A Conceptual Model of Knowledge Elicitation

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Abstract

This article reports briefly on certain work conducted at the University of Lund to investigate the problems and motives involved in the development of expert systems. According to the results of a survey conducted between1989-1991, seven various knowledge elicitation techniques were identified. The investigation showed that the most popular elicitation technique used for extracting knowledge from experts was the structured interview. In this paper an attempt is made to outline a conceptual model of knowledge elicitation and puts forward a number of propositions and suggestions which can contribute to our knowledge of expert systems development.

Keywords: Expert Systems (ES), Knowledge Acquisition (KA), Knowledge Elicitation (KE), Experts, Knowledge Engineer (KEN), Knowledge Engineering (KENG), Artificial Intelligence (AI)

1. INTRODUCTION

Expert systems development is a significant branch of artificial intelligence (AI) and they are probably the most practical applications of AI (Rauch-Hindin, 1986; Rich E, Knight K, 1991). There are various types of information systems serving different organization levels such as: strategic-level systems, management-level systems, knowledge-level systems and operational-level systems (Laudon and Laudon, 2007; O'Brien, 2007). Organizations have Expert Systems (ES) and Executive Support Systems (ESS) at the strategic level; Management Information Systems (MIS) and Decision Support Systems (DSS) at the management level; Knowledge Work Systems (KWS) and Office Systems at the knowledge level; and Transaction Processing Systems (TPS) at the operational level. Information systems at each level are specialized to serve each of the key functional areas. An information system is comprised of many different varieties of software platforms and databases. There is no doubt that information technology is one of the most important components of development in today's societies. It is rare to find a field not influenced by information technology (Bruegge and Detoit, 2000; Haug et al., 2002; Sagheb-Tehrani and Ghazarian, 2002).

Today, it is recognized that information systems knowledge is vital for managers because most organizations require it in order to survive and succeed (Laudon and Laudon, 2007). Worldwide changes have altered the business environment. According to the US Department of Commerce (2002), knowledge and information work now account for 60 percent of the American gross national product and about 55 percent of the labor force. Between 1980 and 2003 (US Dept. of Commerce, 2003), private business investment in information technology grew from 19 percent to more than 35 percent. By 1991, U.S companies spent more on information technology than any other form of investment. Investing in Information Technology does not by itself guarantee good returns. There is a vast variation between firms (Laudon and Laudon, 2007). What accounts for this failure of investment in information technology? From the author's point of view,

the answer can lie in the concept of the knowledge acquisition process.

In the following sections of this paper, the author suggests a concept of the knowledge elicitation process in a way that leads to more successful expert systems development.

1.1 Research Method

This study asserts, to put in plain words, the concept of a knowledge elicitation (KE) process by defining various vital perceptions and their relationships involved in the KE process. The research introduced here draws upon social system theory in the functionalist sociology defined by Burrell & Morgan (1979), who approach the subject matter from an objectivist perspective. The conceptual model presented here is based on the "holistic view" school (Social System Theory). The conceptual model is based on non-technical prescriptive guide. An exploratory investigation was designed (Sagheb-Tehrani, 1990b) to identify the motives and some problems when developing expert systems. For a brief explanation of the survey please see (Sagheb-Tehrani, 1990a).

1.2 Data Collection and limitation

The survey instrument used was a questionnaire which was mailed to twelve Swedish companies. It studied the potentials of expert systems development as early as 1991. Eight companies (developed a total of fifteen experts systems) answered the questionnaire completely. Some of the companies had developed more than one expert system. All companies which participated in the questionnaire belonged to two unrelated business fields. Eleven belonged to the industrial field and one was a consulting company. The chosen unit for the study was expert systems.

1.3. Hypothesis

This study as a whole attempts to address the following hypothesis:

Hypothesis-1: Various knowledge elicitation (KE) techniques can generate disparate KE processes.

Hypothesis-2: KE is sub-process of knowledge acquisition (KA) process.

Hypothesis-3: The concept of knowledge acquisition (KA) process can contribute to KE process.

Hypothesis-4: Disparate KE process can cause various problems.

