XIII ICSMFE, 1994, New Delhi, India / XIII CIMSTF, 1994, New Delhi, Inde

# EXPERT SYSTEMS

# SYSTEMES SELON LES REGLES D'ART

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## INTRODUCTION

The general area of Artificial Intelligence has always attracted great interest and believers in its almost unlimited possibilities. As a graduate student at Harvard in the early 50's, I remember sitting in the audience at a Doctoral Dissertation examination at which there was a heated debate about the possibilities of using digital computers for machine translation from Russian to English. The computer people were fairly certain that successful machine translation was just a few years away, the linguists were much less optimistic, and some doubted it would ever be possible.

Though many of the more general goals of Artificial Intelligence are still a long way from being achieved, a great deal of progress has been made in certain specific areas. One such area, Expert Systems or Knowledge-based Systems, as they are frequently called, have achieved a certain measure of success.

There are numerous definitions of Expert Systems, varying primarily in the degree to which they claim to perform at a level equal to, or for that matter to outperform, human experts. A commonly accepted definition is:

> user friendly interactive computer program that incorporates the expertise of an expert or a group of experts in a well defined domain.

Expert Systems in Geotechnical Engineering are therefore expected to be able to assist the geotechnical engineer to improve his level of performance and to be a useful supplement to text books, manuals , codes of practice and even occasionally making it unnecessary to require human expert advice.

## EXPERT SYSTEMS IN GEOTECHNICAL ENGINEERING

Arthur Casagrande's Airfield Soil Classification System (later to be known as the Unified Soil Classification System) was certainly one of the early examples of an Expert System. There was a clear decision tree, based on Casagrande's and others experience, that used gradation and plasticity for classifying soil into groups that could be expected to exhibit similar engineering properties. To use today's buzz words, it was eminently clear to anyone who attended Saturday morning tutorials in Pierce Hall, that Casagrande was clearly the acknowledged "domain expert". He used heuristics, commonly known as rules of thumb, that in some cases were to be taken literally. (Polishing a cube of clay with your thumbnail could help distinguish between a CH highly plastic clay and a CL clay of low plasticity). When first published (Casagrande, 1948), the soil classification system was for obvious reasons not computerized.

The geotechnical community was among the first to recognize the potential and take advantage of digital computers for analysis. A paper entitled "The Use of an Electronic Computer for Slope Stability Analysis" by Little and Price appeared in Geotechnique in 1958. The computer used was described as being able to store 402 numbers in internal memory and 8192 numbers on a magnetic drum. An internal publication of a large Geotechnical Consulting firm, dated 1961, reported that a digital computer acquired for accounting work was quickly appreciated as also being useful for geotechnical computations.

At the 9th International Conference on Soil Mechanics and Foundation Engineering, Tokyo, 1977, there was a Specialty session on Computer Analysis in Soil Mechanics: Present and Future. Professor Schiffman in his closing remarks describing the session said "Furthermore, the power of the computer, as an information processing device is in its infancy with regard to geotechnical engineering applications." (Schiffman, 1978).

To paraphrase Feigenbaum and McCorduck, (1983): Even though a lot of the professional work of geotechnical engineers involves the use of mathematical formulae and computational algorithms, the fact is that the difficult choices, the matters that set experts apart from beginners are inferential and rooted in experiential knowledge.

There is a growing interest in the use of Expert Systems in Civil Engineering, as may be evidenced by a perusal of the table of contents of the Seventh ASCE Conference on Computing in Civil Engineering held in Washington D.C. in 1991. It would appear that there are many systems already in use by various organizations and many more in the development stage. In geotechnical engineering interest in Expert Systems has been sporadic. Several very interesting systems have been described in the literature (Adams et al, 1989), (Wong et al, 1989). Most of them are prototype systems that have been developed at Universities. The writer does not know of any Expert Systems in the geotechnical area that are available commercially. There are probably good reasons for this. The market is small, and prototype systems are after all adequate as a basis for journal or conference publication, which in the "publish or perish" situation at most Universities is the primary source of motivation.

## EXPERT SYSTEM DEVELOPMENT TOOLS

Language plays a central role in defining and also imposing limitations on how we communicate with others. The choice of language is also important when communicating through the use of a computer keyboard and screen. Expert systems have been written using languages such as LISP and PROLOG which were developed for general artificial intelligence programming. It is also possible to write Expert Systems in BASIC, Fortran, Pascal etc. It is however suggested that if you are not an experienced programmer, it would be wise to use one of the numerous available expert system development tools.

Early expert system devlopment tools required large computing facilities and expensive software, costing thousands of dollars. In 1985 software costing $500 and less, for use on Personal Computers, started appearing on the market. Claims were made that if one had expertise in a particular area, one did not have to be a computer expert to develop Expert Systems in that area, with this newly developed software. In fact it was felt by many that this new class of computer programs would soon join the ranks of word processors, data base managers and spread sheets that had already become so popular. This, like many other predictions, was before its time. However it was at this point that I decided to see what could be done with this new technology, by trying to develop Expert Systems in Geotechnical Engineering. My first efforts (Wiseman et al, 1987) were in fact made using a $50 rule based, If-Then-Else Expert System shell.

Microcomputer based expert system shells are specifically aimed at professionals whose expertise is not in artificial intelligence computer programming. The most popular of these shells consist of an inference engine for processing if-then rules, editors, user interfaces., access to external computational routines etc. These allow the developer to concentrate on the all important expert system knowledge base.

Recently we have been using a development package called KnowledgePro which in addition to the if-then-else rule based logic, uses modules or "topics" for system organization. The topics themselves can store a set of rules, contain questions for user input, and store information for presentation to the user either automatically by the program or as called for by the user. Further flexibility and user control is provided using a feature called "hypertext" in which key words are chosen by the programmer and appear highlighted on the screen. If such a keyword is selected by the user, a topic by the same name is activated.

Customised help screens are easily prepared using hypertext. These help screens can provide guidance, if needed, in answering questions posed by the system to the user, or other background information that may be useful to the user. With KnowledgePro, scanned photographs are easily incorporated into the system and external computational routines are easily accessed. It is these features which make expert systems so useful in making computational computer programs much more user friendly. Sample screens are shown in Wiseman et al. (1991, 1992).

## CONCLUDING REMARKS

Expert Systems can only be judged when sitting at a computer, preferably with a good colour display and working with the system on a real problem on which one would like assistance. To date we have freely distributed the prototype Expert Systems we have developed to almost any engineer showing an interest, and prepared to comment on their usefulness. All responses to date have been favourable and numerous suggestions for improvements have been received. We have written Expert Systems for Soil Classification, Pavement Evaluation, Subsurface Exploration and for Foundations on Expansive Soils that we have used in teaching Civil Engineering students. They all report finding the programs easy to use and very useful in helping them acquire expertise and a feeling of having also acquired experience (albeit, second hand).

Trying to stay up to date in the wide range of constantly expanding possibilities (both software and hardware) available to the developers of Expert Systems in geotechnical engineering is an almost impossible task. As the Queen said to Alice in Through the Looking Glass 'Now, here, you see it takes all the running you can do, to keep in the same place. If you want to get somewhere else you must run at least twice as fast as that'

## ACKNOWLEDGEMENTS

The author would like to acknowledge the help and enthusiastic encouragement of Prof. J.G. Zeitlen who has been a partner to most of the efforts in expert system development described above.

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