

Knowledge acquisition for expert systems in construction

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KEYWORDS

Expert systems. Knowledge acquisition.

ABSTRACT

Assembling knowledge for an expert system depends on the nature of the domain. Types of domain include

- Codifying topics that have hitherto been largely undefined (e.g. selecting appropriate construction plant).
- Ensuring that nothing gets overlooked (e.g. the check points in a building design).
- Providing positive guidance in interpreting regulations (e.g. Fire Regulations).
- Providing pointers to strategic design (e.g. the type of heating system).

Methods also depend on the type of shell program to be used, the number and type of goals to be defined, and the firmness of the available knowledge.

Current research is being undertaken by a team comprising specialists in building, computer science and social science. The paper describes the team's experience, offers a classification of the constraining conditions and gives provisional pointers to the methods of knowledge acquisition appropriate to the constraints. As the research is continuing, further information will be available for presentation at the Congress.

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RESUME

Le recueil des données nécessaires à l'élaboration d'un système "expert" dépend de la nature du domaine.

Y sont inclus les domaines suivants:

La codification de sujets qui jusqu'à présent restent mal définis. (par exemple la sélection du matériel de construction approprié).

L'assurance que rien ne soit négligé (par exemple les points de vérification dans un plan de construction)

La mise à disposition de conseils facilitant l'interprétation des règlements (par exemple l'observation des consignes d'incendie)

La mise à disposition de conseils pratiques sur l'emplacement et le choix des éléments essentiels (par exemple type de système de chauffage).

Les méthodes dépendent également du type de "Shell Program" à utiliser, du genre et du nombre de buts à atteindre et de la solidité des connaissances que l'on a à sa disposition.

Des recherches sont actuellement effectuées par une équipe comprenant des spécialistes en construction, informatique et sciences sociales.

L'exposé décrit l'expérience de l'équipe, présente une classification des conditions restreignantes et fournit des renseignements provisoires sur les méthodes de l'acquisition des connaissances appropriées. Comme la recherche est toujours en cours, des informations complémentaires seront disponibles et pourront être présentées lors du Congrès.

PREAMBLE

This paper is based on current research. It is divided into 3 parts

- Initial observations
- The current study
- Some interim conclusions

Although our interest lies in the exploitation of expert systems in Construction it is clear that knowledge acquisition problems are dependent on factors that are largely independent of the nature of the domain. For this reason we have extended our studies to some domains outside the realm of Construction.

INITIAL OBSERVATIONS

The comments in this part are based on our experience at Loughborough prior to mid 1985 and on discussions we have had with

- The Construction Engineering Research Laboratory, Champaign, Illinois. (CERL)
- The University of Illinois
- Stanford university

It is clear that the nature of the situation within which the knowledge is acquired will have a major influence on the method(s) to be selected. The categories so far identified are

1. The knowledge is held in largely intuitive undefined format.
2. As category 1 but some closely similar domains have been examined.
3. Cases can be defined that reflect a body of decision-making within the domain.
4. There is published material about the domain.
5. The domain expert has sufficient knowledge about expert systems to enable him to define the knowledge (or at least to play a significant role in its definition).

Superimposed on this list of categories are other dimensions such as

- The "depth" of knowledge to be represented i.e. does it represent fundamental knowledge such as that relating to molecular structure or "heuristic" knowledge which includes a substantial amount of personal opinion.
- The extent to which a consensus among experts can be found.

The foregoing categories are now elaborated.

Intuitive knowledge

In developing a system to select materials handling equipment we thought initially that we should use a prototype, university based system as a means of soliciting views from construction industry experts. Careful advance consideration of this approach led us to the opinion that it could prejudice the views of respondents and thus bias the knowledge base. We therefore adopted the approach of patiently discussing the domain with selected experts and being prepared to talk around the subject until the knowledge in suitable form emerged. Initial sections of knowledge were coded by way of demonstration and this expert-generated knowledge was used as the spring board.

Our discussions at Stanford indicated that this method was used in developing "PROSPECTOR". It is currently being used by CERL for several domains relating to site quality control.

Intuitive knowledge with precedents

While the foregoing process avoids most of the problems of bias it is consuming of time, patience, and money. Where systems have already been made for similar domains it should be possible to short-cut part of the process by the use of structured interviews. These would be based on the experience gained in dealing with previous domains.

Defined cases

The system EXPERT-EASE, and similar "rule induction" systems, are designed to infer rules from cases. The process has some resemblance to multiple regression analysis.

At first sight this approach has much to recommend it. However the tests undertaken at Stanford and Loughborough have revealed some limitations. For example

- The rules induced are strict hierarchies. No cross linkage between the branches is possible.
- Uncertainty relationships are not induced.
- The rules induced appear to be very sensitive to small changes in the data.

One important advantage however is that these systems impose a discipline on the user to consider all combinations of antecedents.

More sophisticated systems are apparently being developed and the new versions will be studied with interest. However our extensive experience with regression analysis suggests that the practical problems of implementation will remain substantial.

Even without a rule-inducing system sets of relevant cases must be beneficial. Ad hoc, common sense deductions from these cases must help to establish the framework of the rule base.

Published material

There is a lot of interest in the use of expert systems to guide users in the interpretation of regulations and codes of practice. Clearly, in this situation, there should be no problem of human interaction as the views of the human experts should be fully recorded in the published text. As an aside it should be noted that attempts to "computerize" regulations were made before the recent surge of interest in expert systems. These attempts often revealed inconsistency and vagueness which made full "computerization" difficult. Some investigators have suggested that this should be anticipated as differences between the views of the members of the drafting committee eventually have to be resolved by compromise.

