Systematic Design of Expert System Using Unified Modelling Language

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Abstract. An expert system as an expert knowledge-based information system has been widely used by interested parties to consult their problems. Therefore, an expert system should be well designed so as to meet the requirements for a software to store knowledge, explain problems, and recommend solutions. The purpose of the present study is to develop a systematic design of an expert system using Unified Modeling Language (UML), which is one of popular object-oriented modeling languages. The research method was a literature review as the main source for analyzing the expert system requirements. The developed design was then clarified, verified, and validated in a Focus Group Discussion (FGD). To evaluate the model, a review of some related studies was conducted. The research respondents were informatics lecturers at UIN Sunan Gunung Djati Bandung. The results of the study revealed that the systematic design of expert system was well-developed because it was user-friendly, flexible, easy to be modified, and able to propose solutions for various problems..

1. Introduction

An expert system is a system that stores a human expert's knowledge in order for the computer to be able to solve problems using that knowledge [1] [2] [3]. The purpose is not to replace the expert in question, but as medium to solve problem without direct intervention from him. Therefore, a good expert system will involve an expert in its development [3] [4]. Generally, all expert systems have same patterns despite the fact that problems they solve are different. This paper describes a uniform model for the development of expert system analysis and design. The model is presented systematically and implemented easily and flexibly for various problem-solving purposes.

Analysis and design modeling of a software development is important to ensure the quality of both process and product [5] [6] [7]. The current trend in the analysis and design modeling is object-oriented. Unlike the structured modeling, the object-oriented modeling situates objects as the main viewpoints [8] [9] [10] [6] [5]. The analysis and design modeling for this expert system is done using UML and Model View Controller (MVC) patterns. Numerous studies have proven that UML is a popular modeling language that has a good system visualization and documentation performance. The UML modeling even can generate ready-to-implement programming codes [11] [12] [13] [14] [15] [16] [17]. MVC is a paradigm where objects are grouped into model, view, and controller [18] [19] [20]The MVC pattern organizes the interaction between model objects, view objects, and controller objects. This makes the modeling that uses MVP pattern work systematically [19] [18].

In this paper, we describe a development of systematic design of an expert system through UML modeling using MVC pattern. This expert system can adapt to various expert system case studies flexibly, is easy to understand, modify, and implement. Its systematic design is clarified, verified, and validated conceptually in an FGD. Conceptual validation is a validation process using axioms and theory as the basis for measuring the compatibility of concept or model that is being designed [21]

[22]. FGD is one of conceptual validation activities [21], which can decide things that cannot be explained statistically, based on the perspectives, experiences, and practices of a group of people with the same scientific field [23] [24] [25].

2. Requirements Analysis of Expert System

An expert system is a part of artificial intelligence to solve complex and rigid problems, so the system is designed not based on the analysis and design from the developers, but in accordance with the knowledge of the expert [26] [27] [28]. In general, there are two main important parts in the expert system: the knowledge base, which is an expert's knowledge, and the inference engine that stores an expert's reasoning concept [29] [27] [30]. But also, an expert system needs explanation and learning [27]. An expert system user needs to explain what problems an expert system needs to learn to generate the right solutions. Figure 1 is the structure and architecture of an expert system that shows relations between knowledge base, inference, and expert system components as concluded from some research studies.
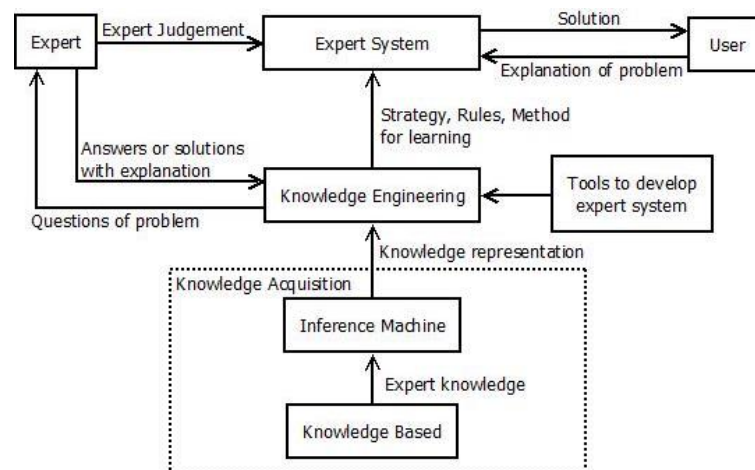
Figure 1. The architecture of expert system [1] [3] [4] [29] [26] [28]

