Report on a Visit to ICOT

Raymond Reiter
Department of Computer Science
University of Toronto
Toronto, Ontario M5S 1A4
Canada
and
The Canadian Institute for Advanced Research

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1 Introduction

On the kind invitation of Dr. Koichi Furukawa, I spent the period Oct. 15 - 26 as a guest of ICOT. Like many of my colleagues throughout the world, I have known about, and followed much of the research being done at ICOT, especially as it relates to my own interests in knowledge representation and reasoning. Accordingly, I saw my visit as a unique opportunity to gain firsthand knowledge of the activities at ICOT.

2 Scheduled Lectures

Prior to my visit, I had agreed to give four lectures on some of my recent work, three at ICOT, and one at ASTEM in Kyoto which was a repetition of one of my ICOT talks. The topics of these lectures were

Diagnostic Reasoning This was a survey of some of my original research of three years ago on a theory of diagnosis from first principles. together with a recent refinement of the theory done collaboratively with Johan DeKleer and Alan Mackworth. This talk was repeated at ASTEM.

Theory of Databases This talk presented my recent ideas about the uses of an epistemic logic for database queries and for the representation of integrity constraints.

The Frame Problem This material describes research in progress on a simple solution to the frame problem in the situation calculus, and its use in a systematic regression-style proof procedure for plan synthesis.

3 Interaction with ICOT Researchers

During my visit, I had a number of meetings with individual researchers, both formally and informally. From these meetings I obtained what I believe to be a good perspective on the research objectives and achievements of ICOT. In addition, I attended the demonstrations of the Multi-PSI machine during the ICOT/DTI-SERC Workshop which gave me an excellent overview of this component of ICOT's research program. Since I am not an expert on prolog implementations or parallel computing, I cannot comment intelligently on this work. Instead, I shall restrict my comments to those interactions from which I learned something of interest to my own research. or to which I believe I might have contributed in some way to the research objectives of ICOT.

The Model Generation Theorem Proving Project For the past few years I have been interested in the applications of logic to the problem of high level computational vision. According to the approach which is described in a paper by Alan Mackworth and myself, it is possible to axiomatize the information in an image of a scene, general knowledge about the scene, and the properties of the mappings between the scene and the image. An interpretation of an image is then defined to be a model of these axioms. The computational problem of image interpretation is therefore to compute some, or all models of a set of first order axioms. Currently, Michael Gruninger, a student of mine at the University of Toronto, is considering this problem. Prior to my visit to ICOT, I knew of no general approach to model generation in the AI literature so it was with great interest that I learned of ICOT's model generation theorem proving project. In particular, I understood from Dr. Hasegawa's explanation of the theorem prover that it could be used not only to prove theorems but also to generate models of a satisfiable theory. This is exactly what is required for computational

vision. Dr. Hasegawa kindly provided me with several papers on the project, as well as sequential Prolog code for the theorem prover which incorporates his ramified stack algorithm. Upon my return to Toronto, I plan to work with Michael Gruninger on experimenting with this theorem prover on a particular application of image interpretation for which we have an axiomatization. In exchange, I have offered to send to Dr. Hasegawa the axioms we are using. This will provide his theorem proving project with a new application domain. Moreover, computer vision seems intuitively to be very natural application of parallel processing so it will be very interesting to discover how well the Multi-PSI machine performs on this domain.

APRICOT/0 I liked this system. For one thing, it solved some interesting problems in design and seemed to have wide applicabibility. For another, I learned about RETE networks from Katsumi Inoue and could see how to use many of the ideas of APRICOT/0 in my work on computational vision.

Object Oriented Databases Kazumasa Yokota gave me a history of Quijote and explained its semantics. This was all new to me, never before having thought about OODs. While I had no technical suggestions to make, it occurred to me that there is an interesting, and fundamental distinction between the semantics of OODs and deductive databases. The latter are of the traditional Tarskian kind, and make reference to *truths about some external world.* In contrast, OOD semantics are oriented much more towards data structures and implementation level issues (e.g. object identity, modules) and therefore are much closer to traditional *programming language semantics.* This suggests to me that it will be extremely difficult (impossible?) to combine these two perspectives on databases in a reasonable way. If we take it as a long-term goal of databases to provide a declarative view of representations, then a declarative semantics for OODs (in the sense that statements are understood to be truths about some external world) will be necessary. This strikes me as an extremely interesting research problem.

Theory Revision and Update Semantics Ken Satoh and Hirofume Katsuno described their recent work on this subject. They have observed some interesting connections between conditional logics and the postulates of Gardenfors, Lehmann and Makinson, as well as postulates by Katsuno and Mendelzon. It turns out that recent work by my

student Craig Boutilier on conditional logics is of some relevance to the theories of Katsuno and Satoh and I shall encourage Boutilier to interact with them in possible future research. A nice coincidence is that two of the principals - Boutilier and Mendelzon - are both at the University of Toronto.