2. CLARIFICATION OF CONCEPTS

2.1 Expert Systems

One of the most practical applications of artificial intelligence (AI) in business is the development of expert systems (Award, 2003; Giarrantand J.C and Riely G.D 2004; Jackson, 1999; Motlaghi et al., 2008; Turban E and Liebowitz, 1992; Yazdani, 1986). AI has two main objectives. The first aim is to create an intelligent machine. The second goal is to find out about the nature of intelligence (Sagheb-Tehrani, 1993a, 1993b). Put it differently, the goal of AI is to develop a machine that can see, as well as think, hear, talk and feel (Laudon and Laudon, 2007; O'Brien, 2007; Rich and Knight, 1991). Expert systems are programs that handle real-world problems requiring human expertise, i.e., expert systems emulate the behavior of a human expert in a narrowly defined domain of knowledge (Medsker and Liebowitz, 1994; Sagheb-Tehrani, 1991).

2.2 Knowledge Engineer (Designer)

Knowledge engineers are persons who design and build expert systems. They are computer specialists, knowledgeable in AI methods who can apply different AI methods appropriate to real-world problems. The process of knowledge engineering is a very challenging process. One of the main challenges is knowledge elicitation. What knowledge should be elicited (Sagheb-Tehrani, 2006)?

2.3 Knowledge acquisition (KA)

Knowledge acquisition is a crucial stage in the expert systems development process. In other words, KA is an important obstacle and time consuming when constructing expert systems (Kidd A.L, 1987; Kim J.R, 1988; Shadbolt N and Burton M.A, 1989, Weiss S.M and Kulikowski C.A, 1984). KA is the process of eliciting, structuring and representing (formalizing) knowledge from some knowledge source in order to construct an expert system. The terms knowledge acquisition and knowledge elicitation have

been used interchangeably in some of the artificial intelligence (AI) literature. However there is a clear distinction between KE and KA in the creation of a model (Addis T.R. 1987). Regarding the above discussion, I believe, it is important to have a clear distinction between these terms. This leads us to understand the expert systems development problems better. It falls outside the scope of this paper to discuss those concepts in more details. My attempt was to comment upon those concepts and provides a background for better understanding the concept of knowledge elicitation (KE).

2.4 Knowledge Elicitation (KE)

There are a number of ways to elicit knowledge from experts (Evans, 1988; Gammack & Young, 1985; Garg-Janardan & Salvendy, 1987; Hart, 1986; Hoffman R.R, 1989; Counney, 1988; Welbank, 1983; Wright & Ayton, 1987). Different knowledge elicitation techniques are applicable to different forms of knowledge (Gammack J.G, 1987). KE is a critical first step in expert systems development. The performance of the expert systems depends upon the reliability, validity and accuracy of the elicited knowledge (Garg-Janardan C & Salvendy G, 1987). KE has its own problem such as communication between the expert and knowledge engineer.

2.5 Interview Technique

Interviewing is a technique that many knowledge engineers have used to elicit the experts' knowledge (Medsker and Liebowitz, 1994; Sagheb-Tehrani, 1993a,b). The word "interview" has many various connotations depending on the discipline that is defining the term (Sagheb-Tehrani, 1991). There exists a general agreement that the main purpose of an interview is effective communication, and a major benefit of the interview technique is its ability to assist in outcome clarification through repeated probing by the interviewer. Interviews can be classified along a structured dimension. At one end is the structured, goal-oriented interview and at the other end is the unstructured interview.

The survey (Sagheb-Tehrani, 1991) identified seven various knowledge elicitation techniques. Many of the respondents gave multiple answers to this part of the investigation. The investigation showed that the most popular elicitation technique used for extracting knowledge from an expert was structured interviews, which were reported in 11 cases out of 15 (73%). The next two popular techniques were unstructured interviews and documentation analyses which both were reported in 7 cases (47%). Simulation using a prototype occurred in 6 cases (40%) whereas case study analysis and observation of human expert were both reported in 5 cases (33%) as shown in Table 1.

Knowledge Elicitation Techniques	**No. of Expert Systems (total 15 systems)**	**Percentage %**
Structured interviews	11	73
Unstructured interviews	7	47
Documentation Analysis	7	47
Simulation using prototype	6	40
Case study analysis	5	33
Observation analysis	5	33
Induction from Example	1	7

Table 1: Data concerning knowledge elicitation techniques used (source Sagheb-Tehrani, 1991).

