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Improvement Techniques for Enhancing Communication in Expert Systems

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ABSTRACT

The communication between knowledge engineers and domain experts is essential for the development and smooth running of an expert system. Poor communication between these two may result in catastrophic effects on the whole system. This paper focuses on the communication process between knowledge engineers and domain experts. The paper not only indicates the pitfalls of this communication but it also presents some advanced techniques & methodologies for enhancing communication process.

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1) INTRODUCTION

Although the technology of representing and using knowledge in expert systems has been a major focus of artificial intelligence (AI) research for a few decades, however, the practical problems encountered for building such systems have only recently become a topic of intensive research.

This paper focuses and addresses the problems of identifying difficulties of communication in the process of eliciting information from one or more human experts for the purpose of building a knowledge base. The paper also presents some effective knowledge acquisition methods and tools and their merits and demerits.

1.1. KNOWLEDGE

Knowledge is regarded as being everything that an individual "knows" about a specific universe at a given time. "In the knowledge lies the power" has been the motto for most of the AI researchers since 1970s. It was that believe that lead to the construction of the very first knowledge based system in 1990. The most interesting aspect of this system was the manner in which that was constructed. This was founded on a rich base of knowledge to be able to perform different tasks. The real power of a knowledge-based system comes

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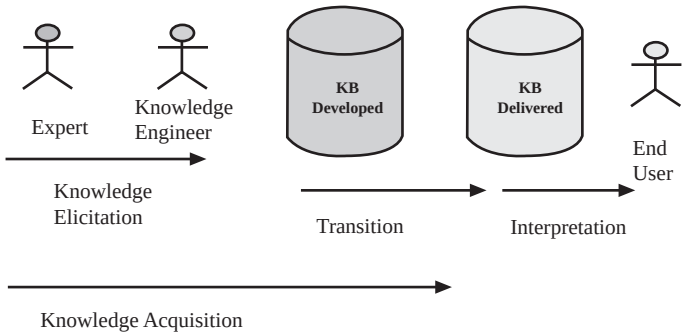
from the expert knowledge it possesses rather than from the inference mechanism or the knowledge representation it uses. The knowledge base is therefore the most important part, since it contains knowledge specific to an application.

Particular knowledge must be associated with an individual, a domain and a moment in order to be distinguishable. Two different persons that observe a specific domain can obtain different knowledge about that domain, therefore the general knowledge possessed by two individuals is seldom identical. Distinct domains generate distinct knowledge and the domain knowledge of individuals usually changes with the passage of time. This is due to the fact that new things are being observed and new conclusions are made so the persons change their perceptions about the aspects of the domain.

Knowledge is more than just knowing facts and principles. It involves having a familiarity with language, concepts, rules, ideas, places and associations and also knowing how to use and access these notions. The facts and principles are meaningless and worthless without the ability to use them effectively.

Figure-1



1.2. THE KNOWLEDGE ENGINEER

The knowledge engineer develops the computer environment. Consequently, much effort is needed to assist the expert in learning and understanding the system that is being developed. The knowledge engineer should also educate the domain expert in knowledge formalization. Formalization is the actual form in which the knowledge in the knowledge base is represented.

The knowledge engineer can implement the software component in the knowledge base to be reused for different sub-problems of the domain within a single environment, and also be reused for different sub-problems within several environments, to gain well-structured and modularised knowledge bases. The components will also customize similar knowledge bases for different end users. It is the responsibility of knowledge engineer to coordinate with and interview to domain expert.

1.3. THE DOMAIN EXPERT

If the domain expert is allowed to model his knowledge without being observed he would feel more comfortable. The expert becomes less dependent of the knowledge engineer and feels more responsible for the project. This increases the motivation, which in turn increases the production of encoded knowledge. Also, more dedicated contribution from the expert can be expected. If the expert is given a substantial part of the design responsibility, the end user can communicate directly with him.

The expert must be motivated to use the tool and should be able to assure the performance of the knowledge base that he encodes.