Discussions on Nonmonotonic Logics and Logic Programming There were so many such discussions, I can't begin to enumerate them. They generally involved subsets of Vladimir Lifschitz, Katsumi Inoue, Ken Satoh, Jun Arima and myself. Topics included truth maintenance systems, deductive databases, circumscription, reasoning by analogy, abduction, and proof procedures. These are all closely related to my research interests. In general, I found these discussions very fruitful. They reinforced my impression that there is a core set of ideas relating these different topics, and that developing a theory that unifies them all is a central task for the theory of knowledge representation.

4 Some General Comments

I believe that the future success of AI will depend to a large extent on positive developments in the theory of knowledge representation. From this perspective, it seems to me that one of the sucesses of the Fifth Generation Project has been to assemble and train a sizable group of very capable theoreticians, and to provide them with the resources and intellectual freedom to pursue their research interests. I understand that the future status of the Fifth Generation Project has not yet been decided. In my opinion, it would be a loss to the field of AI if this group of theoreticians were to be broken up, or if they should be unable to continue the fine research which they have been doing up to now. I hope that it will be possible somehow for them to continue their work, and their international collaborations.

5 Thank You

- To Koichi Furukawa for kindly inviting me to visit ICOT.
- To Katsumi Inoue for being the perfect host for my visit. He always made me feel welcome and I could always count on him to solve any problems that might arise in connection with my stay.

- To Kazuhide Iwata for looking after my financial well being, and for arranging so many of the details of my stay in Tokyo and my trip to Kyoto. The extent to which he anticipated my requirements was truly remarkable. I especially appreciated his invitation to visit his home.
- To Ken Satoh for his friendly help and for acting as my tour guide at Kamakura.
- To Kazumasa Yokota, my "office mate", for all his advice and cheerful company while I was at my desk.
- To the management and directors of ICOT: the executive director, Mr. Hiroichi Hiroshige, the director of the research center, Dr. Kazuhiro Fuchi, and the deputy director, Dr. Koichi Furukawa for supporting my stay at ICOT.

CURRICULUM VITAE
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BIOGRAPHICAL INFORMATION

Personal

Name: Raymond REITER

Citizenship: Canadian

Home Address: 100 Winchester St.
Toronto, Ont. M5X 1B2

Home Phone: (416)929-5069

University Address: Department of Computer Science
Sandford Fleming Building
10 King's College Road
Toronto M5S 1A4

University Phone: (416)978-6324

Degrees Held

B.A. (Mathematics)	University of Toronto (1961)
M.A. (Mathematics)	University of Toronto (1963)
Ph.D. (Computer Science)	University of Michigan (1967)
	Title: "A study of a model for parallel computations"
	Supervisor: Professor E.L. Lawler

Employment

1966-67	Teaching Fellow, Dept. of Communication Sciences, University of Michigan
1967-68	Lecturer, Dept. of Communication Sciences, University of Michigan
1968-69	Part-time Lecturer, Institute of Computer Science, University of London
1969-74	Assistant Professor, University of British Columbia
1974-81	Associate Professor, University of British Columbia
1981-85	Professor, University of British Columbia
1985-	Professor, University of Toronto

Visiting Positions

May 74-Aug.74	Bolt, Beranek and Newman Inc., Cambridge, Mass.
Sept.75-Aug.76	Bolt, Beranek and Newman Inc., Cambridge, Mass.
July 78-June 79 (study leave)	Imperial College, University of London, Dept. of Computing and Control
Jan.82-Dec.82	Rutgers University, Dept. of Computer Science

Honours

Bnai Brith Award in Mathematics, Physics and Chemistry, University of Toronto, 1958-59

Matheson Springer Postgraduate Scholarship, University of Michigan, 1964-65

National Research Council of Canada Post Doctoral Fellowship, Institute of Computer Science, University of London, England, Jan.68-June 69

Awarded Publisher's Prize, with D.E. Etherington, for best paper of Amer. Assoc. for Artificial Intelligence Nat. Conf., Washington, D.C., August 22-26, 1983. (See reference 26 under Publications.)

Senior Fellow, Canadian Institute for Advanced Research, July 84-June 89. Reappointed, July 89-June 94.

Elected Fellow of the American Association for Artificial Intelligence, July 1990.

Memberships in Professional and Learned Societies

Association for Computing Machinery
Association for Symbolic Logic
Canadian Association of University Teachers
Canadian Society for Computational Studies of Intelligence
Association for Computational Linguistics
American Association for Artificial Intelligence
Association for Automated Reasoning