Report on a Visit to ICOT December 1989

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1 Introduction

I was an invited visitor to ICOT for three weeks starting on November 20, 1989. The invitation came as a result of talks with Dr. Furukawa when he was visiting SRI International in January 1989. In fact I have had contact with many researchers from ICOT in the past, notably Ken Satoh, Nicolas Helft, Katsumi Inoue, Jun Arima, Yasushi Fujiwara of Toshiba. Also, I have had discussions with other visitors to ICOT, including Dr. Katagiri of NTT, and Dr. Brewka of GMD. Because of these interactions, I was convinced that a visit to ICOT could lead to a beneficial exchange of research ideas. This has turned out to be the case.

The particular research area of interest for me is nonmonotonic reasoning. This area of AI is currently undergoing rapid development, especially in the application of nonmonotonic formalisms to classical problem domains of AI (action theory, plan recognition, and so forth), and the implementation of systems for performing automatic deduction for nonmonotonic logics. ICOT has researchers actively working in this area, as well as an intense machine-development effort focused on a parallel inference system. This is very close to my own current interests, with the exception of PROLOG: I had never programmed in this language.

2 Summary of the visit

Ken Satoh arranged the schedule of my visit to ICOT. Over the course of three weeks, I presented four talks of current research work:

1. *Surface reconstruction using multiple redundant sonar readings on a parallel machine.* In this talk I presented experiences in using the SIMD Connection Machine for combining multiple sonar readings from a mobile robot project (FLAKEY) at SRI. SIMD machines with high interconnectivity are very different from the multi-PSI machine being developed at ICOT.

2. *Consistency-based nonmonotonic logics.* This talk was of a general nature, describing the class of consistency-based nonmonotonic logics (such as default logic and autoepistemic logic) and pointing out some of the research problems that exist and are currently being worked on.

3. *Implementing autoepistemic logic using a truth-maintenance system.* This talk described my current research on deriving approximate proof procedures for autoepistemic logic. The main idea is to compile autoepistemic statements into rules of a truth-maintenance system. It appears that some of the results from proof-theories of circumscription and the ATMS (assumption-based truth maintenance system) are directly relevant to my research. Katsumi Inoue (Fifth Laboratory) and Nicolas Helft (First Laboratory) are working in this area, and we had useful discussions here. In fact, I learned enough about new proof methods to apply some of them to my research.

4. *An argument system for abductive reasoning.* This talk was about an idea for a new type of direct argumentation system, and its application to problems of abductive reasoning, such as belief ascription and plan recognition. There is general interest in the problem of abductive reasoning in the First and Fifth Laboratory at ICOT.

I had many meetings and discussions with the members of ICOT. With members of the First Laboratory, I discussed work on nonmonotonic reasoning. With members of the Fourth and Fifth Laboratory, I discussed the implementation of applications on the PSI and multi-PSI machines.

Nicolas Helft and Katsumi Inoue are doing excellent research in the area of theorem-proving methods for nonmonotonic logic, especially in developing the general theory of constructing such methods, and in extending the representational power of the ATMS. I am not particularly knowledgeable in this area, and they were very helpful (and patient) in explaining the basic concepts, and guiding me to literature in the field. In return I pestered them by providing challenges for their theories. In the middle of my visit, we were joined by Dr. Poole, who is also very interested in proof methods for abductive reasoning. We all concentrated on providing solutions to the 8 queens problem, using our respective theories.

I had several discussions with Ken Satoh about his research in providing a probabilistic semantics for model-preference theories. This work considers nonmonotonic reasoning at a very high level of abstraction, characterized by a consequence relation with very general characteristics (this is the work of Lehman, Kraus, and Magidor). By showing that the consequence relation also has a probabilistic semantics, Ken has shown a strong connection between a nonmonotonic logic and probability theory. I believe this to be an important area of inquiry, and this is a solid contribution, on the level of Pearl and Geffner's work on epsilon-semantics.

I also talked with Jun Arima about his work on circumscription. One of the problems with this formal system is that no consequences can be inferred regarding the equality relation. Jun has developed a system called *connotative circumscription* that gets around this problem. In discussing this with him, I pointed out that, although formally correct, connotative circumscription may have certain undesirable consequences as a system of commonsense reasoning. Jun said he would try to examine the example I gave him.

I talked with Katuhiko Toyama of Nagoya University about his work on two-agent autoepistemic logic. The idea was quite interesting, and I recommended that he try to use his system to formalize speech act theory. I also spoke with Yasushi Fujiwara of Toshiba about his current work on extending the ATMS to include the nonmonotonic rules of the original truth-maintenance system. His work is interesting, but is still preliminary. The main problem seems to be incorporating nonmonotonic rules without sacrificing expressive power of the formalism.

The members of the Second and Fifth Laboratories were very generous in providing demonstrations of the PSI machines, DUALS, and various applications. I met with Dr. Katsumi Nitta, Katsumi Inoue, and Yoshihiko Ohta to discuss Guarded Horn Clauses and their implementation on the

multi-PSI machine.