1.4. KNOWLEDGE ELICITATION AND ACQUISITION

The Knowledge Elicitation (KE) represents the process of the knowledge engineer acquiring an understanding of the expert's knowledge as shown in figure 1. This does not necessarily imply that a knowledge base will be written. Whereas the process of Knowledge Acquisition (KA) means the work of encoding the expert's knowledge into a formally organized computer-based knowledge base. It also includes the processes that adds new knowledge to a knowledge base and refines knowledge that has previously been acquired. Knowledge is broken down into knowledge chunks in the knowledge base, which are selected and combined to suit certain situations. The process of transfer of knowledge from the domain expert to the end user is one of the goals that a knowledge based system has to achieve.

1.5. TRANSITION

The term transition is the activity of moving the knowledge from the knowledge base, created by the domain expert and knowledge engineer, to an environment where it is made available to the end user. The result should be interpreted by the end user so he/she will be able to understand and apply the knowledge. The interpretation can, for example be an advice to the end user, which may increase the performance of the end user's work. KA has come to be seen as a bottleneck in the process of building expert systems (B.G. Buchanan.et.al, 1998).

This task (sometimes called "extracting knowledge from human experts") can be slow, inefficient, and frustrating for both domain expert and knowledge engineer. As Stefik and Conway noted, "... knowledge acquisition is sometimes considered a necessary burden, carried out under protest so that one can get on with the study of cognitive processes in problem solving." (M. Stefik, 1999). There have been numerous attempts to solve the knowledge acquisition bottlenecks.

One approach has involved the development of automated or semi-automated methods of knowledge acquisition. These include intelligent editors, such as Teiresias, Roget, Mole, More and ETS (R. Davis, 1997, J.S.Benett, 2000, L.Eshelman,1999, G.Kahn, 1998, T.H.Boose, 1989).

Another approach has been the creation of tools for aiding in the conceptualization of a knowledge base. Such tools include protocol analysis (D.A. Waterman, 1981) and personal construct theory (J.H. Boose, 1990). A third approach involves the development of heuristics for knowledge engineering (B.G.Buchanan, 1998, W.J.Clancey). Although KA typically requires a lengthy interview process, it would be impossible to learn how to carry out an interview from the AI literature alone. While recent publications have come closer to address some of the practicalities of interviewing for KA (A. Hart, 1986 and D.S. Prerau, 1987, they still suffer from the general tendency to name methods without providing much information on how to apply them. To date there is no sufficient literature available in AI that could serve as a useful "how to" guide for the novice knowledge engineers.

In short, AI researchers know a good deal about how to represent and manipulate knowledge in expert systems, but have very little systematic understanding of how best to gather that knowledge in the first place. Attention to this problem is a prerequisite for speeding up an effective knowledge acquisition.

In the following section, some of the pitfalls have been given that are normally observed in the knowledge elicitation process. And finally, some preliminary conclusions will be presented.

2) SOME PITFALLS OF KNOWLEDGE ELICITATION

There is a great deal of understanding what an expert says and then what one can obtain from interview material alone, or from interview material supplemented by textbooks. Such materials are not self-evident; it must be interpreted (H.M. Collins, 1987 and J.Breuker, 1987). This job requires, for example, that one filter through the experts' reports about their own thoughts and actions, and adds in information that was not reported but that is necessary for understanding the nature of their expertise. This may include tacit knowledge (M. Polany, 1970), contextual information, and unreported actions that experts may or may not be aware of, but which nevertheless constitute part of the process being modeled.

To an anthropologist it appears obvious that the best approach to knowledge elicitation would be to apply ethnographic methodology. In this case, knowledge engineers would attach themselves to an expert or group of experts as participant observers for a period of weeks or months. This would enable them to learn as much as possible about a particular sort of expertise by observing, questioning, and attempting to apply the skills themselves, while simultaneously learning about the social and material context in which the expertise is normally constituted and practiced. Such participant observation would provide knowledge engineers with the opportunity to notice and collect informal and uncodified information, some of which may not be directly accessible to the experts themselves.

