperative Work - Ways it Will Change the Science of Computing, Marilyn Mantei (U. Toronto)
10:50-12:05. SESSION: Issues In Interaction.
Chair: Mark Green (U. Alberta)
Movement time prediction in human-computer interfaces, I. Scott MacKenzie (U. Toronto/Guelph)
ARCBALL: A user interface for specifying three-dimensional orientation using a mouse, Ken Shoemake (Otter Enterprises)
Designing video annotation and analysis systems, Beverly L. Harrison and Ronald M. Baecker (U. Toronto)
13:30-15:10. SESSION: Ray Tracing.
Chair: Marceli Wein (NRC)
A data parallel algorithm for ray tracing of heterogeneous databases, Peter Schroder and Steven M. Drucker (Thinking Machines)
Object space temporal coherence for ray tracing, David Jevans (Apple)
Ray tracing polygons using spatial subdivision, Andrew Woo (Alias Research)
Parametric height field ray tracing, David W. Paglieroni and Sidney M. Peterson (Loral Western Labs)
15:40-16:55. SESSION: Image Representation and Stochastic Models.
Chair: Marceli Wein (NRC)
Partitioning tree based image representation and generation, Bruce Naylor (AT&T Bell Labs)
Escape-time visualization method for language-restricted iterated function systems, Przemyslaw Prusinkiewicz and Mark Hammel (U. Calgary)
The object instancing paradigm for linear fractal modeling, John C. Hart (U. Illinois, Chicago)
18:30- Banquet.

Friday, May 15, 1992
Graphics Interface '92 Technical Papers
08:55-10:10. SESSION: Modelling and Rendering II.
Chair: Brian Wyvill (U. Calgary)
Algorithms for intersecting parametric and algebraic curves, Dinesh Manocha and James Demmel (UC Berkeley)
An interval refinement technique for surface intersection, Michael Gleicher (CMU) and Michael Kass (Apple)
Physically-based methods for polygonization of implicit surfaces Luiz Henrique de Figueiredo, Jonas de Miranda Gomes (IMPA, Brasil), Demetri Terzopoulos (U. Toronto), and Luiz Velho (U. Toronto/IMPA)
10:50-11:55. SESSION: Animation.
Chair: Brian Wyvill (U. Calgary)
Matrix animation and polar decomposition, Ken Shoemake (Otter Enterprises) and Tom Duff (AT&T Bell Labs)
Generating natural-looking motion for computer animation, Jessica K. Hodgins, Paula K. Sweeney (IBM Yorktown), and David G. Lawrence (Stanford)
Beyond keyframing: An algorithmic approach to animation, A. James Stewart (U. Toronto) and James F. Cremer (Cornell U.)
13:30-14:30. SESWION: Invited Speaker.
A minimalist global user interface Rob Pike (AT&T Bell Labs)
14:30-15:20. SESSION: Environments and Applications.
Chair: Saul Greenberg (U. Calgary)
A multi-layer graphic model for building interactive graphical applications, Jean-Daniel Fekete (U. de Paris Sud)
A linear constraint technology for interactive graphic systems, Richard Helm, Tien Huynh, Catherine Lazzez, and Kim Marriott (IBM Yorktown)
15:50-16:40. SESSION: Illumination.
Chair: Saul Greenberg (U. Calgary)
Non-uniform patch luminance for global illumination, Buming Bian (U. Texas, Austin), Norman Wittels (Worcester Polytechnic), and Donald S. Fussell (U. Texas, Austin)
A two-pass physics-based global lighting model, Kadi Bouatouch and Pierre Tellier (IRISA)

