# Report on a Research Visit to ICOT

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## 1 Introduction

I was invited to visit ICOT for a period of two weeks, in the second half of October, 1990. I was delighted to accept this invitation, as I had much to discuss with several ICOT researchers working in the area of nonmonotonic reasoning. Also, I wanted to learn more about what had been done at ICOT in other areas. During this visit, I gave three presentations about my own work—two at ICOT and one at the ASTEM Research Institute in Kyoto.

## 2 Research on Nonmonotonic Reasoning at ICOT

ICOT is fortunate to have a strong group of researchers working on the theory and applications of nonmonotonic reasoning. Mr. Jun Arima, Mr. Katsumi Inoue and Mr. Ken Satoh impressed me, first of all, by their excellent knowledge of the literature, including the most recent European and American publications. (On one occasion, after I described one of my half-baked ideas to Mr. Inoue, he pointed out to me that it was similar to a proposal made in a forthcoming Stanford technical report that I was unaware of!) In fact, I know very few research centers where it is so easy and pleasant for me to disuss ideas related to nonmonotonic logic and to the foundations of logic programming. From the first minute, our discussions were totally free from misunderstandings, and long explanations were unnecessary, as if we had been working together for years. The high professional level of the research done by Mr. Arima, Mr. Inoue and Mr. Satoh demonstrates their perfect command of the technical apparatus of the theory of nonmonotonic reasoning. Their ideas are original and relevant,

and it is pleasure to read their papers because of their elegant mathematical style.

Mr. Inoue explained to me his work on algorithms for computing circumscription. His most recent contributions to this field include extending the methods developed earlier to the case of existential queries and to answer extraction problems. It would be interesting to see if these methods are applicable to the formalizations of action in which circumscription is used for solving the frame problem. Answer extraction for such theories can be applied to planning. This would be a natural extension of the classical work by Cordell Green.

The other subjects that I discussed with Mr. Inoue are contradiction resolution, abduction, and the semantics of epistemic queries and integrity constraints in the context of extended logic programs. He has contributed both to the development of the theoretical framework for studying these problems and to the investigation of possible computational mechanisms.

Mr. Satoh's work on "soft constraints" is an interesting example of the use of prioritized circumscription for formalizing commonsense reasoning. First Mr. Satoh explained to me the theoretical framework, and then, in another meeting, gave an impressive demonstration of how his main example could be done automatically by a CHAL (Hierarchical Constraint Logic Language) system. Many examples of prioritized circumscription arising from soft constraints problems can be probably handled also by the symbolic procedure for the elimination of varied predicates in circumscription, developed in my IJCAI-85 paper, *Computing Circumscription*. We applied that method to his main example, and it worked out without much difficulty.

I have also learned about Mr. Satoh's current research on computing abduction using a nonmonotonic truth maintenance system. His ideas extend earlier work by Elkan, Eshghi and Kowalski, Kakas and Mancarella, Sacca and Zaniolo, and others. This is a hot research area, and it is certainly worthwhile to do more work in this direction.

## 3 Other Discussions with ICOT Researchers

On the first day of my visit, Dr. Kazuhide Iwata explained to me the aims, organization, and the system of funding of the FGCS project, the structure of ICOT, its interaction with industry and universities, and the directions of research pursued here. He told me about ICOT international exchange activities, and I was impressed by their scope and magnitude. The exchange program has certainly made an important contribution to the development of contacts and cooperation between Japanese scientists and their Western colleagues, and tremendously benefitted both sides.

Dr. Iwata introduced me to Dr. Kazuhiro Fuchi, and I had a chance to thank him personally for the invitation to conduct research at ICOT. I also met Dr. Kazunori Ueda, who is a co-editor of the special issue of *New Generation*

*Computing* collecting selected papers from the Seventh International Conference on Logic Programming. I gave to Dr. Ueda a copy of my contribution to the special issue (joint with Michael Gelfond). We also discussed Dr. Ueda's work on the organization of the next logic programming conference.

On the same day, two interesting demonstrations were given— of an implementation of a concurrent truth maintenance algorithm and of the use of APRICOT/0 for logic design.

Dr. Koichi Furukawa told me about his interest in Muggleton's work on application of resolution to learning. Indeed, the use of "inverse resolution" for inventing new predicates seems to be the first real bridge between learning theory and logic. I will not be surprised if this idea leads to a major breakthrough in the area of learning.

Mr. Jun Arima explained to me his abduction-based approach to the problem of modelling analogical reasoning. Since I am not familiar with the earlier work on analogical reasoning which serves as a foundation for his research, I cannot speak with real confidence, but my impression is that Mr. Arima's approach is sound and promising.

