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DISCUSSION ON PAPER 8970 ENGINEERING MANAGEMENT GROUP

PROLOG-based expert systems in civil engineering

S. Alim and J. Munro

Mr I. E. G. Davey-Wilson, *Oxford Polytechnic*
Dr I. M. May and Mr W. Tizani, *University of Bradford*

The Paper highlights the potential opportunities of expert systems in civil engineering by describing one such system for soil problems. There is, however, no mention of the limitations of this expert system or of expert systems in general.

64. The long awaited Fifth Generation of computers will undoubtedly accelerate developments in artificial intelligence and stimulate applications of declarative languages such as micro-PROLOG. Even greater steps will be made when parallel processing becomes widely available, as this will increase by several orders of magnitude the speed of processing available. Consequently, the number of rules or facts (in a rule based expert system) that can economically be tested, will likewise increase to produce more powerful and realistic models of expertise.

65. The Authors may have found that executing numerical calculations for design purposes in micro-PROLOG is somewhat cumbersome, although other versions of PROLOG, notably ESI PROLOG-2, are capable of handling complex arithmetical statements easily. The development of integrated expert systems and computer aided design programs is to be welcomed, but the distinction between the two may become blurred as expert system techniques are used to enhance design programs. Work is currently being carried out into this area at the University of Bradford and Oxford Polytechnic. However, micro-PROLOG based systems are probably better suited to purely knowledge based expertise with small amounts of calculation, as in the system described.

66. With reference to the uses of expert systems in civil engineering, it is easy to theorize on the likely areas of useful expertise. The hard-pressed, inexperienced site or design engineer is unlikely to want to go to the trouble of mastering a complex computer program to answer a trivial question; a quick telephone call or request for advice from a more experienced colleague would be far more efficient.

67. The use of fuzzy logic to produce a numerical 'degree of belief' is a useful technique, common to many expert systems. There is a danger, however, that a numerical value for the belief in the system's solution will intrinsically suggest a higher degree of certainty than is warranted by some of the data. Perhaps in some applications, it would be more appropriate to qualify the particular solution with less precise comments.

68. The expert system described appears quite comprehensive and well controlled; modularity is of considerable benefit in development and execution. APES considerably improves the friendliness of mirco-PROLOG but it still requires expertise of the user to realize its full potential, even with later editions of the software. A

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detailed knowledge of the program is needed to be able to ask a question that exactly matches a rule or fact in the knowledge base. The user must also have an understanding of the type of information in the knowledge base to enable the system to be fully explored. For these reasons, other versions of PROLOG which produce menu driven systems are likely to be much more useful to the practising engineer. More work has to be put into the improvement of such friendliness, ease of use and accessibility of such systems.

69. The explanation facilities of APES appear well used in the system. However, it is clear that with a fairly long and detailed interaction, the subsequent explanations are necessarily complex too, clarity being a little clouded by the use of numerical degrees of belief.

70. No mention is made of the possibility of being able to re-enter an interaction to alter some of the data supplied and so tune the model for the user's optimum solution. Micro-PROLOG based expert systems contain their knowledge in rules and facts that can be accessed by a variety of questions unrelated to a specific problem; this would enable the system to be used as a relational data base. Were these possibilities investigated?

71. Several of the questions asked in the interaction seem quite trivial, while others require a reasonable knowledge of the subject to answer, prompting the question: Who is the system aimed at? The variability of the interaction is unavoidable in many expert systems, but can be frustrating for the user. Has the system been tried on potential users and what was their reaction? Unlike this expert system, some systems solve problems with trivial solutions that the user could easily deduce. Expert systems must demonstrate complete knowledge in a domain if they are to be used with confidence. By definition, the end user will not usually be the system developer.

72. In conclusion, this application of expert systems demonstrates the potential of artificial intelligence in civil engineering, but it may well end up like the vast majority of expert system and never actually be used in practice. Expert systems certainly have a future in civil engineering but the gap between theory and practice has to be bridged. The development and supply of expert systems must eventually be led by demand from the potential customer or user—once the customer is aware of current expert systems developments.

Dr Alim and Professor Munro*

The writers have pointed out that the limitations of this expert system (ES) have not been mentioned. It is necessary to admit that this ES is only a small beginning and has its limitations. One of the most important limitations is related to the software. The version of PROLOG used here is not as well developed as some other versions which are in existence today. Another area which is not entirely developed is related to the modelling of imprecision and uncertainty.

74. With reference to § 64, I would like to add that when the selection of PROLOG was made, future trends in software and hardware development were, in fact, kept in mind. It is expected that, in future, parallel processing will be a common feature of computers. Software suitable for exploiting parallel processing will therefore make other existing software obsolete. PROLOG is a declarative language capable of exploiting parallel processing.

75. With reference to § 65, it is true that new and more powerful versions of

* Deceased.

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PROLOG are being developed, which not only may be faster in handling arithmetic statements but may not require interfacing with sequential languages such as FORTRAN for mathematical processing.

76. With reference to § 66, an ES in which domain-related knowledge has been completely represented and which fulfils all the prerequisites of a truly useful and robust system is unlikely to be developed for many years to come, by which time, every young engineer, however hard pressed or inexperienced, should be quite comfortable with a computer, by virtue of the changing academic environment.

77. The point raised by the writers in § 67 is not absolutely clear to me.

78. With reference to § 68, it must be clarified that questions are limited to 'How?' and 'Why?'. Hence the user may ask these questions at any stage or about any statement of the the knowledge base without a detailed knowledge of the program. However, I would agree with the writers that a menu driven system or some other form of improved friendliness needs to be thought about.

79. I agree with the comment in § 69 that the clarity of the ES has been clouded by degrees of belief, and I will in fact work on trying to improve this area.

80. With reference to § 70, changes to a PROLOG knowledge-base are extremely simple. Since knowledge exists as declarative statements there is no difficulty in changing any existing knowledge or adding new knowledge. Any contradictions in the knowledge base will be automatically detected by PROLOG itself.

81. In § 71, the writers have raised the question of whether the system has been tried on potential users. This has not been done to any great extent but I certainly agree that this is important and it should be done. The system does not pretend to represent complete knowledge of the problem domain and a great deal more needs to be done.

82. I agree with the writers' concluding comments that the development and supply of Expert Systems must be led by demand from the potential customer.

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