EXPERT SYSTEMS : THE FIFTH GENERATION - MORE THAN A GENEALOGICAL PURSUIT

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The views expressed in this article, are those held by the author and in no way reflect the views of his colleagues or employer.

Abstract

This article describes the nature of Expert Systems and outlines their possible use in the field of building economics. Their usefulness in terms of quantification of uncertainty is also examined. It was found that the benefits of developing Expert Systems are tremendous, but that the success of Expert Systems would be determined by their acceptance by the general public.

Keywords:
Artificial Intelligence, Building Economics, Expert Systems, Quantification of Uncertainty.

1. INTRODUCTION

Sir Clive Sinclair, referring to Artificial Intelligence, stated that "...`Fifth Generation' [computing] is the greatest battle-ground of the century. If we lose we are out of the game" (Brandon, 1984).

Bowen and Edwards (1985) emphatically admit that no evidence exists to prove that there is a need for this paradigm shift and also that the hunt for a new paradigm emanates almost entirely from an academic pursuit of knowledge.

Does this in any way lessen the credibility of Sir Clive's statement that "the `Fifth Generation' is the greatest battle-ground of the century"?

So far the Japanese government has invested US $500 million to this cause and the British government £200 million (Brandon, 1984).

This paper, by way of describing the nature of Expert Systems, outlining their possible use in the field of building economics and by commenting on their usefulness in the quantification of uncertainty, will help to decide whether the `battle' is worth fighting.

2. NATURE OF EXPERT SYSTEMS

Expert Systems are a specialised form of Artificial Intelligence which are still in their embryonic stage (Brandon, 1990). The text that follows will describe the nature of Expert Systems.

2.1 Definitions: (Addis, 1984; Brandon, 1983; Fiegenbaum, 1984; Goodall, 1985)

Many authors have put forward definitions for Expert Systems. They all include terms which refer to the capturing of human expertise within a system which allows interaction with a person of lesser expertise, so that the latter will be able to solve significant problems by using the knowledge of the former. Naylor (1983) extends this definition by saying that the capability of the system to justify its own line of reasoning in a manner intelligible to an enquirer is a further desirable characteristic. Buchanan and Duda (1983) encapsulate the fuller concept of an Expert System by defining it as a computer program that provides expert-level solutions or advice to problems and is heuristic (self learning), transparent and flexible.

2.2 Development

As mentioned earlier, Expert Systems are specialised forms of Artificial Intelligence (Brandon, 1990). Bowen and Erwin (1991), citing Newton (1986) and Steels (1988), propose two types of Expert Systems, viz. first generation Expert Systems which are founded largely on heuristic reasoning based on rules and second generation Expert Systems which incorporate the above concept as well as deep reasoning based on a model of the problem domain, i.e. a self-learning capacity.

Jackson (1986), however, proposes a three stage development. Firstly, the Classical period (1960's) characterised by "game playing heuristic" models. Secondly, the Romantic (mid 1960's to mid 1970's) involving the data capturing of specific and general principles. Lastly, the Modern period (mid 1970's to date) which leans towards self-learning knowledge based Expert Systems.

2.3 Character

The purpose of Expert Systems, among other things, is to increase the understanding of the future, serve as a reference point and to provide a "skeleton for professionals to flesh out"(Brandon, et al 1987). This in turn would lead to further benefits such as enhancement and improvement of expertise, increased consistency in decision making and a speedier decision making process (Brandon, 1988). In addition to this, Bowen and Edwards (1985) see a replication and union of expertise and an improvement in documentation.

Most Expert Systems at present are successful in areas involving surface knowledge, i.e. domain dependent knowledge (Basden, 1983), whereas the real success of Expert Systems lies in the area of deep reasoning, which is domain independent (Bowen and Erwin, 1991). Expert Systems are by nature very competent. They are able to replicate, although to a limited extent at present, the thinking process of humans (Winfield, 1982). Winfield (1982) and Brandon (1990) contend that Expert Systems overcome the `black box' effect in that they allow for interaction with the user by allowing the user to question their "chain of reasoning" and to override any assumptions that have been made. This transparency of Expert Systems establishes confidence in the user as it allows actual control over the system.

Stockley (1987) maintains that with regard to Expert Systems it is important to realise the limitations of any Expert System when using it so as to avoid failure. Kidd and Weldbank (1984) state that for an Expert System to be successful it must contain "the richest collection of information possible about the knowledge which the expert uses."

3. USE OF EXPERT SYSTEMS IN THE FIELD OF BUILDING ECONOMICS

Brandon (1987) says that traditional cost models are found wanting due to their inherent nature. These inherent problems of inexplicability, unrelatedness and determinism are well documented by Bowen and Edwards (1985), Beeston (1987) and Bowen et al (1987). A paradigm shift was therefore needed to overcome these problems (Kuhn, 1970).

