A Framework for Expert Knowledge Acquisition

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Summary
In the artificial intelligence field, knowledge acquisition and reasoning are important areas for intelligent systems, especially knowledge base systems and expert systems. Knowledge acquisition is not an easy task since transferring expert knowledge required different methodologies and techniques based on expert domain, type of knowledge, knowledge engineer and expert domain. The success of the project depends on good knowledge management (KM). This paper presents a framework for manual knowledge acquisition. The proposed framework is for both types of knowledge (tacit and explicit). Using proposed framework allow organization to acquire knowledge from experts and get useful from it.

Keywords
Expert system, knowledge engineering, knowledge acquisition, tacit knowledge, explicit knowledge.

1. Introduction

Expert systems (ES) are very important field in the area of artificial intelligence (AI) and it may be considered the most used applications of AI [1, 2]. Most of large 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 [3, 4, 5].

During the last decade there is an increasing order on technology and information systems. Information system becomes a very important issue needed by any organization to survive and sustain. And it is unexpected to find a huge organization which is not influenced by information technology. So there is no doubt that information technology is one of the most important issues of development in digital era [6, 7, 8].

Knowledge is the key of success. Nowadays, knowledge is the critical factor of success for most organizations which is required in order to survive and sustain [4].

Transferring expertise from an expert to the computer and then to the user involves four activities: knowledge acquisition, knowledge representation, knowledge inference and knowledge transfer. This paper will focus on knowledge acquisition.

It is known that in the artificial intelligence field, knowledge representation and reasoning are important areas for intelligent systems, especially knowledge base systems and expert systems [9].

Knowledge acquisition is a general term used to represent the process of acquiring expert expertise. Also Knowledge acquisition is the general term used for the process of developing a computational problem-solving model, specifically a program to be used in some consultative or advisory role [10]. Programs built based on knowledge acquisition from experts is called "Expert Systems" [11].

No doubt that Knowledge acquisition plays a significant function in building knowledge based system. Any way, evaluating different KA techniques has been difficult since the cost of using human expertise in real experimental studies is high [12, 13].

Knowledge-engineering process includes five major activities [14]: Knowledge acquisition: which mean acquisition of knowledge from its different resources such as experts, books, and documents. Knowledge representation: This means organizing the knowledge. Knowledge validation: this means verifying the knowledge quality. Inferencing: design suitable software which allows Inferencing. Explanation and justification: this means design an explanation facility to answer questions.

There are several methods of knowledge acquisition and also there are several steps of knowledge acquisition which will be discussed later in this paper. The aim of this research is to build a framework which could be used for most organizations to acquire expert expertise in an effective manner.

This paper is organized as follows. In the next section, we review relevant literature, section three explains knowledge acquisition, section four is about knowledge acquisition methods, developing a Theoretical Framework for Manual Methods of knowledge Acquisition detailed in section five. And the last section of this paper presents our conclusion.