Knowledge engineering process contains a knowledge acquisition process based on an expert's knowledge processed by an inference engine so as to result in a knowledge representation. There are many knowledge representation forms such as rules, semantic networks like neural network, frames, scripts, and logics [3] [4] [28]. The main key in an expert system is the expert judgement that determines its accuracy and quality in problem solving. The expert system verification and validation are not just testing the software in such a way that errors, faults, and failures are not found to be said to be good and reliable because an expert system stores an expert knowledge and reasoning. Sometimes what the software thinks is correct does not necessarily mean that it is also correct according to the expert [31] [32]. Still, the verification and validation have to be carried out. The verification can be done through dependent and independent domains, and the validation may use both qualitative and quantitative methods such as rule validation, heuristic, test cases, control group, and so on [31] [32]. Some of expert system requirements can be analyzed using UML Use Case in Figure 2.
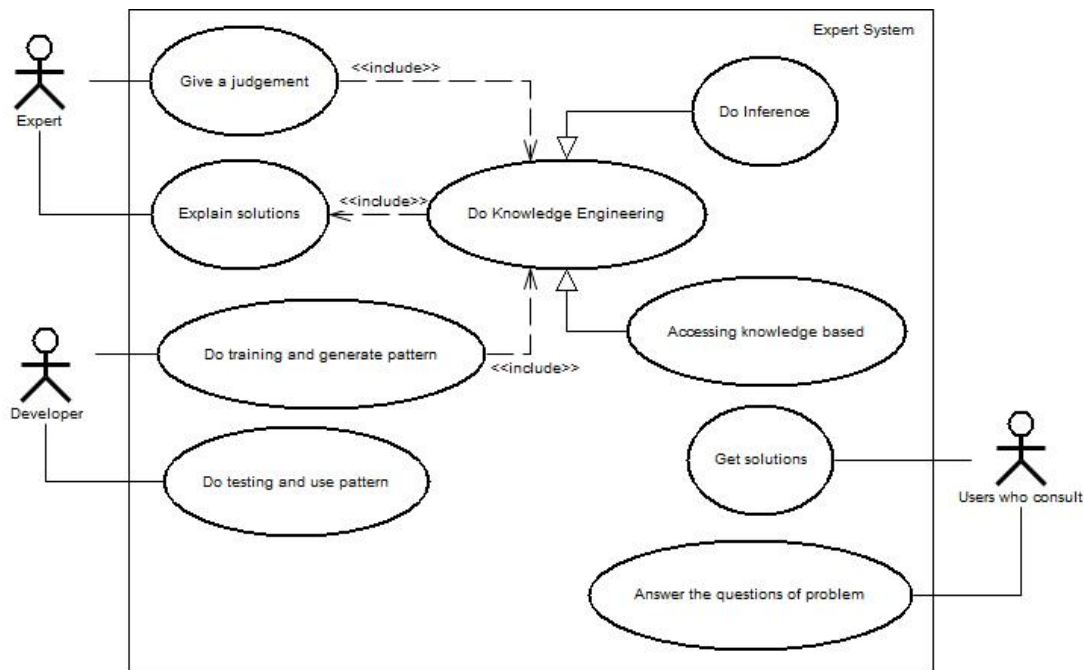
Figure 2. Expert system use case diagram