At present, however, few knowledge engineers have received some training in ethnographic methods and few seem open to trying this approach. On the contrary, under pressure of time and money, most appear to want to spend less rather than more time with their domain experts (D.E. Forsythe, 1987. Since knowledge elicitation generally involves face-to-face interviews with one or more experts, the discussion below aims at encouraging knowledge engineers to undertake these interviews in a more informed and self-conscious way.

Knowledge engineers, particularly novices, can encounter various difficulties in connection with the communication aspects of knowledge acquisition. Following are the two major types of pitfalls that one may observe during interview sessions. Errors of the first type reflect problems in interview technique, in which the knowledge engineer misapplies or fails to apply appropriate interview strategies. Errors of the second type involve inappropriate assumptions that knowledge engineers may bring to the job of face-to-face data gathering.

We are particularly interested in alerting knowledge engineers to the importance of communication on the non-verbal as well as the verbal level. Although few knowledge engineers seem to be aware of this fact, the way in which they ask questions of the expert may influence the success of their enterprise as much as the content of those questions.

2.1. INTERVIEWING PROBLEMS

Because interviewing takes place through the medium of conversation, and because the conversation is an everyday activity, knowledge engineers sometimes assume that KA is just a matter of chatting with the expert. As Gorden comments, "the uninitiated, interviewing is 'just talking to people!' " (R.L. Gorden, 1988) The influence of this attitude among knowledge engineers can be seen in two examples from the literature. First, in an article on "methods for knowledge acquisition," Olson and Rueter [(J.R. Olson, 1993) describe interviewing in the following terms:

"Interviews are the most common method for eliciting knowledge from the expert. In conversation, the expert reveals the objects he/she thinks about, how they are related or organized, and the process he/she goes through in making a judgment, solving a problem, or designing a solution. There are simple guidelines that can be followed to make interviewing efficient."

Second, one of Gammack's "rules of thumb" is, "If interviewing comes naturally to both parties, then interview methods may be fruitful."(J.G. Gammack).

These statements sound immature. Interviewing does not just happen; the knowledge engineer must make it happen. Far from coming naturally, interviewing is a difficult task that requires planning, management techniques, and a lot of self-control. It also demands different type of, in some cases opposite to those usually required for graduate students, corporate employees, or programmers. Unfortunately, it is very easy to interview badly, with the result that one may learn little and/or alienate the expert. Interviewing is such a particular process that no general solutions could be presented to many of these problems. Rather, the goal of this work is to increase awareness of the problems themselves, since that is the first step toward finding appropriate solutions.

2.1.1. OBTAINING DATA VERSUS RELATING TO THE EXPERT AS A PERSON

Experts are people with personalities and agendas of their own, and they frequently have the authority to refuse further interviews. Successful interviewing requires negotiating and maintaining a balance between obtaining data and acknowledging the expert as a person and a professional. To some extent, these two goals are in conflict: our data include examples of interviewers who were highly personable but didn't learn much about their topic, and others who were so topic-oriented that the expert felt irritated and even abused. Concerning a knowledge engineer in the first category, the expert commented, "He wasted my time." Concerning one in the second, the expert said, "He treated me like a dog".

2.1.2. TWIN DANGERS OF OVER- AND UNDER-DIRECTEDNESS

Interviewing also requires maintaining a balance between being directive and being responsive. This principle applies in several senses, including both decisions concerning the subject matter of particular interviews and the degree of intrusiveness used by the interviewer in steering the expert. Knowledge engineers must find a middle ground between deciding upon an approach and a list of questions beforehand, and being completely open to changing approach on the basis of what the interviewee says and does.

Similarly, they must consciously weigh the cost in time and efficiency of letting a talkative expert carry on at will, versus the possible cost in good-will (and possibly data) of interrupting repeatedly to keep the expert on course. Some interviewers were so preplanned that they ignored the expert when he/she showed irritation or suggested that their approach was inappropriate. For example, some stuck inflexibly to a case-based approach when the interviewee was trying to tell them rules.