Manuscript received August 7, 2010
Manuscript revised November 20, 2010

2. Related work

Mehdi [3] in his research studied the techniques for elicitation knowledge and he said that the structures interview is the most famous method for elicitation knowledge from expert. He also tried to outline a conceptual model of knowledge elicitation. His research puts forward a number of propositions considered important to develop the knowledge of expert systems.
William [10] in his research shows that the expert systems can make use of the small set of terms and relations to describe many rule based expert systems. He refers for a method for solving problems by using classification heuristically. His model can be used as a framework for knowledge acquisition, particularly in the early stages for organizing the expert's vocabulary and decomposing problems. The model suggests a set of heuristics for recognizing whether a problem can be solved by classification and for systematically acquiring the knowledge network.
Gheorghe [15] in his research presents an automation knowledge acquisition method for expert systems. He mentions that an expert system is viewed as explicit model of human expert's performance. . He distinguishes three phases in the development of such a model. The first one consists of defining a framework for the model, in terms of knowledge representation formalism and an associated problem solving method. The second phase consists of defining a preliminary model that describes the basic concepts of the expertise domain. The last phase consists of incrementally extending and improving the domain model through learning from the human expert. in his research he presents the learning system NeoDISCIPLE which illustrates the usefulness of six principles for automating the knowledge acquisition process: expert system building as a three-phase modeling of human expertise, understanding-based knowledge extension, knowledge acquisition through multistrategy learning, consistency-driven concept formation and refinement, closed-loop learning, and cooperation between the human expert and the learning system.
Marie José [16] in her thesis she propose to examine the problems of knowledge acquisition and more particularly the possibilities of automated knowledge-acquisition systems, she mention that Dedicated knowledge acquisition systems for one particular expert system (or group of expert systems) seem to work very well. Also knowledge-acquisition systems that can handle not too complex tasks are satisfying.
Hussein H. Owaied [17] in his research he proposes a framework for shell expert system. The proposed scheme is the mixing of the Rule-base and the Case-based forms using Blackboard in order to include the three facilities in one scheme. The research presents the implementation of the proposed scheme as a Rule-Case-based shell expert system. Also, presents illustrated examples of using the framework model together with the evaluation of the proposed framework model.
Tri M [12] in his research he talks about evaluating knowledge acquisition methods. Also in his research he talks about the errors a human expert can make during building a Knowledge base system (KBS). He evaluates his approach by using variants of practically successful KA methodology Ripple Down Rules (RD). His results show that there is a relation between levels of expertise and performance of resulting knowledge bases. Finally he said that a simulation of the key factors in building a KBS is possible.
Hendra [18] in his thesis he proposes a framework which combines incremental knowledge acquisition and machine learning. This integration is made in a successful way because the machine learning is not only applied to data but also to knowledge provided by expert. Ripple Down Rules (RDR) is a techniques which provides a very simple way for the expert to provide knowledge with very little knowledge engineering. The aims of RDR are to simplify interaction between an expert and the KBS tool and to minimize the collaboration between a knowledge engineer and an expert. He proposes machine learning methods30 that can be integrated into the RDR knowledge acquisition framework. These methods aim to address RDR limitations such as: rule redundancy, task repetition and lack of modeling.

3. Knowledge Acquisition

Expert system (ES) is one of most success fields in artificial intelligence. Expert system is a system that uses human knowledge captured in different ways to solve problems which usually require human expert. Knowledge acquisition is one of most critical issues in building any expert system.
Transferring expert expertise is not an easy task. To understand the problem of knowledge transferring, it is important to understand how expert deals with his expertise. Also the domain expert has an amount of knowledge (facts and rules) which usually not aware and so he does not know exactly what is needed for the expert system. Also some experts lack computational and representational power [16].
Knowledge engineer has a very important role in building an expert system. The interaction between a knowledge engineer and the domain expert affects the performance of the resulted expert system. So knowledge engineer must be aware of the methods used for knowledge elicitation and have an excellent idea about the best method used for knowledge acquisition based on the type of knowledge and type of organization.
Transferring expert knowledge to a computer system is done by conducting several steps, each of which has its

own characteristics and merits. Figure (1) shows the main steps of building an expert system. This paper will focus on knowledge acquisition method.

The power of any expert system depends on the knowledge it possesses. Knowledge is acquired from experts through different methods called knowledge elicitation or knowledge acquisition. The success of any expert system depends on its knowledge acquired in initial phases of building the expert system. So the emphasis in building an expert system should be on the knowledge acquisition phase [16, 19].

In general, knowledge acquisition is a general term used for the process of computational problem-solving model. Also it is used to builds program which will be used as consultative or advisory role which called "expert systems" [10, 11].

