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Foreword

The roots of this book can be traced back to a conversation I had with Gerhard Strube at the German Workshop on Artificial Intelligence (GWAI) in September 1989. As spokespersons of the Special Interest Groups (SIG) Cognition and Knowledge Engineering of the German Society for Informatics (GI) Gerhard and myself were wondering whether any knowledge engineering tools could be applied or analyzed in cognition research and what insights and methods of cognitive science might be relevant for knowledge engineers. To answer these and related questions we decided to have a common workshop organized by the two SIGs. At the next SIG meeting on knowledge engineering in April 1990 at Berlin, I asked Franz Schmalhofer and Thomas Wetter to organize such a workshop together with Gerhard. This joint workshop was then held February 21–22 at Kaiserslautern.

At the workshop, the first thing I learned was that the relationship between our two disciplines is not a simple import/export business. For instance I was told that repertory grids, the best automated knowledge elicitation technique of all, are not very popular with scientifically oriented psychologists. And imagine, knowledge engineers imported it blue-eyed! On the other hand, I would never bore and consequently nerve an expert with a repertory grid technique, even if some psychologist told us that enraged experts tend to answer more to the point.

But how should knowledge engineers, being too busy to become a semi-expert for each new application, keep up-to-date with cognitive science as well? Nor could we require cognitive scientists to become knowledge engineers! Well, we have to keep ourselves mutually informed about the hot spots, will say, problems, approaches, trends, or shifts of paradigm in each discipline. This is exactly what we did at our workshop.

- For instance, the last few years have witnessed a shift of paradigm in knowledge engineering. It was recognized that expertise cannot be simply extracted from the human expert and his books and mapped onto the machine. Neither is an expert's head a container of thousands or millions of rules. Second-generation knowledge engineering, as we might call it, is viewed as a creative process that engages knowledge engineers and experts in (re-)constructing knowledge and problem solving methods so that they can be made to run on a computer, resulting in an expert support system rather than an expert replacement system. While first-generation knowledge engineers might have been able to simply import methods from other disciplines to extract the knowledge, cognitive science is now becoming more important in the new paradigm. This subject came up quite a number of times.
- A more specific issue concerned the generic problem solving methods which are being adopted by more and more knowledge engineers. Are experts actually in command of such generic procedures which they suitably instantiate for their respective tasks? Or don't they distinguish domain-specific and generic knowledge at all? Another question addressed to cognitive scientists inquired their opinion on multimedia representations.

- As a second type of cooperation it was suggested that cognitive scientists could take the knowledge engineer's methods, tools, or expert systems back into their laboratories in order to experimentally determine their cognitive adequacy, whatever is meant with this term.
- A subject where both disciplines were already cooperating is that of cases, both as they arise during knowledge acquisition and as they are used for case-based reasoning. Questions tackled were: How do humans proceed from cases to more general rule-like knowledge? When do they reason by cases or by analogies, when do they use heuristics or first principles? How does case-based reasoning work, and how is it related to learning?

The workshop benefitted from international contributions from Canada, England, France, Switzerland, and the USA, demonstrating how knowledge engineering and cognitive science are interwoven between those countries. But to be quite honest with you, the (potential) reader of this book, I was not the only attendant of the workshop who was surprised by the wide gap between our two disciplines.

Then why did we write this book? Because by now we understand much better which questions we should ask and which we should better forget. And although Franz, Gerhard, and Thomas put lots of work and pain into organizing the workshop and editing the book (and this foreword), it still does not answer all the questions we raised. Reading this book will consequently not give you any final answers, but hopefully provide you with intriguing stimulations for producing your own answers. Those of you who are only interested in a quick import/export affair, need not go on reading. Our book is intended for persons who are really interested in the cognitive science aspects of knowledge engineering. But be warned: the articles reflect their authors' different backgrounds. And they assume a certain familiarity with central notions. For instance, you should have heard about KADS or MOPS.

The book is structured into three parts: The first one contrasts work in knowledge engineering with approaches from the side of the "soft sciences". The second part deals with case-based approaches in expert systems. Cognition research and the cognitive adequacy of expert systems are discussed in the third part.

My personal route through this book, which I do not want to conceal from you, deviates from this structure and is more oriented towards the course of the workshop:

Franz Schmalhofer sets off to explain the paradigmatic shift leading to a second generation of knowledge engineering approaches. He argues that the import/export attitude which sometimes emerged during the workshop must be replaced by interdisciplinary approaches.

How he personally experienced the shift of paradigm in his knowledge acquistion project is reported by *Marc Linster*. He sees the new task of cognitive scientists in helping to find an adequate modelling terminology and later in evaluating the resulting expert systems.