A number of problems when attempting to extract knowledge from experts were identified in Table 2. Problems with experts occurred in 10 cases out of 15 (67%). The most common problem was the limited time with the expert, which was reported in 7 cases (47%). The next most common problem was the limited access to the expert which was reported in 4 cases (27%). Misunderstandings were reported in 3 cases (20%). In addition, the problem of

unqualified experts was reported in 2 cases (13%). See Table 2.

Some Problems With the Experts (HE)	No. of Expert Systems (total 15 systems)	Percentage %
Limited time	7	47
Limited access	4	27
Misunderstanding	3	20
None	3	20
Unqualified expert	2	13
Limited cooperation	1	7

Table 2: Data regarding some problems with human expert (source Sagheb-Tehrani, 1991).

From the author's point of view, the designer of any system can be referred to as a user of that system. Users are the people who actually use the system directly or indirectly. There are disparate definition of the term user and how this term is classified. For diverse taxonomies of user, see Guimaraes (1999) and Rockart and Flannery (1983). Put differently, any person who is affected by an Expert System directly or indirectly is referred to as system user.

3. A CONCEPTUAL MODEL OF KE

Effective structuring of a knowledge elicitation (KE) process requires some type of model. That is, the knowledge engineer must have some understanding of how KE sub-process is organized. In this section an attempt was made to introduce a conceptual model of KE based upon separate issues which have been discussed so far. This conceptual model with its structural linkage is presented in the following figure. The deeper discussion of the study propositions may also accentuate that possible efforts are often complex with both positive and negative connotations.

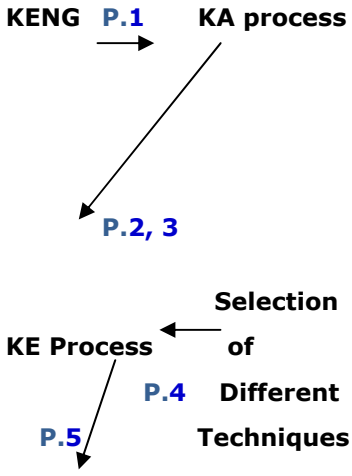

Fig. 1: A conceptual model of KE

**The numbers refer to propositions in the text*

3.1. The study propositions

The conceptual model may suggest a number of propositions regarding impacts of KE process. The study propositions are stated in general terms. The objective is to suggest important outcomes that need to be studied further.

Proposition-1: Knowledge acquisition (KA) is a part of knowledge engineering (KENG) process.

Proposition-2: Knowledge elicitation (KE) is a sub-process of KA process.

Proposition-3: The concept of KA process can contribute to KE process.

Proposition-4: Various knowledge elicitation (KE) techniques can generate disparate KE processes.

Proposition-5: Disparate knowledge elicitation (KE) processes can cause various problems.

According to the literature study (Medsker and Liebowitz, 1994) and an investigation (Sagheb-Tehrani, 1990b), the most common problem in expert systems development was knowledge acquisition which is practiced by knowledge engineer. See table 3.

Some Obstacles of Expert Systems Development	No. of Expert Systems (total 15 systems)	Percentage %
Problem with knowledge acquisition	12	80
Problem with experts	10	67
Hardware and software problem	9	60
Limited time and budget	5	33

Table 3: Data regarding some obstacles of expert systems development, (source, Sagheb-Tehrani, 1990b).

It has been stated that one of the central concepts which lead to an improved expert system development (ESD) is the design process (Sagheb-Tehrani, 2006). So, it is also very important that the ES builder consider the concept of design process at the outset of developing such systems.

3.2. Summary and concluding some remarks

The author has described the knowledge acquisition process and knowledge elicitation. The findings support all the hypothesis of the study. The author has not intended to suggest which KE technique is best. It seems that the answer to the question "what KE technique is best?" is an empirical question like any of the other important questions in KE process. However, research which empirically compares knowledge elicitation techniques is still in its infancy. This requires more research (Hoffman R.R, 1989). According to this empirical study (Sagheb-Tehrani, 1990b), the structured interview technique was the most common KE technique used for developing expert systems. This paper presents a conceptual model relevant to the KE process. The model may allow one to conceptualize the KE process in a way that contributes to the successful implementation of an expert system project. It must be mentioned that this study aimed to be an initial step towards the exploration of the KE process. One direction that future research might take is, to develop KE methods that can effectively elicit reasoning used by human experts.

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