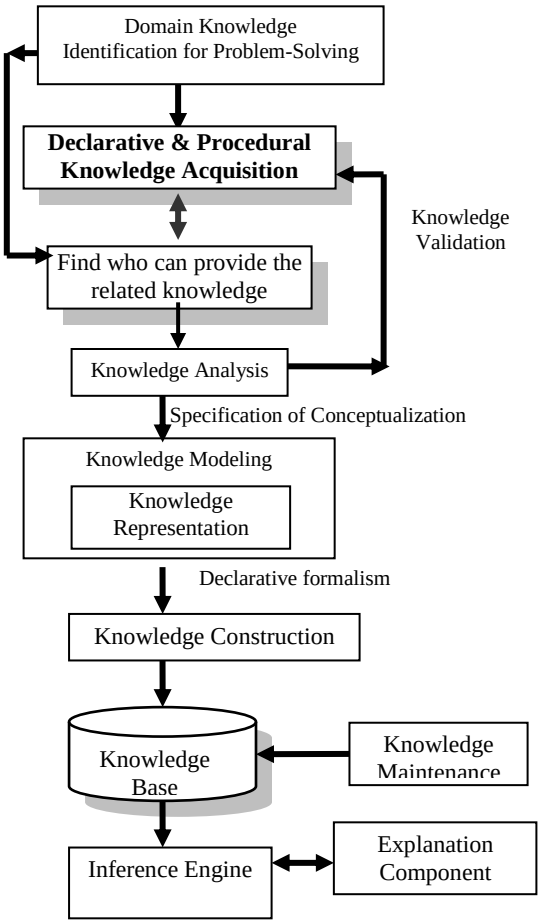

Figure 1 Main activities of knowledge engineering

To acquire expert knowledge through knowledge acquisition or elicitation methods there are several steps: first, selecting a problem to be solved (domain area); second, interviewing an expert; third, codifying the knowledge using a suitable representation language; fourth, refining the knowledge base by testing it [10].

4. Knowledge Acquisition Methods

There are several methods and techniques for knowledge acquisition; in the following paragraph we will summarize main methods:

[14, 20, 21, 16, 23, 24]

Manual methods: in this method the knowledge engineer extracts expert knowledge and then codes it in a suitable format. There are many known manual methods like interviewing, process tracking, protocol analysis, observation, case analysis, critical incident analysis, discussions with the users, commentaries, and brainstorming.

Semi-automatic methods: This method is intended to increase the productivity of cogniticians and experts. They are divided into two categories: methods that support exports in building a knowledge base, without cogniticians help and methods that support cogniticians in executing the specific phases of the knowledge acquisition rapidly and efficiently with less help of the experts.

Automatic methods: in this method the roles of both the expert and the knowledge engineer are minimized or even eliminated. Knowledge acquisition is made by the plan architect analyst.

5. A Framework Development of Manual Acquiring Expert Knowledge

In this section, we will focus on manual knowledge acquisition and we will develop a framework; which could be used for most organizations.

Manual method is the most commonly used method for knowledge acquisition. Manual methods are basically based on structured interview and work field observation techniques. Frameworks are developed to capture the terms of skeletons of knowledge acquisition techniques. It focuses mainly on the similarity amongst skeletons by identifying commonalities amongst them in terms of commonalities in the structure and functionality exercised making use of the objects involved.

Whatever the kind of acquiring technique is applied (interviews or work field observation), the knowledge engineer should work within the predefined time that is specified in the scheduling time of intelligent software project management

1. Identifying the domain knowledge when we firstly identify restricted or limited area. It is achieved when we determine what the problems within the area are.
2. Nominate which knowledge engineer(s) is qualified to acquire knowledge of specific domain.
3. Determine the domain human experts.
4. Describe the problem semantically; describe its solution in terms of domain vocabulary. Most of

knowledge acquisition is done simultaneously with the requirement specification phase in knowledge engineering.

5. Explore and acquire all the potentially usable domain knowledge, classes, concepts, their related meaning, their attributes, their values, and their relationships. Identify the verbs as the actions (i.e. events) in the domain.
6. Gather the set of pre-conditions; the condition that should be happen or satisfied before executing the action. Gather the set of post-conditions; the conditions that produced after executing of the action.
7. Each interview meeting or observation meeting should focus on one or a part of problem-solving task. Taking into consideration different ways to solve the same domain problem, and indicating the solution difficulties, commonalities, needing for auxiliary knowledge of other activities.

There are two kinds of expert interview meeting:

First: *Non-structured interview with experts*: it is used to acquire a preliminary problem-solving knowledge.

Second: *structured interview with experts*: it is used to get a specific, and detailed acquired knowledge about concepts, properties, relationships of the problem-solving and the expert work environment.