Gerhard Strube picks up a panel discussion which, according to the opinion of many participants, was the highlight of the workshop. It centered around the fuzzy notion of cognitively adequate expert systems. Everybody claims to build such systems – just like everybody claims to follow a model-based approach – but Gerhard elaborates at least three different readings of that notion. He argues why we should strive at building "strong cognitively adequate" systems, and thus imposes certain requirements on knowledge engineering paired with concrete advice on the first steps to be taken.

Four articles present different methodological views on knowledge engineering. Although I would not call them completely incompatible, they demonstrate how far the field is still from having a consistent view of itself.

- In their very detailed survey on psychological literature, *Brian Woodward, Mildred Shaw, and Brian Gaines* stress the cognitive processes going on while knowledge engineering.
- *Beate Schlenker and Thomas Wetter* view knowledge acquisition as an iterative process of scientific theory formation driven by falsification. They try to reformulate a scientific paradigm in order to make it applicable for knowledge engineering.
- *Dieter Fensel* argues that knowledge acquisition and qualitative social science have common goals, and suggests how to adopt techniques developed by the latter for knowledge engineering.
- *Rolf Pfeifer, Thomas Rothenfluh, Markus Stolze, and Felix Steiner* present the most concrete approach. They suggest how to match think-aloud protocols with generic problem solving models. Thus they partially answer one of the questions I raised above.

The next three articles report on experiences with actually employed knowledge acquisition systems. The tools developed by the three groups are candidates to be taken back to the laboratories of cognitive scientists.

- Their work on knowledge acquisition front-ends that are to completely replace the knowledge engineer drives *Frank Puppe and Ute Gappa* to pose two urgent questions to cognitive scientists, namely the ones I already mentioned before: How cognitively adequate are "canned" problem solving methods, and what about graphical knowledge representations?
- *Nigel Shadbolt* presents problems that arose in designing an integrated knowledge acquisition workbench in the ACKnowledge project. He discusses different types of users whose different needs have to be taken into account.
- *Geoffroy Dallemagne, Georg Klinker, David Marques, John McDermott, and David Tung* describe Spark, Burn, Firefighter, a knowledge-based software engineering tool. It helps application programmers with workplace analysis, selecting pieces to be automated and configuring these programs from available mechanisms.

The last group of articles is about cases, as they arise during knowledge acquisition and in case-based reasoning.

- *Klaus-Dieter Althoff* establishes the terminology and gives a survey of case-based approaches as compared to machine learning. His article should help to classify the following ones.

- In a short survey, *Sonja Branskat* gives the flavour of a tool she developed to support the knowledge engineer in gradually transforming cases as they appear in the real world, laden with context, to the formal and often decontextualized representations used by case-based reasoners.

- *Peter Reimann and Thomas Schult* report on experiments they conducted to find out how humans learn from examples in physics text books. In particular, they deal with the basic mechanisms involved in learning from cases in complex domains. Their results should carry over to knowledge engineers who typically are confronted with such situations.

- *Franz Schmalhofer, Christoph Globig, and Jörg Thoben* describe how they built a system implementing the generic problem solving method of skeletal plan refinement. They elicited cases to acquire the skeletal plans employed by their system. Their system is situated in the sense that new skeletal plans can be acquired during normal operation. They relied on the expert's experience, perception, and selected attention which enable him to identify the right cases as a basis for refinement.

- *Ralph Bergmann* goes on to present the explanation-based learning method used to automatically abstract cases into skeletal plans. They are partially based on common sense knowledge.

- *Michel Manago and Noel Conruyt* describe their extension of the ID3 induction algorithms to a frame-based knowledge representation language. They show that mechanical learning techniques can be considerably enhanced when the knowledge engineer imposes a suitable structure on the representation of cases. Their paper includes a one-page comparison between learning and case-based reasoning.

- From their cognitive science perspective, *Dietmar Janetzko and Gerhard Strube* compare case-based reasoning approaches with those using generic problem solving methods, coming up with suggestions of how to integrate both. By transferring ideas from cognitive science into the knowledge engineering terminology of the KADS methodology, their article builds a bridge between the two disciplines.

In his concluding remarks, *Thomas Wetter* does a tremendous job in bringing together many controversial arguments we encountered at the workshop and presents, if not a final word, a comparative assessment.

Now you are asked! What is your opinion about this book, and more importantly, about the questions it raises, and the tentative answers it proposes? Please let us know, possibly using the forum of our two special interest groups in the GI. Hopefully, we thus get loaded with a lot of dynamite for a successor workshop.

St. Augustin, May 1992 Angi Voss

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