adopt other approaches as heuristics or as richer representations of the issues involved. It seems that Spiegelhalter's approach has been similar.

Secondly, one could validate an expert system by its comparison with expert performance. One can ask whether the diagnosis achieved by Spiegelhalter's system was better or worse than that achieved by competent diagnosticians. There is of course a debate over whether an expert system should be appraised in this way. Is the goal to reproduce the abilities of an expert, or to improve on the abilities of available human judges? If it is the former, then indeed it is sensible to compare performance with experts, but in this case one wonders why one should not use the experts themselves. This could be answered by observing that very often experts are in short supply. If, on the other hand, our goal is to improve on human inference behavior, then the criterion of conformity with some expert performance is not appropriate. A final measure of the appropriatness of an expert system is user satisfaction. To what extent do the people who interact with the expert system feel that the system is of use to them? In Spiegelhalter's case there are two kinds of people involved, namely the patients and the doctors. As Spiegelhalter observes, it is very important that the doctors are supportive of the endeavor and that they do not feel that their professional competence is in any way being threatened. It is perhaps more important, however, that the patients feel that they are being properly attended to. Spiegelhalter seems to have achieved success on both fronts.

4. SUMMARY

Although the purpose of the conference was to discuss the use of the different theories for the representation of uncertainty in expert systems, the principal speakers, perhaps wisely, devoted their discussion mainly to arguing the cases for the use of their different theories in general. On the basis of the discussions we had at this conference, it seems to me that one can summarize as follows. Probability theory has a strong intellectual support and in principle there is no reason why one should not be satisfied with this theory. Its use does, however, lead to enormous problems of complexity, and as a matter of practice it is necessary to seek for approximations. Fuzzy set theory can be viewed as a heuristic for handling those situations where imprecise inputs and imprecise inferences are required without the need to resort to the greater complexity of probability theory. Belief function theory can be thought of as a way of representing inferences from evidence within the probabilistic framework.

There are yet other alternative approaches to handling uncertain inferences which were not mentioned at the conference, and notable among these is the nonmonotonic logic of Doyle. Recently Cohen (Cohen, Watson and Barrett, 1985) has suggested a combination of Doyle's theory with both Shafer's and Zadeh's which he has referred to as the nonmonotonic probabilist. This seems an exciting possibility for approaching the problem at the heart of this conference.

ADDITIONAL REFERENCES

COHEN, M. S., WATSON, S. R. and BARRETT, E. (1985). Alternative theories of inference in expert systems for image analysis. Technical Report 85-1, Decision Science Consortium, Falls Church, Va.

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Comment

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The papers by Shafer and Spiegelhalter are valuable summaries by acknowledged leaders in active research fields. There is much food for thought in both papers, and many of the techniques and issues raised by these authors will gradually become better understood as the field of uncertainty assessment in expert systems advances. Our research on models and techniques for belief function analysis (Kong, 1986; Dempster and Kong, 1986) is complementary to that of Shafer and Spiegelhalter. We all seek to provide tools for real applications, based on carefully constructed analyses expressed through mathematically well-articulated principles of uncertain reasoning.

Lindley is on a different track. He rehearses familiar normative arguments for the Bayesian paradigm, evidently seeking to persuade less committed colleagues to abandon their fallacious ways. Unfortunately, he shows no interest in understanding how his

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