Wednesday, May 13, 1992
Vision Interface '92 Technical Papers
08:30-09:30. SESSION: Invited Speaker. Computer vision: attitudes, barriers, counselling, Azriel Rosenfeld (U. Maryland)
09:30-10:20. SESSION: Texture Analysis.
Chair: James J. Little (UBC)
Hierarchical Maximum Entropy Partitioning of Visual Feature Frequency Matrices for Texture Classification, D. K. Y. Chiu (U. Guelph) and H. C. Shen (U. Waterloo)
Characteristic Colors for Texture Image Analysis: A Parallel Distributed Approach, J. Scharcanski, H. C. Shen and A. P. Alves da Silva (U. Waterloo)
10:50-12:05. SESSION: Segmentation And Representation.
Chair: James J. Little (UBC)
Realtime Image Segmentation with 2n-tree Classifiers, Byron Dom and David Steele (IBM Almaden Research Center)
The Ensemble Representation, Yerucham Shapira (Ecole Polytechnique de Montreal)
Extracting Polyhedral Models From A Range Image: A Hybrid Approach, Kamal Gupta and Xiao Ming Zhu (SFU)
13:30-15:10. SESSION: Modelling And Estimation.
Chair: Rejean Plamondon (Ecole Polytechnique de Montreal)
Adaptive neural tree for pattern recognition, T. Li, Yuan Yan Tang, and C. Y. Suen (Concordia U.)
Observing Agents Under Uncertainty, Tarek M. Sobh and Ruzena Bajcsy (U. Pennsylvania)
Premise-Based Estimation, Eyal Shavit (U. Toronto)
Discovering Regularities and Irregularities Based on The Distribution of Probability Estimates, Abdul Rahim Halabieh and David K. Y. Chiu (U. Guelph)
15:40-17:20. SESSION: Character Recognition.
Chair: Rejean Plamondon (Ecole Polytechnique de Montreal)
Handprinted Character Recognition Using Relative Relation of Plural Classification, Daisuke Nishiwaki, Jun Tsukumo and Tsutomu Temma (NEC)
Database Development by Learning from Samples for Handwritten Chinese Character Recognition, Ying Ren and Siwei Lu (Memorial U. of Newfoundland)
Recognizing Sequences of Letters in Mixed-Script Handwriting, Caroline Barriere and Rejean Plamondon (Ecole Polytechnique de Montreal)
A Polygon Classification Approach on Remotely Sensed Image, Hazem Raafat and Qinghan Xiao (U. Regina)
17:20-18:30. CIPPRS Meeting.
20:00-21:45. Electronic Theatre.
Thursday, May 14, 1992

TECHNICAL PROGRAM cont...

Vision Interface '92 Technical Papers
08:30-10:10. SESSION: Motion and Stereo.
Chair: Ze-Nian Li (SFU)
Accurate Early Detection of Discontinuities, James J. Little (UBC)
Use of Colour in Gradient-Based Estimation of Dense Two-Dimensional Motion, Janusz Konrad (U. Quebec)
Models of Statistical Visual Motion Estimation, Minas E. Spetsakis (York U.)
Shape from Rotation using Stereo, Yizhi Edith Li and M. R. M. Jenkin (York U.)
10:40-11:55. SESSION: Tracking And Motion Estimation.
Chair: Ze-Nian Li (SFU)
Model-Guided Grouping for 3-D Motion Tracking, Xun Li and David G. Lowe (UBC)
A Two-stage Robust Approach to Motion Estimation, Sun Xuening and Minas E. Spetsakis (York U.)
Acquiring object models using vision operations, Tilo Messer (FORWISS)
13:30-14:30. SESSION: Invited Speaker. Curve detection and shape description, Steven W. Zucker (McGill U.)
14:30-15:20. SESSION: Architecture I.
Chair: Minas E. Spetsakis (York U.)
Fast Line Detection in a Hybrid Pyramid, Ze-Nian Li and Danpo Zhang (SFU)
Efficient Image Processing Algorithms for Reconfigurable Meshes, Stephan Olariu, James L. Schwing and Jingyuan Zhang (Old Dominion U.)
15:50-17:05. SESSION: Architecture II.
Chair: Minas E. Spetsakis (York U.)
SIMD Geometric Matching: From Poyhedra to Planar Curves, Martin Usoh and Hilary Buxton (Queen Mary and Westfield College)
An Adaptive Parallel memory System for Image Processing, Zhiyong Liu, Xiaobo Li and Jia-Huai You (U. Alberta)
Computing the Hough Transform on Reconfigurable Meshes, Stephan Olariu, James L. Schwing and Jingyuan Zhang (Old Dominion U.)
18:30- Banquet.