Finally, I visited the NTT Basic Research Laboratories, headed by Dr. Takeuchi. They demonstrated their current ELIS Lisp Machine hardware and software, and talked about plans for a fourth generation machine. Their system is very impressive. My main purpose in visiting NTT was to talk with Dr. Katagiri concerning a suitable theory for reasoning about a user's plans and intentions. We discussed several of the problems in representing intention and belief, and I presented work on the argument system I have been developing.

3 Research and implementation results

My visit to ICOT proved useful from both a theoretical and implementation viewpoint, although I did not accomplish as much as I had hoped in terms of a parallel machine implementation. In discussions with Nicolas Helft, Katsumi Inoue, and Dr. Poole, I was able to discover a proof method for translating a subset of autoepistemic theories into a TMS (truth-maintenance system). I borrowed heavily from techniques that had been developed by Inoue and Helft. I hoped to implement this theory on the PSI and multi-PSI machines. Unfortunately, I had no experience with PROLOG, so it took a long time to write the first programs in this language. Nicolas Helft and Katsumi Inoue provided invaluable assistance, and Nicolas Helft even wrote major portions of the code. The program successfully solved the 8-queens problem as a test, and Yoshihiko Ohta kindly ported it to the ESP language on the PSI machine. The performance of this machine was quite impressive.

The implementation occurred at the end of my visit, so there was no time to transfer it to the multi-PSI machine. The algorithms that I developed use little backtracking and are inherently parallel, so it should be possible to make the transfer without reworking them too much.

4 Assessment

I hesitate to provide any assessment of the ICOT project, since my stay was so brief, and I saw only a small portion of the current projects. Yet perhaps my small experience may be useful.

First, there is good research in different aspects of nonmonotonic reasoning being carried out by many members of the First and Fifth Laboratory. I have mentioned these researchers above, and the concentration of expertise is very impressive, and the papers produced of high quality.

I am less sanguine about the interaction between the theoretical research and the hardware and software effort. Although there was some evidence of collaboration, for example between Katsumi Inoue and Yoshihiko Ohta, in general the theoretical researchers did not seem to be aware of the possibilities of the hardware being developed. I think this is unfortunate, because one of the purposes of ICOT is to try to develop a parallel machine that can be used for research and development.

There seem to be several reasons for the lack of interaction. It is extremely important to have good software development tools on a computer system. Although a substantial effort was devoted to developing the APRICOT in ESP on the PSI machine, many potential users of the machine are not happy with them, and continue to use more familiar systems like Unix.

For parallel hardware, which is conceptually difficult to use, the need for development tools is even more critical. The multi-PSI machine is in an early stage of development, and does not yet have these tools. Perhaps more work on the simulator would make it acceptable to the users.

In addition to development tools, the parallel hardware itself must facilitate programming. There seems to be a general feeling that the communication regime of the multi-PSI machine is simply too slow, and that guarded Horn clauses may be difficult to use. The only way to disprove this is to try to get the researchers to implement their theories, and see how well or how poorly they do.

5 Thanks

I wish to thank the management and directors of ICOT: the executive director, Mr. Hiroshige, the chief of the First Laboratory, Dr. Hasegawa, the Director of the Research Center, Dr. Kazuhiro Fuchi, and the Deputy Director, Dr. Furukawa, for their kindness in supporting my stay at ICOT. I warmly thank Ken Satoh of the First Laboratory was extremely kind in providing me with research materials and generally keeping me entertained. I am especially grateful to Dr. Kazuhide Iwata and Kumiko Karakawa for their efforts in dealing with all the problem a foreigner has in a different world.

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SPECIALIZED PROFESSIONAL COMPETENCE

Computational linguistics; Bayesian methods in expert systems; formal methods for commonsense reasoning; support of large AI systems

REPRESENTATIVE RESEARCH ASSIGNMENTS AT SRI (since 1977)

Expert systems: use of Bayesian and information-theoretic inference techniques in PROSPECTOR

Natural language understanding: interpretation of utterances relative to a conceptual schema; metarules for encoding linguistic generalizations

Planning: knowledge/belief contexts in a multiple-agent planning environment

OTHER PROFESSIONAL EXPERIENCE

Member of the Center for Study of Language and Information, Stanford University

Invited lecturer, Laboratoire d'Informatique Fondamentale et d'Intelligence Artificielle, Grenoble, France (February 1986)

Invited lecturer, Departimento di Informatica e Sistemistica, Universta degli Studi di Roma ''La Sapienza,'' Rome, Italy (October 1984)

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ACADEMIC BACKGROUND

B.A., European studies and physics (1975), Amherst College Amherst, Massachusetts

M.S., computer science (1978) University of Massachusetts, Amherst, Massachusetts

Ph.D., computer science (1984), Stanford University, Stanford California