Expert System and it's Requirement Engineering Process

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Abstract— **Expert systems are basically developed to help in solving complex problems by reasoning about knowledge already known like a human expert does. It does not follow the procedure as followed in the conventional programming by a developer. In this paper basic introduction of expert systems consisting of their composition, basic characteristics and advantages of expert systems are covered. Apart from this, considering the development process of expert systems, it's not as easy to develop successful expert systems as it seems. There are certain factors which can lead to failure of expert systems and among them requirement engineering for expert systems is the one. While developing expert systems developers pay least attention to the requirement engineering process. Instead requirement engineering is very crucial to gather all the requirements that are needed for an expert system. If the requirements do not fulfill all of the client's wishes and needs, then in that case expert system is considered fail even though it works perfectly. Therefore, for successful development of expert systems its necessary that emphasize on requirement engineering process of expert systems should be laid down. Here, analysis of expert system attributes, requirement engineering processes in expert system development and the possible techniques that can be applied to expert system development are done. Next, the most appropriate techniques for the expert system development based on the analysis are proposed.**

Keywords- Requirement engineering techniques; expert system; knowledge base; requirement elicitation; modelling; requirement analysis; validation and verification; requirement management.

I. INTRODUCTION

The first definition of Artificial Intelligence can be given as creating machines or computers which can think and behave like human beings. Whenever there is a need of making complex judgments, computers can't take place of humans. But with the help of artificial intelligence, computers can be trained to think and behave like humans do. It is basically the ability of a computer or some other machine to perform activities that are normally expected for their completion where intelligence is required. Hence, artificial intelligence aids computers in learning from experience, from large amounts of complex data patterns can be recognized and complex decisions based on human knowledge and reasoning skills can be made. With artificial intelligence, we can build computers, in collaboration of thousands of computers that can all work in parallel to solve our complex and most dire problems.

AI research can be divided into several major topic areas like robotics, logic and natural language programming, automatic programming and expert system, which is also one of the major research areas [7].

II. EXPERT SYSTEM

An expert system is a computer system that intends to act in or behave in all respects like a human expert. Expert systems are basically designed to solve very complex and rigid problems not by following the procedure of a developer as is the case in conventional programming but by reasoning about knowledge in the same manner as an expert does.

Expert systems like SAINT by James Slagle of MIT which stood for Symbolic Automatic Integrator which solved integral calculus problems and STUDENT written by Daniel Borrow of MIT which solved high school algebra word problems leads to the evolution of expert systems [7]. But a general problem solving programs like these were not sufficient at all. Actually these are the features of an expert system which were needed- a computer program which simulates a human expert's behavior by applying reasoning techniques to a base of knowledge in some area of specialization, may indicate the reliability of the solution and can explain the reasoning which produced that solution [7].

A. Architecture of Expert System

Constituents of expert systems can be basically classified as [7]:

- Knowledge Base: The knowledge base contains the set of facts and rules which form the human expert's knowledge; this expert knowledge is a critical component to achieve expert performance. Knowledge and thinking processes of experts are collected and encoded into knowledge base. The knowledge base is domain-specific, that means, it pertains to a particular area of specialization. The knowledge base is expressed with natural languages rules "IF... THEN....." For example:"IF figure D is a rectangle and IF all four sides of D are equal THEN the figure is a square or a rhombus".
  This format of representing rules is advantageous because it is used in everyday language and is very

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rare in computer science. Rules provide the knowledge that is used by the expert system.

- Inference Engine: The inference mechanism or inference engine defines the manner in which new knowledge can be derived from the current knowledge by guiding the user through the knowledge base. It contains the algorithms which are used to search the knowledge base and other information necessary to select rules or to match rules to given input situations. In addition to this search strategy, the inference mechanism may contain facilities that enable it to trace the rules which lead to a conclusion; this allows the expert system to explain its results.
- Working Memory: The information concerning the specific problem to be solved is stored in the working memory section, sometimes referred to as the assertions portion.
- User Interface: A user communicates with the expert system through a user interface.