After getting knowledge, the knowledge engineer needs to review the specified knowledge, analyze the knowledge either informally or formally, discuss the knowledge with experts who gave the knowledge and with the others who have knowledge and skilled to solve such problems. Evaluate the knowledge helps to find miss-understandability, redundancy, and inconsistency. The knowledge engineer will formalize the knowledge into a suitable format to be stored later into knowledge base.

Interview and observation are very important techniques in knowledge acquisition since using them in a proper way allows knowledge engineers to acquire tacit knowledge (highly personal knowledge which is hard to formalize and difficult to communicate or share with others) and explicit knowledge (can be expressed in words and numbers and shared in the form of scientific data) [22, 25, 26, 27].

Interviewing a domain human expert with an excellent preparation for the interview can result in a huge amount of useful explicit knowledge acquisition. Here are some good ways to prepare for an interview with experts: identify your domain area in a very specific way; determine exactly what type of knowledge (or particular problem-solving knowledge) you need to acquire; put an open and closed questions to clearly satisfy your request; identify some good examples from your past experiences where you think that there are top skills that employees may need;

Observation is considered as an excellent method for acquiring tacit knowledge. This type of knowledge is hard to elicit using regular methods such as interviewing or other methods. It is useful to use monitoring programs in large organizations especially in industrial organizations. Monitoring experts during performing sensitive tasks can be very useful for acquiring tacit knowledge embedded in expert minds and then if the organization makes a discussion session with all interested employees with the experts to explain their behavior and to clarify every action done during performing their sensitive tasks will be very helpful in the process of knowledge acquisition.

Also, it must be mentioned that acquiring expert knowledge is vary from one organization to another based on the organization (or Domain type) type and culture (culture of knowledge engineer). The authors' opinion here that the eastern culture may be more suitable for knowledge transferring since the relationships between individuals in the organization may be friendlier more than US and Europe.

Organizations can enhance the relationships between employees (expert and non expert) by following and applying different methods which is very important for the tacit knowledge transferring between individuals. Authors suggest the following to enhance tacit knowledge acquisition: regular meetings, regular discussion sessions after each critical task, regular dinner parties, practicing any form of sports inside the organization for two hours weekly, managing regular visits between different departments to acquire general knowledge about other departments and to enhance relationships between employees, and any other suitable methods which can be chosen by managers based on organization type and culture.

In figure 2, the authors create a theoretical framework for manual knowledge acquisition from experts which could be used as guidelines for explicit knowledge acquisition from experts for most organizations.

The proposed framework could be used as a framework for acquiring explicit knowledge from experts. Interviewing is the main method and is a very important technique. This technique must be planned carefully to get its benefit. Also, it must be noted that the interview results must be subjected to thorough verification and validation methodologies.

Authors suggest sequence of steps in figure 1, and recommend that the knowledge engineers must follow the guidelines mentioned in figure 1. Following the mentioned guidelines allows the knowledge engineers to acquire knowledge in systematic methods (way) which means acquiring useful knowledge which could be used for developing the intelligent system in an organization.

In the following paragraph; authors will create a theoretical framework for tacit knowledge acquisition

which in our vision based on the heuristics of human expert so this will need observation methods.
In figure 2 the authors create a theoretical framework for manual knowledge acquisition from experts which could be used as guidelines for tacit knowledge acquisition from experts for most organizations.