In the context of this paper, a model is defined as a tool for evaluating, in terms of cost, different design options at a stage early enough to permit design-to-cost control at the point where control is most needed, i.e. prior to sketch design (Newton, 1987).

3.1 Purpose and Usage

Brandon (1987) sees the Expert System cost model as being to the advantage of society, the client, the employer and the expert. He also maintains that the Expert System will be able to serve the building economist in his decision making process by fulfilling the role of a decision support system. This is echoed by Blanning (1984) and Hamilton (1987), the latter adding that the Expert System should act as a checklist for the practitioner. To be meaningful as cost models for use in building evaluation, Expert Systems should be applicable throughout the building procurement process (Bowen et al, 1987), should conform to a positive design/data/model/output interface (Raftery, 1987) and should be iterative. The iterative concept is supported by Higgin and Jessop (1964) and Morrison and Stevens (1980).

3.2 Problems and Developments

Gray (1987) says that due to the complexity and specialist nature of the building industry, Expert Systems have had limited success. This confirms Rittel's (1966) statement that construction problems are "wicked" and that human input cannot be excluded. According to Birrell (1980) these problems can be overcome. He proposes that there are rules by which construction work is executed. This would thus accommodate the development of a rule-based system.

Bowen et al (1987) has decided to follow Beeston's (1983) approach in opting to find a solution via the implementation of realistic models, as opposed to `black box' models (Brandon, 1982). They, however, add that this resource based model must take variability and uncertainty into account and will be based on PERT/Network type modelling. Erwin and Bowen (1990) in reply to Gray's (1987) argument that networks cannot be accommodated by a rule-based system, contend that a script-based knowledge representation system can overcome this problem.

A major problem with decision making however, is the fact that different experts have subjective views as to which solution is best (Brandon, et al 1988). Mathur and Heah (1990) approach this problem with the solution of a multi-domain system which negotiates compromises. The solution is realised by developing a "conflict solving multiple domain system".

Expert Systems will play an important role in the field of building economics in the future. It must be remembered that these models are only in their infancy stage and tremendous development still needs to occur. It is the author's opinion that ways should be found to favourably introduce

Expert Systems into the industry. This can be achieved by making the systems more user-friendly and by structuring them along lines which are familiar to practitioners in the industry.

4. THE USEFULNESS OF EXPERT SYSTEMS IN THE SPECIFICATION OF UNCERTAINTY.

Existing cost models according to Higgin and Jessop (1965), Harris and Wijesundera (1986) and Bowen and Erwin (1989) lack the ability to handle uncertainty satisfactorily. Uncertainty may be defined as a state of knowledge about the variable inputs to an analysis (Marshall, 1988) and is brought about due to the objectives, constraints and consequences of possible actions not being precisely known (after Bellman and Zadeh, 1970).

4.1 Types of Uncertainty

According to Mamdani and Efstathiou (1985) no one technique exists that adequately treats all forms of uncertainty, viz. imperfect knowledge, intrinsic randomness, inherent indeterminancy and categorical uncertainty as is referred to by many authors (Bellman and Zadeh, 1970; Zadeh, 1979; Buchanan, 1982; Tong, 1982; Pang et al, 1986; Klir, 1987; Scott et al, 1988; Allwood, 1989 and Ng and Abramson, 1990).

4.2 Handling Uncertainty

Traditionally, uncertainty was handled by way of techniques such as decision analysis, sensitivity analysis, input estimation, etc., but these were found to be lacking in their practical applicability (Marshall, 1988). Bowen and Edwards (1985) propose that to overcome problems of quantifying uncertainty, there needs to be the development of a model which encapsulates Stochastic (random) simulation. Mathur (1982) also takes this approach and suggests that Expert Systems can find their true niche in the development of models dealing with stochastic variability and uncertainty.

4.3 Expert System-based Approaches to Uncertainty

According to Erwin et al (1991), Expert Systems provide many built-in features for the handling of uncertainty, as well as functions which facilitate calculations with probabilities.
Uncertainty features of Expert Systems can be classified into two main areas. Firstly, the ability to handle uncertainty of outcome. This concerns the aspect of conditional probability (Scott et al, 1988) and forward chaining (Erwin et al, 1991). Secondly, the ability to handle uncertainty of explanation. This refers to methods such as explanation description (Waterman, 1986), backward chaining (Holsapple and Whinston, 1987) and abduction (incomplete reasoning) (Giarratano and Riley, 1989).

Therefore, according to Erwin et al (1991), "various Expert System based techniques for handling uncertainty exist" and they "appear suitable for use in a construction context".

5. CONCLUSION

It can thus be concluded that although empirical data for the need for Expert Systems does not largely exist, the benefits of developing Expert Systems are tremendous.

The main benefit is that expertise will be unlocked for access by all thereby allowing more competition between "monopolising" professional bodies (Brandon, 1984). The success of Expert Systems, however, lies mainly in the acceptance by the general public of the ability of Expert Systems.

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