On the other hand, some interviewers were so nondirective and so unplanned that they simply struggled without appearing to have any approach in mind. Once again, the goal is to maintain balance: during steering the interviewee gently while remaining open to the possibility of having to change course.

2.1.3. FEAR OF SILENCE AND FAILING TO LISTEN

Some interviewers don't allow the expert sufficient time to speak. This may be the result of nervousness and/or a rapid interaction rhythm on the part of the interviewer. Novice knowledge engineers may confuse an interview with an examination, and waste time unnecessarily trying to demonstrate their own competence to the expert. Simple as it

sounds, it is very important to learn to listen; for many interviewers this requires considerable self-control. Silence is a helping tool in this task.

Knowledge engineers should not be afraid to sit silently for a while in case the expert has more to add, or in order to gather their own thoughts. It has been observed that many

knowledge engineers who were so afraid to let the conversation lag, they fired questions at the expert without really listening to the responses. In such cases no one's goals were met, the experts were offended because they didn't feel they had been heard, while the knowledge engineers gathered information that was less accurate than it could have been.

2.1.4. DIFFICULTIES IN ASKING QUESTIONS

Asking good questions well is an art. Knowledge engineers may encounter several problems in this area. First, for some knowledge engineers, questioning the expert at all is clearly difficult. The age, gender, status, and cultural background of both interviewer and expert are likely to affect this situation. After all, an interview is a social encounter as well as a professional one. It is impossible usefully to prescribe a particular strategy or style. The observations illustrate that the tactics appropriate in any particular situation depend on the individual knowledge engineer and expert involved. Clearly, face-to-face knowledge acquisition demands considerable sensitivity and flexibility on the part of the knowledge engineer (and the expert) to be able to assess and adjust to the social constraints posed by the interview. Whatever the tone of the interaction, the interviewer must actively question the expert. The worst pitfall of all this is to fail to ask for information.

Second, since the questions one asks influence the answers one gets, knowledge engineers need to pay attention to question formulation. Almost everyone finds it challenging to formulate carefully worded questions that are appropriate to a particular domain, interactional situation, and stage of research. This is especially difficult when the domain is unfamiliar. Payne (S.L. Payne, 1980) provides a useful discussion of some of the issues involved in question formulation. Observations suggest that novice knowledge engineers in particular should ask one short, clear question at a time and then stop talking. Resist the temptation to repeat and elaborate questions. Also try to speak the expert's language.

Third, a lack of awareness of different types of questions makes it difficult to conduct an interview. Knowledge engineers must have at their command a collection of questions that perform such tasks as:

- Probing for further information ("Tell me more about that") and checking for completeness ("Is there anything else?");
- Asking for clarification ("I don't understand; could you explain?", "How does that relate to our topic?");
- Following up points mentioned by the expert ("How/why/when do you do that?", "What do you do next?");
- Prompting to keep the expert talking ("I see", "Um hmm');
- Feeding back information to check on its accuracy ("Let me try to summarize, please correct me if I'm wrong").

2.1.5. INTERVIEWING WITHOUT A RECORD

Interviewing is difficult in part because it requires the knowledge engineer to pay attention on many levels at once. In addition to asking questions and monitoring progress, knowledge engineers must maintain awareness of time, personality, interactional and sometimes political factors, as well as hardware and software requirements of the proposed expert system. Given these demands, it is expected that the interviewer will miss some of what the expert says. Therefore, it is necessary that some sort of objective record of each interview be maintained. The easiest and least obtrusive recording device is a small tape recorder.

To sum up these comments on interview techniques, no single approach or method will work all the time; rather, an interviewer must be able to draw upon a collection of approaches. It pays to prepare carefully ahead of time, planning what seems like a sensible way of focusing the interview, but remaining flexible in case this turns out not to be the best way

of doing things. An interview is a social occasion during which social convention and personalities enter in significant ways. It is necessary to analyze the expert's personality, interactional style, and tolerances, and adapt oneself to them. This requires flexibility. Knowledge engineers also need to be aware of their own personality, interactional style, etc., and to try to keep them under control while interviewing.