Human expert produces his own rules

Some interesting work has been done by Professor Logcher of MIT in developing an expert system for "analysing construction project risks". Clearly his expertise in the use of computational methods, coupled with his knowledge of the domain, has enabled a system (or at least a system framework) to be generated by one person without the need for knowledge extraction. Similar examples will no doubt occur in future. The resulting knowledge base, may be very sophisticated but the "knowledge acquisition" process is no problem: it has been eliminated by the single person approach.

Comment

As the study of knowledge acquisition develops it seems likely that additional categories of situation will be defined along with recommended methods. The additional dimensions mentioned above i.e. knowledge depth and extent of consensus will also influence the methods of assembling knowledge. It seems likely that in many instances methods will be adopted on an ad hoc basis and retrospective analysis of their effectiveness will provide pointers for future study.

Human reactions to the knowledge acquisition process are clearly important. Some experts welcome the use of expert systems as a means of releasing them for more interesting work. Others may fear that their position will be usurped by the machine.

CURRENT STUDY

Our current study has only just started. So far we have started a retrospective analysis of how some expert systems have been created; we have also done some initial tests on the use of a computer to induce rules. Our plans for a major part of the study are centred on the development of a system for selecting cranes for multi-storey construction. We intend to monitor this work carefully regarding the methods of knowledge acquisition that emerge in response to the constraints of the organization(s) that provide facilities for the work.

Retrospective case studies

Our current list of cases comprises

- The work we undertook for CERL on materials handling for multi-storey construction (1984-85).
- The development (by Prof Trimble and Dr Allwood) of a system to diagnose the cause of dampness in buildings (commissioned by the Building Research Establishment, England).
- A system by the Polytechnic of the South Bank, London for the design of Air Conditioning Installations.
- A system developed by the Department of Computer Studies Loughborough for a firm of management consultants. The objective of the system is to select staff appropriate to the conditions of each assignment.

It quickly became apparent that different participants will have widely differing views on the way in which the application has been undertaken. We identified several classes of participant namely

- Client or initiator
- Knowledge engineer
- Domain expert

It was also clear that there are at least two distinct kinds of situation namely

- A client has identified his own need for an expert system and engaged an employee or contractor to deliver a system to the client's requirements.
- An enthusiast, typically an academic, has defined an interesting application and has persuaded host organizations to provide relevant knowledge.

In this review of applications we have so far found that the initial observations still appear plausible. Our main finding to date is that the nature of the relationship between the client (or host organization) and the knowledge engineer is of crucial importance. Where a client has defined his own needs it is likely that the experts will be readily available and that they will be uninhibited by company policy and commercial confidentiality. They may still be inhibited by their own motivations. At one extreme they may be eager to impart the knowledge in order that the expert system will eventually relieve them of routine tasks which have degenerated into boring chores. At the other extreme they may fear that revealing their knowledge will undermine their own security and generate a situation where they become redundant. Where an application is undertaken by an enthusiast who has defined his own objectives the experts will be less readily available and may be strongly inhibited by commercial considerations. This type of situation however may be more fruitful in revealing deeper, intuitive knowledge, provided that the knowledge engineer can encourage the experts to join him in his research objective i.e. that of revealing hitherto uncharted relationships.

Machine induction of rules

Our study has demonstrated that a great amount of effort is required to assemble even a relatively modest knowledge base. The incentive to use some form of machine assistance in the process is therefore substantial. We are currently conducting tests on the raw data assembled for the dampness in buildings application to assess how far it would be possible to generate rules by machine induction. The induction process is akin to regression analysis in that it calculates a "best fit" for a set of user-defined cases. The relationships found are therefore statistical rather than causal. Our tests to date suggest that attempts at machine induction are beneficial in that they impose the necessity to describe the cases with a degree of precision that is seldom found in the more usual interview and ad hoc rule formulation method. They may also help to get the expert closer to the knowledge assembly process and thereby capture, and perhaps retain, his involvement. The person responsible for the finally adopted rule base must always check that the rules reflect cause and effect.

Once a knowledge base has been assembled, in practice, it will have to be verified. Though still in its infancy the process of computer assisted knowledge verification shows promise. Two themes are currently under investigation. The first is a computer led interaction between the expert and the draft system. Work by Barbara Hayes-Roth at Stanford and by C D B Boyle of Queen Mary College London follows this approach. The second theme has yet to be tested. It consists of using the system (which may comprise a shell plus a knowledge base) to evaluate goals against either a systematic or a random selection of responses to the potential questions. The evaluations will then be used as the basis for sensitivity charts. The validity of the charts will be assessed by the expert without the need for tedious re-examination of rules on a one by one basis. It is hoped that this will expedite the verification process and make it more effective.

Crane selection system

Work has not yet started. However the host organization is proposing to participate actively. We hope to generate an arrangement whereby the organization acts as though it were the client. We believe that this will result in a better end product and in greater enlightenment regarding the knowledge acquisition process.

INTERIM CONCLUSIONS

As our study is continuing we can offer only interim conclusions at this stage. They are

- The knowledge engineer should be aware that different situations will call for different approaches to the process of acquiring knowledge. This paper may alert him to some of the possibilities.
- If possible persuade a "client" to define his requirements and his objectives and to provide you with good access to information.
- It is easier to expand a client led situation into one with research spin-

off than to convert a research-oriented situation into one that has the beneficial discipline and access that can be expected from an active client.

- If you attempt to use machine assistance in the induction of rules always check that the rules you adopt reflect cause and effect.
- Machine assistance in knowledge verification is likely to pay dividends.

ADDENDUM

At the date of the conference our studies will have proceeded further. Our verbal presentation will offer up-dated views on the topics discussed above.