## 4 My Presentations at ICOT

Here are the abstracts of my talks at ICOT.

> *Deductive Databases and Default Theories* (talk at the meeting of the DDB and AI Working Group, October 24). In current research on logic-based languages for data intensive applications, the procedural semantics of Prolog is rejected in favor of a purely declarative approach. In particular, the meaning of negation as failure needs to be defined in a declarative way. Several attempts have been made to relate the declarative semantics of negation as failure to nonmonotonic formalisms, such as circumscription and default logic. Default logic turned out to be the most appropriate tool for this purpose.
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> *Open Defaults* (October 26). In Reiter's default logic, the parameters of a default are treated as metavariables for ground terms. We propose an alternative definition of an extension for a default theory, which handles parameters as genuine object variables. The new form of default logic may be preferable when the domain closure assumption is not postulated. It stands in a particularly simple relation to circumscription. Like circumscription, it can be viewed as a syntactic transformation of formulas of higher order logic.

Since both talks have to do with default logic, the fact that Prof. Reiter's visit to ICOT was scheduled at the same time as mine was a particularly fortunate

coincidence, as I could benefit from his comments and criticisms. Other participants, too, asked interesting questions. I enjoyed giving seminars at ICOT very much.

## 5 Visit to ASTEM

Prof. Reiter and I spent Monday, October 22 (and the preceding weekend) in Kyoto, where we met with Mr. Chiaki Sakama. He told us about his research on the semantics of disjunctive databases, which is one of the problems that I am currently working on.

Some of the ICOT researchers visited Kyoto on the same day and attended the talk that I gave at ASTEM. Here is the abstract of the talk:

> *Classical Negation in Logic Programs and Disjunctive Databases.* An important limitation of traditional logic programming as a knowledge reprersentation tool, in comparison with classical logic, is that logic programming does not allow us to deal directly with incomplete information. In order to overcome this limitation, we extend the class of general logic programs by including classical negation, in addition to negation as failure. The semantics of such "extended" programs is based on the method of stable models. The concept of a disjunctive database can be extended in a similar way. Some facts of commonsense knowledge can be represented by logic programs and disjunctive databases more easily when classical negation is available. Computationally, classical negation can be eliminated from extended programs by a simple preprocessor.

After the seminar, I learned that some of the ASTEM researchers had independently arrived at similar ideas about handling incomplete information in logic programs. The exchange of opinions on this subject was enjoyable and fruitful.

## 6 Concluding Remarks

As I was writing these lines, I received a copy of the report on the visit to ICOT just completed by Prof. Reiter. I would like to say that I enthusiastically support the views he expressed in Section 4 of the report ("Some General Comments"). The creation of a group of people capable of doing good quality basic research in AI is an important achievement of ICOT. Is there a way to assure that, after the termination of the project in 1992, this group of researchers will not be dissolved, but will be able to continue the work that they are doing now? I would like to believe that this can happen.

## 7 Acknowledgements

First I would like to thank Dr. Fuchi for inviting me to ICOT. My thanks go to Dr. Iwata for making all the arrangements before and during my visit, and especially for honoring me with an invitation for a dinner party and a tea ceremony at his home. Thanks to Mr. Hiroshige and Dr. Furukawa, who hosted an ICOT lunch and a welcome party for us.

I am grateful to Mr. Satoh for initiating the idea of this visit, for being such a wonderful host, and for taking me on an exciting tour of Kamakura. Mr. Arima and Mr. Inoue helped him to take good care of me during my stay in Tokyo. Thanks to Mr. Sakama for inviting me to Kyoto on the best possible day—October 22—and to the management of ICOT for sponsoring that trip.

# CURRICULUM VITAE

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## EDUCATION

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| 1971 | Ph.D. in Mathematics from the Steklov Mathematical Institute, Leningrad, USSR. |
| 1968 | Degree in Mathematics (B.S., M.S. equivalent) from Leningrad University, Leningrad, USSR. |

## RESEARCH AND TEACHING APPOINTMENTS

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| 1985-now | Senior Research Associate, Computer Science Department, Stanford University. |
| 1982-84 | Associate Professor of Computer Science, University of Texas at El Paso. |
| 1979-82 | Assistant Professor, University of Texas at El Paso. |
| 1977-79 | Visiting Assistant Professor, Brigham Young University. |
| 1976-77 | Research Associate, Stanford University. |
| 1971-74 | Research Associate, Institute of Mathematics and Economics, Leningrad, USSR. |

## MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS

American Mathematical Society.

American Association for Artificial Intelligence.

Association for Computing Machinery.

Association for Symbolic Logic.