2.2. CONCEPTUAL PROBLEMS

A second category of pitfalls in knowledge acquisition is conceptual errors that have methodological implications. Three such assumptions will be mentioned here.

2.2.1. TREATING INTERVIEW METHODOLOGY AS UNPROBLEMATIC

Some knowledge engineers seem to perceive the question of interview methodology as trivial or "just a matter of common sense" (D.E. Forsythe, 1987). The KA bottleneck is a matter of clear concern to knowledge engineers themselves. It is suggested that there is a connection between this bottleneck and the apparent reluctance to take seriously the question of interview methodology.

This point has major implications for expert systems development, because interview technique may affect the quality of the data gathered as well as the time it takes to collect them. If the information that goes into a knowledge base is poorly understood or incomplete, the most sophisticated representation or inference schemes will not produce a good system.

As Gorden (R.L. Gorden, 1988) pointed out: "It is clear that no amount of refinement in data analysis can counteract the effects of faulty data-collection methods that provide raw information which is false, distorted, or incomplete. Nevertheless, there is still a tendency for the advances in data-gathering methodology to lag behind those in data analysis."

Gorden (R.L. Gorden, 1988) identifies several causes of this attitude, two of which are relevant here: "First, there is an unfortunate tendency to consider data gathering as a lower status activity than data analysis. Another barrier to the actual application of the best data-gathering methods is the fact that it often costs more in time or money to collect valid data than it does to collect invalid data."

2.2.2. BLAMING THE EXPERT

Knowledge engineers often blame the expert for difficulties encountered in the elicitation process. This attitude was expressed in interviews; for example, one experienced knowledge engineer asserted, "experts are a cantankerous lot."(R.H. Hill, 1996). However, where AI scientists suspect a lack of interviewing expertise on the part of the knowledge engineers involved and/or an inappropriate pairing between interviewer and expert.

2.2.3. REIFYING KNOWLEDGE

Knowledge engineers appear to think of knowledge as a material entity, a thing that lends itself to extraction like a diseased tooth (D.E. Forsythe, 1987). Rather than conceptualizing knowledge as a material entity, it is suggested that it is more useful to view it as shared understanding produced through the collaborative efforts of interviewers and respondents (C.L. Briggs, 1996), (E.G. Mischler, 1999). However, KA involves the following:

- Employing a technique to elicit data (usually verbal) from the expert.
- Interpreting these verbal data (more or less skillfully) in order to infer what might be the expert's underlying knowledge and reasoning process.
- Using this interpretation to guide the construction of some model or language that describes (more or less accurately) the expert's knowledge and performance.

"Knowledge engineers need to recognize that this is the basic process in which they are engaged" (A.L. Kidd, 1999).

3) THE NON-TECHNICAL NATURE OF THESE PITFALLS

Accustomed to thinking in terms of technical problems with technical solutions, knowledge engineers may be unimpressed by the fact that the KA pitfalls identified here are nontechnical in nature. However, this is one reason they are pitfalls for knowledge engineers, since the training and biases of the latter may lead them to overlook such difficulties. However, many important insights seem obvious once they have been articulated; the trick is to notice and articulate them. Furthermore, people do not always do what is obvious. Therefore, repeatedly saying that every factor just discussed has been observed constantly to interfere with the knowledge acquisition process.

4) CONCLUSION

This paper has pointed out that discussion of knowledge acquisition methodology in the AI literature has neglected consideration of techniques involved in gathering data in a face-to-face context. However, observations of actual knowledge acquisition sessions reveal that knowledge engineers frequently commit errors in interviewing the expert and/or in gathering the amount or quality of data.

The job of the present-day knowledge engineer is not exclusively technical; it requires communication skills in several areas, one of which is knowledge elicitation. It follows that the education of knowledge engineers should not be exclusively technical either. At best, it should include formal training in the social sciences. At least, it should include training in interview methodology, interview theory, question formulation, interactional rhythm, and nonverbal communication, and in the sociology of knowledge.

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