3. Purpose of Systematic Design of Expert System using UML
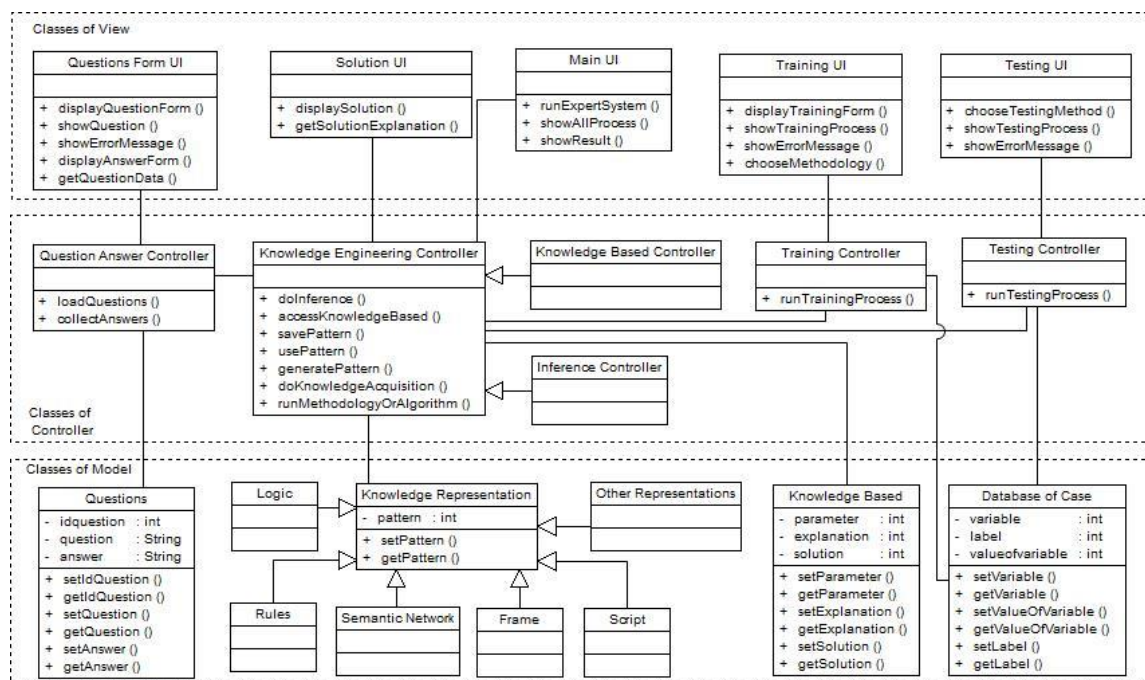

Figure 3. Expert system class diagram

Generally, some of expert system requirements can be described and modeled in some UML diagrams like use case, class, and sequence. The proposed model described in this paper is the systematic model that are generally found in the expert system. This model can be used in the expert system development for various types of case studies. Figure 2 is a use case diagram that illustrates the interaction between the actor and the expert system. Figure 3 illustrates the relations between objects in the expert system modeled by the class diagram. The attribute and method in the class diagram can generally found in an expert system. They can flexibly adapt to various problem-solving needs. The

attribute and method can be added to the "Knowledge Engineering Controller" class, and even to classes related to methodology and algorithm like rule-based, knowledge-based, neural networks, fuzzy, object-oriented, case-based reasoning, modeling, system architecture, intelligent agents, ontology, and database [28]. Figure 4 is an example of sequence diagram that illustrates interactions between objects based on time sequence or flow. In this paper, the sequence diagram models the process of normal analysis and the expert system design. Every use case ideally has one sequence diagram for each one of normal process and alternative process. Figure 4 exemplifies some sequence diagram for the "Do Training and Generate Pattern" use case.
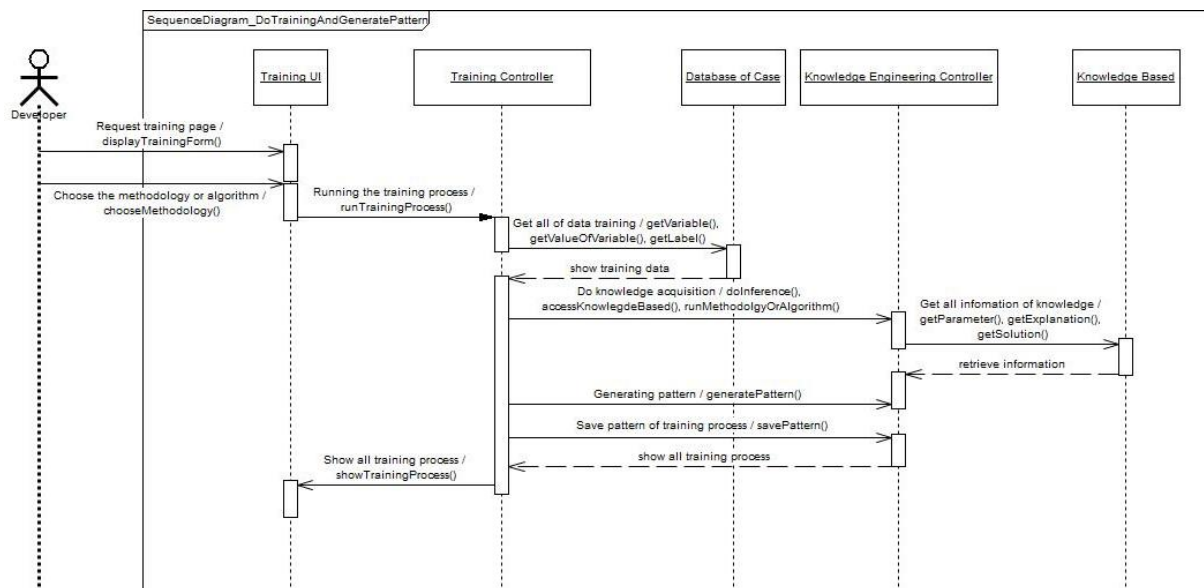
Figure 4. Sequence diagram for the "Do Training and Generate Pattern" use case.