Friday, May 15, 1992
Vision Interface '92 Technical Papers
08:30-09:20. SESSION: Robotics And Motion Planning.
Chair: D. K. Y. Chiu (U. Guelph)
A Dynamic Motion Planning Problem Using Alarms, Rajeev Sharma (U. Maryland) and Anup Basu (U. Alberta)
Adaptive Logic Networks and Robot Control, Allen G. Supynuk and William W. Armstrong (U. Alberta)
09:20-10:20. SESSION: Invited Speaker. Building robots, Alan Mackworth (UBC)
10:50-12:05. SESSION: Vision Systems.
Chair: D. K. Y. Chiu (U. Guelph)
Object location using Proportions of the Direction of Intensity Gradient (PRODIGY), Graham Robertson and Ken C. Sharman (U. Glasgow)
ARNIE P. - A Robot Golfing System Using Binocular Stereo Vision, Roger W. Webster and Yong Wei (Millersville U.)
Determining the Visible Sites Inside a Simple Polygon, Cao An Wang (Memorial U. of Newfoundland)
13:30-15:10. SESSION: Representation And Transformation.
Chair: Si-Wei Lu (Memorial U. of Newfoundland)
Attitude Determination by Support Function and Curvature, Ying Li (UBC)
A Global 3D Interpolator for Large Voxel Datasets, H. H. Atkinson, Irene Gargantini and R. E. Webber (U. Western Ontario)
RP Transformation for pattern recognition, Yuan-Yan Tang and Ching Y. Suen (Concordia U.)
Using Equivalent Pair Information for Image Component Labeling - An Optimal Algorithm, Amelia F. Lochovsky (Hong Kong U.)
15:40-16:55. SESSION: Boundary Detection.
Chair: Si-Wei Lu (Memorial U. of Newfoundland)
Three Dimensional Border Identification, Xiaoqing Qu and Wayne Davis (U. Alberta)
Zernike Moments-Based Subpixel Edge Detection, Sugata Ghosal and Rajiv Mehrotra (U. Kentucky)
On Image Analysis Via Orthogonal Moments, Miroslaw Pawlak

Call for Papers

Fifth International Symposium on Artificial Intelligence

The Artificial Intelligence Technology Transfer Conference

Applications in Manufacturing and Robotics

December 7-11, 1992
Sheraton Cancún Resort&Towers
Cancún, Mexico

The Fifth International Symposium on Artificial Intelligence will be held in Cancún, Mexico on December 7-11, 1992. The Symposium is sponsored by the ITESM (Instituto Tecnológico y de Estudios Superiores de Monterrey) in cooperation with the International Joint Conferences on Artificial Intelligence Inc., the American Association for Artificial Intelligence, the Canadian Society for Computational Studies of Intelligence, the European Coordinating Committee for Artificial Intelligence, the Sociedad Mexicana de Inteligencia Artificial and IBM of Mexico.

Papers from all countries are sought that **(1)** Present applications of artificial intelligence technology to the solution of problems in manufacturing, robotics and related areas; **(2)** Describe research on techniques to accomplish such applications, **(3)** Address the problem of transferring the AI Technology especially in the context of the Free Trade Agreement among Canada, the USA and Mexico.

Areas of application include but are not limited to:
plant design, process planning, product design, scheduling, assembly, production control, computer-intergrated manufacturing, inspection, quality control, transportation problems, client support, distribution, marketing, decision support, process control, motion control, supervisory and expert control, alarm diagnosis, equipment maintenance, energy savings and pollution control.
Technology Transfer includes but is not limited to:
strategies for introducing and institutionalizing AI technology, human resources formation in AI, justification of AI projects, cooperation programs in the context of the Free Trade Agreement, impact of AI and automation in the social environment of the company.
AI techniques include but are not limited to:
computer vision and digital image processing, speech and natural language understanding, pattern recognition, machine learning, motion planning, neural nets, genetic algorithms, heuristic search, uncertainty management, task planning, parallelism, expert systems, knowledge engineering, knowledge acquisition and representation, and case-based, geometric, temporal, spatial, nonmonotonic, common sense and probabilistic reasoning.

Persons wishing to submit a paper should send **five** copies written in English to:

Hugo Terashima, Program Chair
Centro de Inteligencia Artificial, ITESM.
Sucursal de Correos "J", Monterrey, N.L. 64849, México.
Tel. (52-83) 58-2000 Ext. 5134
Telefax (52-83) 58-1400 Dial Ext. 5143 or 58-2000 Ask Ext. 5143
Net address isai@tecmtyvm.bitnet or terashim@mtecv2.mty.itesm.mx

The paper should identify the area and technique to which it belongs. Papers will be evaluated with respect to their originality, correctness, clarity and relevance. Use a serif type font, size 10, single-spaced with a maximum of 10 pages. No papers will be accepted by electronic means.
Important dates: Papers must be received by **April 30, 1992.** Authors will be notified of acceptance or rejection by **June 30, 1992.** A final copy of each accepted paper, camera ready for inclusion in the Symposium proceedings, will be due by **July 31, 1992.**

The AAI Series on Global Trends in Advanced AI Technology

Volume I Applications and VLSI Implementation of Neural Networks: Recent Trends in the United States and Europe

For almost a decade, Applied AI Systems, Inc. (AAI) has completed extensive studies on the current and future global status of artificial intelligence (AI), as defined in its broadest sense. These in-depth investigations of international leading-edge research facilities, based on extensive site visits, as well as materials collected, are now being presented in a series of publications.