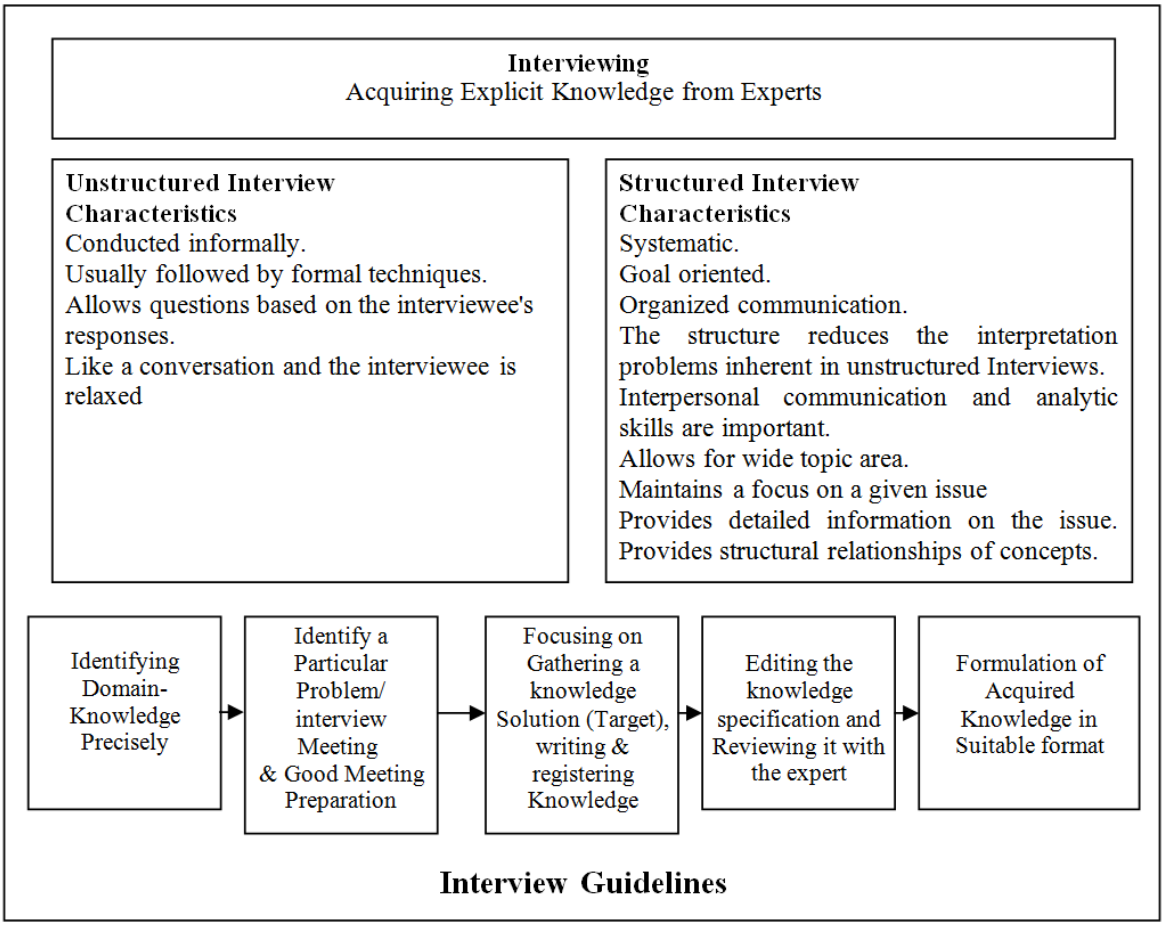

Figure 2 Theoretical Framework for Explicit Knowledge Acquisition form Expert

Sometimes it is possible to observe an expert at work. Also, sometimes it is the most clear and straightforward approach to knowledge acquisition. One of the main problems of observation is that large quantities of (of related and unrelated problem-solving knowledge are being collected. Most of the times only small parts of this acquired knowledge are useful. So if the organization uses a recording or a videotapes, the cost of acquiring knowledge must be considered. In addition, observation is usually expensive.
Observation can be divided into two types: motor movement and eye movement. With observations of motor movements, the expert's physical performance of the task; such as: walking, reaching, talking, expert manual process, etc. is documented. With observations of eye movements, a record is made of where the expert fixes his or her gaze (look) [14]. Eye tracking has been useful in understanding human performance issues in specific areas.
The authors suggest following the observation process mentioned in figure 3. Knowledge engineer has to identify the domain area exactly. This is very important since identifying domain area allows experts to focus on their targets. The next step is identifying critical task that he aims to learn from. After that he has to identify the suitable observation methods -such using videotapes, or any other media- he has to use based on task characteristics. After that applies the selected observation method. At the end, he has to study (review and discuss the acquired observed knowledge with different experts related to the problem solution) the observation and extract useful tacit knowledge. It must be mentioned here that a knowledge engineer has to follow ethical guidelines during his observation strategy proposed in figure 2.