4. Results and discussion

The clarification, verification, and validation were carried out in the Department of Informatics of UIN Sunan Gunung Djati Bandung by people with the same research interest, expertise, and experience. We conducted a focus group discussion [24] [25] with informatics lecturers as experts in the conceptual validation of systematic design of expert system using UML. Most of them deemed the design had fulfilled overall expert system requirements and was ready to be implemented and adapted when developing expert systems. This modeling can be easily understood, used and modified in accordance with the problems to be solved.

To test the model, we also evaluated the models of 20 different expert system case studies as illustrated in Table 1. We attempted to find out if every use case in the systematic design was available in the expert system studies. The class diagram was not evaluated because every object in it would be different, depending on the expert system requirements. Out of 20 studies on expert system, 3 did not describe the knowledge engineering process, 11 did not define or involve the expert judgement, 5 did not define the training and testing process, and 3 did not provide a detailed training and testing process. Based on this evaluation, the systematic model proposed in this paper can be used by expert systems to solve various problems in accordance with object-oriented modeling using UML [8] [11] [7]because some studies have implemented all components of the proposed expert system systematic model despite the fact that some of them did not define the system assessment.

Table 1. The result of evaluation of 2 studies on expert system

DOI	Knowledge Engineering	Expert Judgement	Training & Testing
10.1016/j.eswa.2016.10.053	Available	Available	Available
10.1016/j.eswa.2016.07.019	Available	Available	Available
10.1016/j.eswa.2015.12.028	Available	Available	Available
10.1016/j.eswa.2015.12.011	Available	Available	Available
10.1016/j.eswa.2017.05.008	Available	Not defined	Available
10.1016/j.eswa.2017.04.039	Available	Not defined	Available
10.1109/TDEI.2013.004126	Available	Not defined	Available
10.1109/ISCIII.2009.5342283	Available	Not defined	Available
10.1109/DEMPED.2009.5292755	Available	Not defined	Available
10.1109/ICIE.2009.9	Available	Not defined	Not detailed
10.1109/ICSESS.2016.7883181	Available	Not defined	Not defined
10.1109/ICITACEE.2015.7437776	Available	Not defined	Not detailed
10.1109/ICITBS.2015.208	Not detailed	Not defined	Not defined
10.1016/j.eswa.2016.10.046	Available	Available	Available
10.1109/ICTC.2015.7354493	Available	Not defined	Not defined
10.1109/IGARSS.2015.7326463	Not detailed	Available	Not detailed
10.1109/ICCAS.2013.6703917	Available	Not defined	Not defined
10.1016/j.eswa.2015.07.026	Available	Available	Available
10.1016/j.sbspro.2015.06.416	Not detailed	Available	Not defined
10.1016/j.gie.2016.07.035	Available	Available	Available

5. Conclusion

The expert system as a smart storage system of human expert knowledge has been widely used to solve various problems as a human expert does. Numerous studies on expert system and its application have the same basic concept. In this paper, the expert system concept was modeled systematically using UML. Based on the results of clarification, verification, and conceptual validation in the FGD, it can be concluded that the systematic model has met the expert system requirements and can be implemented in various expert system case studies. In addition, based on the evaluation of 20 studies on expert system application, all use cases are available in the proposed expert system.

For further studies, a more specific model for certain case studies can be designed as each one of case studies has its own requirements. Despite the same basic concept, its details are varied. A measure of the quality of model flexibility should be undertaken in addition to the evaluation of different case studies; for example, using CBO (Coupling between Object Classes) and LCOM (Lack of Cohesion in Methods) metrics.

Acknowledgements

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