Applications and VLSI Implementation of Neural Networks, the first report in a series produced by AAI on Neural Computing, examines the present and future directions of Neural Network Research and Development in the United States and Europe.

Once thought to be a purely esoteric concept, Neural Networks (NN) are steadily and rapidly being incorporated into advanced large-scale practical business, industrial and commercial applications, throughout the world.

This report places an emphasis on current NN applications and hardware implementation issues, in addition to a brief historical overview of the evolution of Neural Networks.

KEY FEATURES INCLUDE:

- Applications of Neural Networks:
  - Machine Vision
  - Visual Pattern Recognition
  - Diagnostic/Expert Systems
  - Language Understanding and Cognition
  - Neurocontrollers
  - Speech Recognition/Synthesis
  - Process Monitoring/Control
  - Automated Document Classification
  - Prediction of Events in Temporal Domain
- VLSI Design & Implementation
  - Digital/Analogue and Hybrid
  - On-chip Learning
  - CMOS & CCD Technologies
- Silicon NN Manufacturing Issues

FORTHCOMING REPORTS

The AAI Series is a newly released collection of the results obtained from on-going international studies into the latest and most advanced AI technologies. Volume II, due to be released in May 1992, is an analysis of worldwide efforts to apply AI paradigms to the problems of intelligent text processing.

Additional volumes, each with similar stress on the latest progressive AI trends, will be announced at the rate of approximately one every six months. Upcoming subjects include: Virtual Reality, Qualitative Reasoning and Machine Translation.

For Further Information Contact:

Applied AI Systems, Inc.
Suite 500, Gateway Business Park
340 March Road
KANATA, Ontario, Canada K2K 2E4
Tel. (613) 592-3030
Fax. (613) 592-2333

Call for Participation AAAI Fall Symposium Series

October 23, 24, & 25, 1992
Royal Sonesta Hotel
Cambridge, Massachusetts

Sponsored by the American Association for Artificial Intelligence
445 Burgess Drive,
Menlo Park, CA
94025 (415) 328-3123
fss@aaai.org

The American Association for Artificial Intelligence presents the 1992 Fall Symposium Series, to be held Friday through Sunday, October 23—25, 1992, at the Royal Sonesta, Cambridge, Massachusetts.
The topics of the five symposia in the 1992 Fall Symposium Series are:

Applications of AI to Real-World Autonomous Mobile Robots: (contact: Marc Slack, Mail Stop z401, The Mitre Corporation, 7525 Colshire Drive, McLean, Virginia, 22102-3481, slack@starbase.mitre.org);

Design from Physical Principles; (contact: Brian Williams, XEROX Palo Alto Research Center, 3333 Coyote Hill Road, Palo Alto, CA 94304, bwilliams@parc.xerox.com, fax: 415-812-4334);

Intelligent Scientific Computation; (contact: Elaine Kant, Schlumberger Laboratory for Computer Science, P. O. Box 200015, Austin, TX 78720-0015, kant@slcs.slb.com, fax: 512-331-3760);

Issues in Description Logics: Users Meet Developers, (contact: Robert MacGregor, USC/Information Sciences Institute, 4676 Admiralty Way, Marina del Rey, CA 90292-6695, macgregor@isi.edu);

Probablistic Approaches to Natural Language: (contact: Robert Goldman, Computer Science Department, 01 Stanley Thomas Hall, Tulane University, New Orleans, LA 70118-5698, rpg@cs.tulane.edu).

Most symposia will be limited to approximately 60 participants. Each participant will be expected to attend a single symposium. Working notes will be prepared and distributed to participants in each symposium.
A general plenary session will be scheduled in which the highlights of each symposium will be presented and an informal reception will be held on Friday evening, October 23.
In addition to invited participants, a limited number of other interested parties will be allowed to register in each symposium. Registration information will be available in July 1992. To obtain registration or symposia information write to AAAI at the address above.

Submission requirements vary with each symposium, and can be obtained by contacting AAAI or the symposia contacts. DO NOT SEND submissions to AAAI. All submissions must arrive by May 11, 1992. Acceptances will be mailed by June 8, 1992. Material for inclusion in the working notes of the symposia will be required by August 10, 1992.