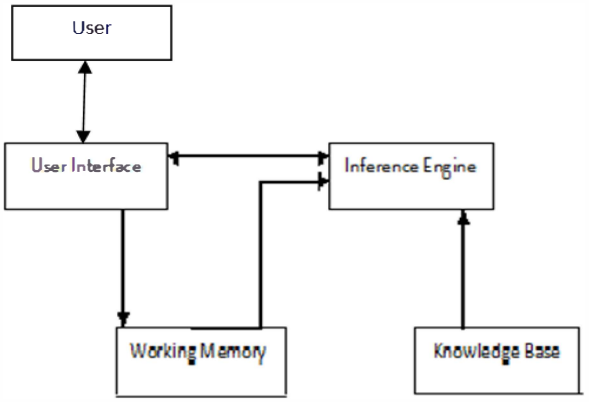

Fig. 1. Architecture of Expert System[7]

B. *Characterstic of an Expert System*

General characteristics of expert systems are as follows [4]

TABLE I. CHARACTERISTICS OF EXPERT SYSTEM

Features	Description
High Performance	should able to respond in the same way as an expert in the same field
Adequate Response Time	must perform in a reasonable time
Good Reliability	must be reliable and not prone to crashes or else it will not be used
Understandable	should have an explanation capability like human experts who can explain their reasoning
Flexibility	should have efficient mechanism for adding, changing and deleting knowledge from the large amount of knowledge

C. *Advantages of an Expert System*

Advantages that make expert systems so useful are [4]:

- Reduced Cost
- Reduced Danger
- Permanence
- Multiple Expertise
- Reliability
- Explanation
- Fast and Steady Response
- Intelligent Database
- Unemotional Response

III. REQUIREMENT ENGINEERING TECHNIQUES FOR DEVELOPING EXPERT SYSTEM

Similar to other software projects, expert systems also need requirement engineering to be done. If the requirements do not match with the client's needs then the expert system is considered as failed even if it works fine. Here, requirement engineering techniques are used to gather requirements to develop a system that can perform tasks that are usually performed by human experts. Requirement engineering is the discipline of determining, analyzing, pruning, documenting, and validating the wishes and requirements of stakeholders for a system [5]. Jiang et al. [3] has stated that bad requirement engineering practice contributes to project's failure. Therefore, suitable techniques should be used which prevent time and cost wastage and prevent rework during the development of expert system.

A. *Need of Requirement Engineering Techniques*

While developing expert systems suitable requirement engineering techniques should be selected for each project as each project has different requirements from the other one. Therefore, outmost care should be taken while selecting the combinations of different techniques because a mistake made at this step may lead to loss of the expert system. One of the remarkable work is done by the Jiang et al. called *Methodology for Requirement Engineering Techniques Selection (MRETS)* which helped requirement engineers to select proper techniques on hand [1]. This was basically applied to industrial software projects which presented the combination requirement engineering techniques because Jiang et al. has stated that there is no single technique which could provide a solution for all requirement engineering problems [3]. On the other hand, a study related on requirement syntax [6] has stated that requirements given by stakeholders are written in unstructured natural languages and that lead to some problems during the system development such as ambiguity, complexity, omission, duplication, inappropriate implementation and understandability. In the early stages of development requirement engineering is always ill-defined and this causes under load or overload of information and hence knowledge engineers might waste time in researching a main problem domain in order to fulfill the stakeholder's requirements. In order to develop a high quality expert system, active involvement of users, customers, and other stakeholders is needed so that they can help knowledge engineers to understand their concerns. So, stakeholders have the potential to illuminate issues and involve during the

progress of program or project implementation. So, there active participation is need [1]. And for this, interviews, workshops and evolutionary prototyping for requirement elicitation can be done.

B. Expert System Requirements

First the analysis of expert system development is done and after that analysis on the requirement engineering process in expert system development is done to identify the objectives and requirements and after that, study on the specific techniques that can be applied in expert system development is done by justifying the selected techniques.

1) Analysis of Expert System Development

It is very important to know that what is the criterion that is need to build a successful system. A successful system is one that is:

- Intelligent: Means which can perform the task as intelligent as human thinking.
- Economic: Errors should be minimized to lowest in order to save cost.
- User Friendly: User friendly system will save time and effort for end users when they first time use the system.

According to Tyran and George [8], there are many factors that can directly affect the success and failure of an expert system. These factors are:

- Organizational Factors: These are external factors that include involvement of stakeholders such as commitment to the project, management support and also end user's participation.
- Implementations Activities: These are user needs assessment, demonstration of the system, training and also maintenance of the expert system.
- Technical Factors: These include technical expertise and expert system software/development tools.
- Ease of use

There are some key attributes and characteristics that have direct effect on an expert system:

TABLE II. FACTORS EFFECTING EXPERT SYSTEM

Factors	Description
Project Size	Different sized projects need different requirement techniques.
Requirement Volatility	High requirement volatility projects need more flexible techniques in requirement engineering.
Project Category	Different techniques needed for different categories of projects.
Safety Criticality	More caution and serious techniques needed for more safety critical systems.
Project Complexity	Complex projects need different requirement engineering techniques.
Project Cost Constraint	Knowledge engineers will have difficulties in completing projects if budget is not sufficient.
Project Time Constraint	Expert system might not meet its requirement if time is limited.

