Report on my Visit to ICOT in August 1989

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1 Introduction

I had my first contact with ICOT when Dr. Iwata visited GMD in the spring of this year. I was very glad to be invited to ICOT, as it is one of the world's most famous research institutes in the IT domain.

2 Discussing EPSILON

Most of my report is concerned with the knowledge acquisition research of ICOT's fifth laboratory, as I spent most of my time discussing these topics during the two weeks of my stay.

2.1 My understanding of EPSILON

I first heard about EPSILON when Mr. Taki visited GMD end of June of this year and gave a talk on his research. Shortly afterwards we met again at the European Knowledge Acquisition Workshop in Paris. I will give a short rendering of my view of EPSILON, as it is implemented now on the PSI machine[1]. EPSILON 1.0 acquires knowledge of two kinds:

[1] I will refer to EPSILON 1.0 if I discuss properties of the current implementation that differ from the description given in the papers about EPSILON. The functionality of EPSILON 1.0 seems to be a subset of the functionality of EPSILON.

- *Expert Models* that contain the procedural aspects of human expertise;
- *Evaluator Groups* that describe how single decisions are taken within the problem solving process described in the expert models.

Currently EPSILON 1.0 acquires knowledge for analytic tasks. It is important to note that in EPSILON the number of building blocks for analytic systems is limited to 7, thus allowing for a typing of the elements of the expert models, which in turn is used to guide (and constrain) the acquisition of the knowledge needed for the evaluator groups.

Current research is concerned with the developement of a comparable set of typed building blocks for the modeling of design tasks.

As mentioned before, the description given above relates to the implemented Version 1.0 of EPSILON. In the original paper on EPSILON, published at IEEE Expert Systems in Governement 1987, more emphasis was given to the separation of the definition of the conceptual structures and the ways human experts use these structures.

According to Mr. Taki the current implementation must be seen as a subset of the future system, that relies on the knowledge acquisition methods available today. No acquisition techniques are known for the acquisition of task knowledge, as it was originally proposed for EPSILON.

During my stay, Mr. Taki reimplemented a sample BABYLON knowledgebase using EPSILON. This allowed me to get a more detailed insight into the mechanisms of his tool, and to compare the knowledge acquisition procedures of KSS0 (a Canadian tool originally used to develop the knowledge base), IRA-grid (my own tool) and EPSILON.

2.2 Relating the knowledge modeling features of EPSILON to the knowledge modeling research at GMD

In GMD's Expert System Research Group we use the KADS (Knowledge Acquisition and Design Structuring) methodology to describe knowledge on several levels. KADS distinguishes 4 kinds of knowledge: *domain, inference, task* and *strategic* knowledge. The *inference level* describes how behavior described on the *domain level* can be used to obtain certain minimal inference functions, the *task level* describes how these inference functions can be used to fulfill goals.

EPSILON 1.0 does not draw such a clear distinction between symbol-level information (this corresponds to the domain-level in KADS) and knowledge-level information (this corresponds to the other three levels in KADS). The expert models of EPSILON 1.0 correspond, in my opinion, to a compiled form of domain, inference and task-level, i.e. they do not describe the use of the knowledge in a generic form, but they represent a particular application of that knowledge. This approach has several advantages:

- compared to the *rapid prototyping* approach, EPSILON obtains a better structuring of the knowledge, i.e. the expert model describes the purpose of a bit of knowledge that is used to operationalize the evaluator of an operation;
- compared with *Chandrasekaran's Generic Tasks*, EPSILON 1.0 allows for higher flexibility, as the building blocks for the problem-solving models are of a finer grain;
- compared with KADS, it seems to allow for easier operationalisation of the knowledge-acquisition process.

I see the following limitations for this approach:

- as EPSILON 1.0 does not distinguish between an inference and the goal of this inference, it may not be able to represent its knowledge in such a form that it can again be used later on by another knowledge-based system that works on a different task;
- EPSILON's expert models are extensional representations of the problem-solving process, they are not generic descriptions of the procedure. In analysis domains this may not be a matter of concern, but I don't see how longer repetitions through problem-solving patterns can be described without loop-constructs using generic representations of the problem-solving procedure. Such descriptions will certainly be needed in applications of EPSILON to general synthetic questions.

2.3 Relating the knowledge elicitation features of EPSILON to our research at GMD

In the KRITON knowledge acquisition project of GMD we have looked at techniques to automate the knowledge elicitation part of the knowledge acquisition process. To this purpose we automated analysis techniques for transcripts of concurrent protocols and interview techniques based on repertory grid.

In the actual phase of the KRITON project we are trying to combine the knowledge elicitation methods, that we have developed with the knowledge-modeling facilities of the KADS methodology. Thus we must define the *knowledge needs* of a problem-solving process and the *knowledge-delivery capabilities* of knowledge acquisition tools and techniques. This will hopefully allow us to match knowledge acquisition tools to specifications of problem-solving processes. We have developed a first prototype, called IRA-grid, that acquires some of the knowledge needed for certain phases of classification and diagnosis processes. IRA-grid uses graphical repertory-grid interfaces to elicit and structure the knowledge. For the analysis of the knowledge we use implication-analysis techniques together with our inference and representation tool BABYLON.

In our approach we assume that it is difficult for an expert to express his knowledge in a straightforward way, and that we must support this process extensively. Furthermore, we use a specific life-cycle view that strictly separates, among others, the phases of specification of the problem-solving procedure (*knowledge level*) from the acquisition of the knowledge needed to solve problems in the specified way (*symbol level*).

In my opinion the approach in EPSILON is quite different, as it seems to assume that experts can easily express their knowledge in a machine understandable form.