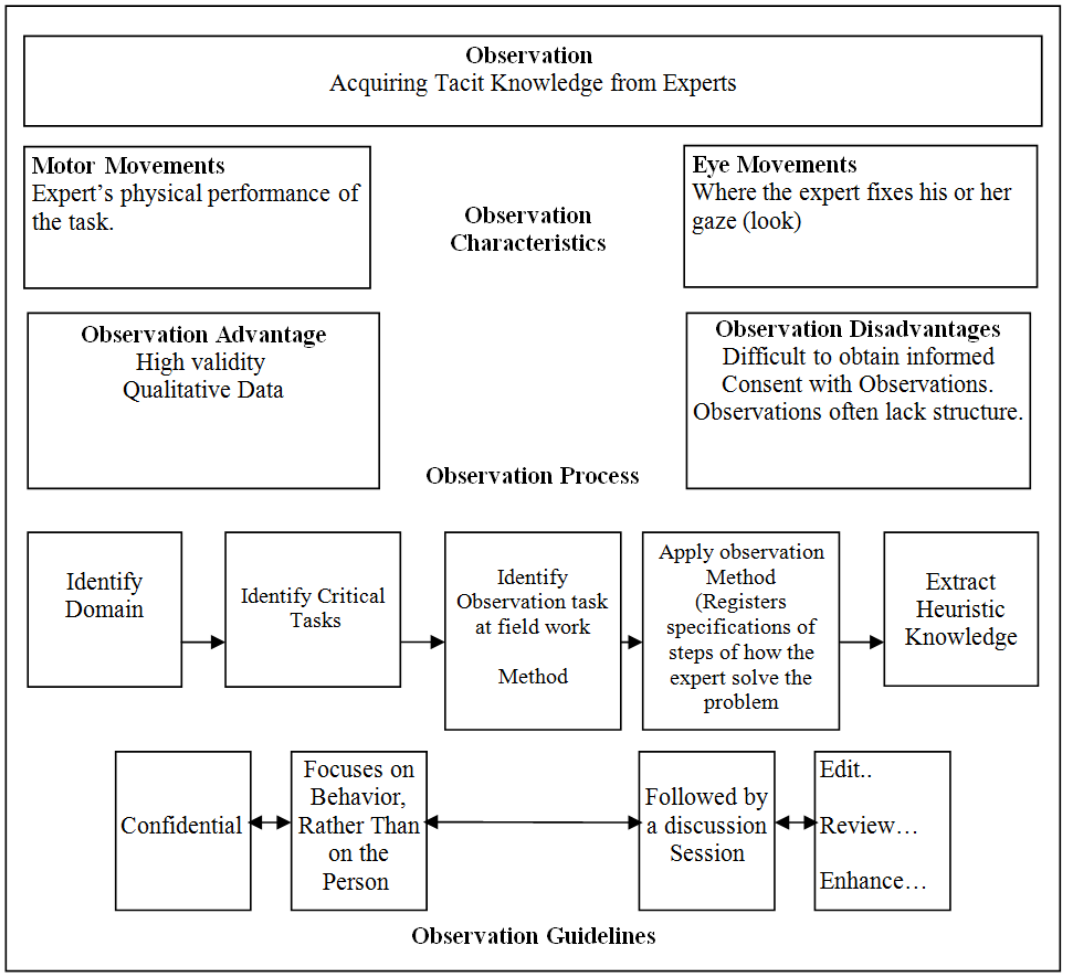

Figure 3 Theoretical Framework for Tacit Knowledge Acquisition form Expert

6. Conclusion

Knowledge acquisition is a very important issue in knowledge engineering. This paper presents a proposed framework for manual expert knowledge acquisition which could be used for most organizations (intelligent systems). The proposed framework of explicit knowledge acquisition focuses on interviewing as a known method for manual knowledge acquisition. The second framework focuses on observation method since it is more suitable to tacit knowledge acquisition. Both of them have clear guidelines mentioned in the proposed framework. Interview guidelines and observation guidelines proposed in frameworks represent an ethical and scientific base which must be followed by knowledge engineers.

Acknowledgment

The authors are grateful to the applied science private university, Amman-Jordan, for the partial financial support granted to cover the publication fee of this research article.

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