2) Analysis of Requirement Engineering Process in Expert System

According to Cheng and Atlee [2], there are five main tasks in requirement engineering which are:

TABLE III. TASKS IN REQUIREMENT ENGINEERING PROCESS

Tasks	Description
Requirement Elicitation	• Here all the requirements are identified to achieve the goal of expert system. • Success rate will increase if we can collect as much of requirements during the early stage of elicitation; hence, we need to identify all the stakeholders of the system. • Interview, focus group and brainstorming are done.
Modelling	• Abstract description is created that is amenable to interpretation [1]. • Data is organised so that it can be understood by all the stakeholders. • ER diagram, UML and data flow diagrams are use to create models here. • Models can be used for references of the development team and each development team should have access of it.
Requirement Analysis	• It is a process of understanding functions, data and interface for new system. • Here, ambiguity, inconsistency and incompleteness can be identified. • Non-functional requirements of expert system are also analysed. • Conflict management, card sorting and viewpoint based analysis is done.
Validation and Verification	• It is ensured that the requirements of expert system are valid so that they are executable for the following development cycles. • Verification makes clear of ambiguous requirements. • Inspection, requirement checklist, requirement testing, and prototype are conducted.
Requirement Management	• Includes the tasks of managing the requirements for all the time. • Requirements are documented.

C. Specific Requirement Engineering Techniques for Expert System

There are lots of requirement engineering techniques like which can be used for expert system development in different tasks Requirement Elicitation, Modeling, Analysis, Verification and Validation and Requirement Management in requirement engineering process. The selecting factors will be based on the factor listed by Kheirkhah and Dareman [5]. The different techniques use different methods to help out the requirement engineering process. Each task deploys number of techniques to completely and successfully accomplish the requirement engineering process. The detailed techniques used

by different tasks are given in the following table. The justification of the selected techniques is listed as:

TABLE IV.SPECIFIC REQUIREMENT ENGINEERING TECHNIQUES

Tasks	Techniques	Conditions to apply
Requirement Elicitation	JAD	When there are different stakeholders from different domains in the team.
	Ethnography	Where functionality and usability are crucial and where elicitation of implicit requirements is essential.
	Focus Group	Where communication is possible.
	Interview	When some stakeholder's opinions are very important.
	Brainstorming	Where ideas be generated.
Modelling	UML Diagram	When project is very complex.
	DFD	When project is very complex.
	ER Diagram	When project is very complex.
	Structured Natural Language Specification	Where unambiguous requirements can be written using notations.
Analysis	State Machine	When project demands consistent and unambiguous states.
	Fault Tree Analysis	When project is very complex.
	Goal Oriented Analysis	When the system has different goal for different users.
	Card Sorting	Where requirements can be prioritized.
	Conflict Management	Where conflict of requirements can be solved.
	Viewpoint based Analysis	Where different views of stakeholders can be identified.
Verification and Validation	Formal Inspection	Where precise and consistent requirements are needed.
	Requirement Checklist	When incomplete requirements can be identified and the project is very complex.
	Prototype	When project is very complex.
	Requirement Testing	When the stakeholders can directly review requirement artifacts.
Requirement Management	Requirement Management	When the quality of requirement specification is main issue and project is very complex.

Based on the expert system attributes suggested techniques are selected. The techniques are applied in each process of requirement engineering and they should be followed in sequences.

IV. CONCLUSION AND FUTURE SCOPE

Requirement Engineering is vital in determining how the expert system will be implemented. Hence, selecting good and appropriate techniques during requirement engineering process is important. They contribute to the overall implementation of the whole expert system project. A good document from requirement engineering process can definitely reduce the workload of the developer in the next step while a good reference of documentation will help to prevent further maintenance problems. Therefore, a list of requirement engineering techniques is chosen that is useful in developing expert system project based on the criteria and project attributes of the particular expert system. Currently, there is no existence of one complete requirement engineering techniques for all the stages in requirement engineering process that can be applied to all of the expert system. Each stage has different requirements and also different techniques are required to complete the stage. Requirement engineering techniques also vary in each project according to the project scales and other variables that affect the project. Hence, problems are still there with these requirement engineering techniques as they can't be applied to all types of expert systems. Sheer research is needed to define requirement engineering techniques that can be applied to all types of expert systems.

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