In one of our discussions, Mr. Taki mentioned the need for the integration of the results of CTAS, an earlier knowledge acquisition tool based on the use of repertory-grids, together with the features of EPSILON. According to Mr. Taki the difference between *ill-structured* and *well-structured* problems must be seen as the motivation for this integration. This would mean that repertory-grids are used as a way to structure a domain before starting the construction of an expert model.

It is my proposal to use repertory-grids to acquire the knowledge needed for the evaluator functions of the expert-models. This implies though, that repertory-grids be used after the domain has been structured. In my view repertory-grids would be used as a knowledge-elicitation interface on top of EPSILON during the *model instantiation phase*.

I will give a brief outline of how repertory-grids can be used for the different operations. For the operations *selection* and *classification*, which basically put their input-elements into one or more output classes according to attribute-values, we can use grids whose traits are attributes, and whose entities are examples. One additional trait is included in the grid that indicates to which output-class the example belongs. Induction algorithms are used to generalize the examples. This use of the grids, i.e. entities as examples and not as solutions is Brian Gaines' view and it is not compatible with the way grids are used by John Boose in ETS/AQUINAS.

The *translation* operation can be implemented in the same way. Here the additional trait represents the results of the translation. Again induction algorithms must provide the more general translation rules.

For the *ordering* operation the use of grids is not so straightforward. An additional trait has to be introduced that represents the distinct ordering of the examples, i.e. their numeric position on an absolute scale. In this case it will be more difficult to induce general rules from the examples. This may not be a very natural way to use grids.

Repertory-grids together with analysis techniques like *induct, focus* and *princom* would, in my view, provide ideal input for the operator-presumption method that Mr. Taki presented at EKAW89.

The use of repertory-grids as expert-friendly interfaces to acquire the knowledge needed for the evaluation functions, is not a contradiction to Mr. Taki's proposal to use grids to structure the domain. I think both proposals are highly complementary.

2.4 Comments on the knowledge acquisition research at ICOT

I was astonished to see how little importance knowledge acquisition has within ICOT, especially as I expected that KIPS (Knowledge Information Processing System) would make knowledge acquisition one of the major research topics. Knowledge acquisition seems to be "only" an application of the capabilities of the computer, and it is not seen as one of the fundamentals of intelligent machines. Furthermore the research at ICOT seems to focus very much on the technical side of the problem. Problems that seem not to be of interest are, e.g. validation, acquisition from multiple experts, use of hypertext/media for knowledge acquisition and integration of acquisition with performance.

3 More Projects of ICOT

I will be very brief in my report of other projects that I got to know at ICOT, as they are outside of my research field.

Mr. Oka gave me a presentation of his work on cognitive models, separating two kinds of computation (central and distributed) by analogy of conscious and unconscious processing in the human mind. The technical aspect of the separation between central and distributed control in the computation process seemed to be a major concern.

Mr. Ishikawa gave me an overview of his work on knowledge-based systems in job-shop scheduling applications. His research on knowledge-based constraint relaxation seems a promising basis for *limited resource reasoning*.

With Mr. Yokoyama I had an interesting discussion on the use of constraints for parametric design and parts selection in the FREEDOM system. I think his research is closely related to work in the domain of *plan refinement*. Plan refinement has been used at Stanford Medical School for the construction of cancer treatment protocols.

Mr. Taki arranged for a meeting with Mr. Furuya, Mr. Uchihashi and Mr. Yamazaki from NTT. They gave a very interesting presentation on their work on repertory-grids, hierarchies and their application to the developement of classification expert systems. There seems to be a high interest for commercial knowledge acquisition tools for those expert system shells that are on the market now.

Mr. Terasaki presented and demonstrated MECHANICOT for me. I think

MECHANICOT is an interesting application of constraint-logic programming to realize parametric design. We shortly discussed the class of problems for which tools like MECHANICOT can be used. It seems to be generally applicable for problems that can be hierarchically subdivided into *separate* subproblems, each related to its own set of design requirements. This is especially interesting as, according to Mr. Terasaki, TQC (Total Quality Control), a method widely used in Japanese industry, produces exactly that kind of problem specifications.

With Mr. Maeda, Mr. Taki and Mr. Terasaki I had a long discussion on knowledge acquisition for design processes. This was very fruitful for me, and I will try to apply the results of our discussion to some problems that we are currently treating at GMD. In brief, we think that for mechanical design we can:

- define functions and parts;
- map the functions to parts;
- relate the functions by constraints, thus aggregating them into more complex functions;
- map the complex functions to aggregates of parts.

The two complex networks on parts and functions that this produces, can be used for *parametric design* systems like MECHANICOT, and hopefully they can be used for for *redesign*, too. For *redesign* we propose to exchange parts or aggregates of parts with other parts or aggregates thereof, as long as the new parts provide adequate functional structures, i.e. their functional structures must fulfill the constraints used to link the functions of the original design.

4 Acknowledgements

I want to thank Dr. Fuchi for inviting me to ICOT, and Dr. Iwata for the just perfect organization of my accomodation. Many thanks to Mr. Ikoma and all the members of the fifth laboratory for welcoming me to their laboratory.

Special thanks to Mr. Taki and Mr. Maeda who both very patiently answered my countless questions on Japanese research, and who treated me to a great visit to Kamakura. I am in great debt to both of them, as they showed and told me much about Japanese life and tried to give me a taste of every aspect of Japanese cuisine.

I would be glad if I could do the same thing for any member of ICOT who visits our lab at GMD.

Personal Profile

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Curriculum Vitae :

born 02.02.1961 in Luxemburg

Diploma in Informatics of the University of Kaiserslautern in 1987

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Area of Research :

Knowledge Acquisition for Knowledge-Based Systems

Co-Chairman of the 2nd European Knolwedge Acquisition Workshop (EKAW88) in Bonn;

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