Book Reviews

Knowledge-Based Design Systems

R. D. Coyne, M. A. Rosenman, A. D. Radford, M. Balachandran, and J. S. Gero, (Addison Wesley, Reading, Mass., 1990, 567 pages, ISBN 0-201-10381-8)

Reviewed by Amit Mukerjee

The task of design is one of the central challenges for AI and merits more attention than it has received in the past few decades. A harbinger of change is perhaps the book *Knowledge-Based Design Systems* by R. D. Coyne, M. A. Rosenman, A. D. Radford, M. Balachandran, and J. S. Gero (Addison Wesley, Reading, Mass., 1990, 567 pages): It presents the problem from a didactic point of view because the volume is based on an extensive teaching program and related research by this group at the University of Sydney.

One opens this book with certain preconceptions: Here is a problem that is somewhat different from the traditional AI bailiwick; perhaps the problems encountered here will also be different. However, going through this book only serves to strengthen the feeling that all the hard AI problems are now converging on the same set of issues and that the problems that preclude ground-breaking progress in design are much the same as those in vision, planning, learning, and so on. These problems include problems identifying concept similarities, non-monotonic reasoning, and reasoning with uncertainty. Indeed, at the end of the book, the authors do what all other AI researchers are doing today— they look briefly toward neural networks in a gesture of half hope and half despair. We are then left with an unanswered question: Isn't symbolic AI enough? Say it isn't so!

The book opens with an excellent discussion of the design task and the role of knowledge in guiding this task. The sophistication of design activity can be measured by the cate-

gories of refining, adapting, and creating prototypes. *Refining* is extending the function of the prototype. *Adapting* is extending the domain of the prototype, and a cogent argument is that to some extent, all creation is an extensive form of adaptation based on previously existing prototypes. Underlying this process is knowledge about the functional aspects of these prototypes. The general paradigm adopted for designs is based on the availability of this knowledge, which is used to identify possible control actions, information that can then be used to refine or adapt the prototype to meet the design goals. The design problem is then reduced to the problem of searching through these possible control actions to identify a sequence that will result in the desired function. Standard search and control techniques are used in this process.

One of the problems of design is specifying the design intent. There is a good discussion of this issue—goals can be expressed as hierarchies, and different aspects of the goal can be achievable by using different prototypes, reducing the problem to a planning-type search through a space of possibly conflicting constraints. Another problem is determining whether a given design description is complete Making this determination is difficult; the constraints can be too few, leaving a large number of possible designs, or there can be too many, resulting in conflicting criteria that cannot all be satisfied. There does not appear to be any clear solution methodology yet. Another problem is determining whether goals have been achieved or whether certain goals creating conflicts might need to be modified before a successful design can be achieved. A related consideration is the evaluation of the design, where one needs to take into account the degree of effectiveness, cost, and other factors.

Design, like other hard AI problems, is a process of metaexploration that is not constrained to the initial bounds of the problem but can call for changes

in the problem statement itself. The contexts of the problem shift as the design becomes better understood, so that there is also an element of learning in the design task. This issue is important, and the book devotes an entire chapter to it. There is also the issue of brittleness in traditional symbolic approaches. The design constructs can be no more general than the symbolic structures already available for the representation: Machine thought cannot transcend its own vocabulary. These two aspects (concept learning and vocabulary inadequacy) may be why the authors turn to analog and neural models in the final chapter.

Where the book falls short is in illustrating the difference between the design task and other traditional AI problems, such as planning or search. Much of the discussion concentrates on issues that are of broader interest in AI and knowledge-based systems· inheritance hierarchies, model-based reasoning, search and control issues, uncertainty and incomplete information, learning and creativity, and even the use of neural networks. Some of the other issues that one would have thought to be of great significance to design are not dealt with in as much detail as one would expect For example, the first three examples given of design prototype knowledge facts are all spatial in nature (inside, next to, and longer than). Indeed, it seems clear that a large number of design tasks are related to spatial reasoning, but discussions on modeling spatial design attributes are restricted to only 7 pages out of more than 500. However, many approaches to spatial reasoning in design have been discussed in the literature, such as using configuration space for kinematic design (Joskowicz and Addanki 1988), hierarchical models (Samet 1990), or qualitative approaches to modeling space (Davis 1990; Mukerjee and Joe 1990). Another area that merits some discussion in a book on design is the topic of traditional computer-aided design (CAD) systems,

their methodologies, and their predilection toward drafting as opposed to design.

A large body of work exists today in the area of design, including Brown and Chandrasekharan (1989) and Dym and Levitt (1991). Also see the Winter 1990 issue of *AI Magazine*, which was guest edited by J. S. Gero with Mary Lou Maher. By virtue of the teaching experience that supports this book, however, it is more comprehensive and presents its viewpoint in a systematic, orderly progression. The differences between the approaches by different groups are slight. For example, the propose, critique, and modify approach of Chandrasekaran's group (*AI Magazine*, Winter 1990) is akin to the prototype creation, refinement, and adaptation idea previously described. The authors do not make a strong attempt to fuse the disparate terminology of the field.

On the whole, however, this book is constructive and thought provoking book and one of the first to take a long, cold look at the problem of design. Traditional CAD systems provide excellent tools for encoding the final forms of a design, but clearly there is a need to embody more of the function and decision making into the CAD process. Do AI techniques have what it takes to provide this power? This book provides no clear answers, but it does shed light on the progress to date and the possibilities ahead.

References

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