International Conference on Object-Oriented Manufacturing Systems

4-6 May 1992 Calgary, Canada

Co-sponsored by:
Society of Manufacturing Engineering
Society of Computer Simulation
Canadian Society for Mechanical Engineering
Operations Research Society of Japan
Object Management Group

Conference focus is object-oriented systems in manufacturing at research, development or applications levels. Pre-conference Workshops. Five major conference themes are: Design; Manufacturing Planning and Control; Modelling Approaches and Simulation; Manufacturing Application Domains; Information Systems and Software. Sessions include: Concurrent Engineering; Product Modelling; Feature-Based Design; User Interfaces; Manufacturing Control Systems; Shop Floor Control Systems; Production Planning and Control; Enterprise Modelling; Hybrid Modelling; Agent-based Architectures; Negotiation-based Scheduling; Modelling and Simulation; Bionic Manufacturing Systems; Layout and Group Technology; Assembly and Maintenance; Robot Programming; Flexible Manufacturing Cells/Systems; Information Modelling.

For information please contact; Madeleine Aldridge, Conference Office, The University of Calgary, 2500 University Drive N. W., Calgary, AB, T2N 1N4 (Phone: (403)220-7319, Fax: (403)289-7282).

JOB LISTING

A postdoctoral position for the project on Machine Learning and Text Analysis for Semi-automatic Knowledge Acquisition.

Candidates should have a completed Ph.D, have a strong background in Machine Learning and Natural Language Processing, with a record of research in at least one of these areas. The position is available immediately and guaranteed for 3 years. The salary is $27,500 per annum (under review), plus an excellent benefit package.

The postdoctoral fellow will be an essential member of the project's team. He or she will play an active role in all aspects of the project, including major research decisions. Duties include participation in the design and development of a prototype system, in supervision of graduate students who will work on the project, and in publications relating to the project.

Interested persons please contact Dr. Stan Matwin (stan@csi.uottawa.ca) or Dr. Stan Szpakowicz (szpak@csi.uottawa.ca).
The mailing address is:
Department of Computer Science
University of Ottawa
150 Louis Pasteur
Ottawa, Ontario, K1N 6N5
Canada
fax: 613-564-9486

KR'92 - CALL FOR PAPERS
THIRD INTERNATIONAL CONFERENCE
ON PRINCIPLES OF KNOWLEDGE REPRESENTATION AND REASONING

Royal Sonesta Hotel, Cambridge,
Massachusetts, USA
with support from AAAI, ECCAI, and CSCSI
in cooperation with IJCAII
October 26-29, 1992
(KR'92 follows the AAAI Fall Symposium Series
at the same location October 23-25)

The idea of explicit representations of knowledge manipulated by inference algorithms provides an important foundation for much 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. In particular, authors will have the opportunity to give presentations of adequate length to present substantial results.
The theme of this year's conference is the relationship between the principles of knowledge representation and reasoning and their embodiment in working systems. Authors are encouraged to relate their work to one of the following important questions:

(1) What issues arise in applying knowledge representation systems to real problems, and how can they be addressed?
(2) What are the theoretical principles in knowledge representation and reasoning?
(3) How can these principles be embodied in knowledge representation systems?

Submissions are encouraged in (but are not limited to) the following topic areas:

KNOWLEDGE REPRESENTATION FORMALISMS
- logics of knowledge and belief
- nonmonotonic logics
- temporal logics
- spatial logics
- taxonomic logics
- logics of uncertainty and evidence

REASONING METHODS
- deduction
- abduction
- induction
- learning
- planning and plan analysis
- constraint solving
- diagnosis
- classification
- inheritance
- belief management and revision
- analogical reasoning

GENERIC ONTOLOGIES FOR DESCRIBING
- time
- space
- causality
- resources
- constraints
- applications classes such as medicine

ISSUES IN IMPLEMENTED KR&R SYSTEMS
- comparative evaluation
- empirical results
- benchmarking and testing
- reasoning architectures
- efficiency/completeness tradeoffs
- complexity
- algorithms

SUBMISSION OF PAPERS
The Program Committee will review EXTENDED ABSTRACTS rather than complete papers. Abstracts must be at most twelve (12) pages with a maximum of 38 lines per page and an average of 75 characters per line (corresponding to the LaTeX article-style, 12pt), excluding the title page and the bibliography. Overlength submissions will be returned. All abstracts must be submitted on 8 1/2" x 11" or A4 paper, and printed or typed in 12-point font (10 characters/inch on a typewriter). Dot matrix printout, FAX, or electronic submission will not be accepted. Each submission should include the names and complete addresses of all authors. Correspondence will be sent to the first author, unless otherwise indicated. Also, authors should indicate under the title which of the questions and/or 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). Five (5) copies of the abstract must be received by one of the program co-chairs no later than April 21, 1992. Papers received after that date will be returned unopened. Authors will be notified of the Program Committee's decision by June 15, 1992.

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