

Book review

Philip E Slatter and Ellis Horwood 1987

BUILDING EXPERT SYSTEMS: COGNITIVE EMULATION

Reviewed by Nigel Shadbolt, Nottingham University

Despite a glut of titles, many of the recent books on expert systems have been lack lustre, covering the same familiar territory. This book attempts to do something rather different. It seeks to understand how the principles of "cognitive emulation" could be used to guide expert system construction.

Cognitive emulation is the attempt to implement the architecture, processes and representations of human expert cognition in the programs of expert systems. In fact the emulation might extend beyond domain experts. The goal is the emulation of any aspect of human cognition that could assist in the construction of expert systems; either emulation of the expert, or of the general user.

It would appear then that cognitive emulation must be based on the findings of empirical and theoretical psychology. Slatter argues that many of the precepts of cognitive emulation have found their way into expert systems from psychology via artificial intelligence. I will have more to say about this claim.

It is possible to discern in the book weak and strong versions of the emulation principle. The weak version is a wish to construct systems in our own image. Systems that will match our own criteria of expertise, that will perform in the same way we do and to the same level. It is taken as self evident that such systems are desirable. A little reflection might make us wonder. Are human experts always so reliable, transparent and user-friendly!

The strong version of emulation asserts that the established "cognitive facts" are already sufficient to help us build better systems. Here there ought to be facts to ascertain, clear evidence of the benefits of embodying psychological principles in programs. It is this stronger version of emulation which might act as a design guide and a prescription for expert system construction. It is this view of emulation that is examined in the majority of Slatter's book.

The book grew out of work the author did for a higher degree at the Open University. It is generally up to date. The main problem with the book is a structural one, it lacks balance. The book has some very short chapters with a very long fifth chapter. Part of the problem stems from the fact that terms are introduced and seldom really defined. More history and scene setting would have helped his exposition and also given the book a better balance.

The first chapter is introductory, it describes the scope and structure of the book and provides a definition of cognitive emulation.

Chapter two begins with a summary of the common assertions that system implementers, rather than psychologists, make about the nature of expertise. For example, it is claimed that expertise demands a great deal of domain knowledge, that experts know the limits of their knowledge, and that they are adept at dealing with exceptions to the general care. It is usually claimed that experts are able to reorganize their knowledge, and that they have insight into their own problem solving methods.

Slatter goes on to say that "most of these statements are broadly consistent with cognitive research". But he adds the caveat "the main restriction in evaluating such assertions has been the lack of coverage of certain topics in the psychological literature".

This is obviously embarrassing for the thesis of strong emulation. Moreover, there is another problem, and it is one that Slatter largely ignores. The fact is that many of the new ideas in psychology have their roots in Artificial Intelligence. Accounts we find used in some of the more up to date psychology texts include appeals to frames, structured objects, hierarchical and nonlinear planning, mechanisms of reason maintenance (cf. for example, Friedman et al., 1987). The detailed

exposition and development of these concepts is to be found in Artificial Intelligence. If we believe that psychology dictates architectures and processes for expert systems, and these turn out to owe most of their content to AI, then we are locked into a vicious circle of justification.

The rest of the second chapter looks at various “research findings” from psychology. Slatter reviews what we know about the structures and processes of long term memory. He describes what is known about the nature of learning and the effects of practice. There is discussion of those abilities that are under conscious control, accessible to introspection and capable of articulation. He deals with the methods of eliciting expert knowledge. He reviews the work that has reported on how humans process and deal with probabilities and uncertainty. These are all discussed with reference to the important psychological literature.

One criticism of the chapter is the extent to which the storage and retrieval model of memory is taken for granted. There is no discussion, for example, of the view that human memory is a reconstructive process. This view, which can be traced back in this century to Bartlett (1932), highlights the importance of experience and expectations in the rebuilding of representations of past events and “facts”.

The very short third chapter is a more detailed exposition of the reasons for adopting cognitive emulation in knowledge engineering.

Chapter four considers in detail why the enterprise of cognitive emulation might be compromised. Slatter mentions some philosophical problems. Emulation might fail because the human cognitive system cannot be reduced to a physical symbol system. Then there are practical problems for cognitive emulation. Human expertise may often be idiosyncratic and in some cases incommunicable. Some of the features of good knowledge engineering practice may not be features of expert cognition. Slatter outlines the potential conflicts. One of his examples is the requirement that knowledge can be represented in a modular manner. This is desirable from a knowledge engineer’s standpoint because, amongst other things, it produces a knowledge base that is easier to modify, simpler to comprehend and easier to manipulate. One manifestation of this requirement is a knowledge base built as a set of production rules. However, we know from psychology that a human being’s knowledge is often highly integrated and interdependent—there is none of the autonomous modularity of productions.

Not all of the potential problems lie with psychology. Our expert systems technology is not all that we might desire. It is possible that the tools at the disposal of knowledge engineers are insufficient to emulate what little we do know.

The fifth and major chapter of the book examines the place of emulation in current knowledge engineering practice.

Slatter first considers the question “How far can we emulate individual experts?” A good deal of the discussion focuses on the difficulties of knowledge elicitation. This is a problem that requires us to take psychological research seriously. Psychology has furnished us with techniques of elicitation. Moreover, there are recommendations about how to conduct elicitation based on the theoretical matching up of domains with elicitation techniques. However, there is, as yet, little hard empirical evidence to support these recommendations.

In the rest of chapter five Slatter does a good job of reviewing work which, whether by design or accident, emulates human information processing. At the end of the chapter there is a brief discussion of emulation in its starkest form—connectionism. Connectionism challenges the assumption held by many psychologists that we can abstract away from the detailed neural architecture of the brain. The connectionist approach embodies the belief that hardware matters—that we need to be emulating not just the software!

The sixth and concluding chapter presents a summary which is a little weak and repetitious. However, the bibliography is excellent.

Slatter has reviewed a lot of material in this book. If anything it has been “boiled down” too much. Nevertheless, the book is a rich source of references to important psychological and expert systems literature.

What of emulation? It is hard to see how it can yet guide system design. Undoubtedly system

builders would be well advised to understand the characteristics of human cognition and to build systems that synergize rather than antagonize. But the experimental findings that constrain and direct expert system construction are rather thin on the ground. Here the problem is partly historical. The effort in cognitive psychology has not been directed to understanding expert cognition in other than a few unrepresentative domains (*pace* Slatter). It is a challenge to which psychologists should respond.

References

- Bartlett, F.C., *Remembering*. Cambridge University Press, 1932.
Friedman, S.L., Scholnik, E.K. and Cocking, R.R. (eds), *Blueprints for Thinking*. Cambridge University Press, 1987.