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Dynamic Knowledge Map and RDB-based Knowledge Conceptualization in Medical Arena

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Abstract

Management of human knowledge is an interesting concept that has attracted the attention of philosophers for thousands of years. Artificial intelligence and knowledge engineering has provided some degree of rigor to the study of knowledge management systems and expert systems (ES) are able to use knowledge to solve the problems and answer questions. Therefore, the process of conceptualization and inference of knowledge are fundamental problem solving activities and hence, are essential activities for solving the problem of software ES construction. Especially, the access to relevant, up-to-date and reliable knowledge is very important task in the daily work of physicians and nurses. In this study, we propose the conceptualization and inference mechanism for implicit knowledge management in medical diagnosis area. To this purpose, we combined the dynamic knowledge map (KM) and relational database (RDB) into a dynamic knowledge map (DKM). A graphical user-interface of DKM allows the conceptualization of the implicit knowledge of medical experts. After the conceptualization of implicit knowledge, we developed an RDB-based inference mechanism and prototype software ES to access and retrieve the implicit knowledge stored in RDB. Our proposed system allows the fast comfortable access to relevant knowledge fitting to the demands of the current task.

Keywords: Expert systems, Implicit knowledge, Artificial intelligence, Conceptualization, Dynamic knowledge map, Relational database.

1. Introduction

Once people start seriously discussing the knowledge asset of an organization, the issue of what knowledge is and if information or data is knowledge soon emerges. Then, there was a growing effort to develop ontology or conceptualization mechanism that will help to clarify the area of applied knowledge (Gordon, 2000). Traditionally, conceptualization involves two fundamental activities (Gómez et al., 2000): analysis and synthesis. Analysis is a descriptive activity, by means of which components of the problem under study can be identified, whereas synthesis restructures and reorganizes the above model to represent the problem-solving process under examination. However, the access to relevant, up-to-date and reliable information is a time critical, but nevertheless very important task in knowledge management. The medical occupation requires a widespread and up-to-date access to various knowledge resources, for instance, text books, documents, files, journals, guidelines, medical indexes, selected Internet sites, news groups, colleagues and medical experts. An efficient use of these knowledge resources in clinical routine is hampered by the heterogeneity and spatial distribution of the data (Beier & Tesche, 2001). To this purpose, several medical information retrieval systems were developed, such as (Internet) search engine, vector space model and medical expert systems. However, traditional information retrieval tools and expert systems have several limitations. First, search engines collect each page, disregarding its medical or non-medical content. Thus, the inquirer will receive numerous non-medical contents. Second, translation to other languages of interest is usually not performed. In most retrieval tools, they use simple question and response to represent patients' or experts' knowledge. Third, the vector space model most search engines use, calculates a hit ranking order based on word frequencies at document level. Unfortunately, the expert's knowledge may changed by environmental effects, experience, other information resource, and etc.

In this paper, a medical expert system (MES) to retrieve medical contents is presented, which tries to overcome most of the above mentioned pitfalls. To this purpose, we use the dynamic knowledge map and relational database (RDB). Dynamic knowledge map could help an expert, who wants to transform his implicit knowledge into explicit knowledge. Then, RDB could help a medical knowledge manager to link distributed medical knowledge with relationships. Therefore, the developed MES enables an interactive navigation by using dynamic knowledge map and RDB of the medical knowledge. The knowledge contained at dynamic knowledge map is utilized to control the search for documents or other information related to the query.

2. Methodology

Computer-based expert systems (ES) and artificial intelligence (AI) have also made an important contribution to our understanding of knowledge. For this activity to succeed, researchers had to be very clear about what they meant by knowledge and had to develop rigorous representations for knowledge so that the knowledge could be brought to life in a computer program (Shortliffe, 1976).

There are several accepted methods of knowledge representation that have been devised for AI-type applications. Some of these are also suitable for use and interpretation by humans and can form a bride between human knowledge and machine knowledge (Gordon, 2000). As one of useful methods of knowledge representation, in this study, we use knowledge map (KM).

KM is the name given (McCagg & Dansereau, 1991) to a type of mental diagram by means of which complex ideas can be easily and quickly set out in a logical order. KMs are a graphic representation of the connections made by the brain in the process of understanding facts about something. They are built starting with the attribute that defines the problem to then develop a graphical diagram that sets out on paper the manner in which the mind comes up with ideas in the process of understanding (Gómez et al., 2000). The details of Gómez et al.'s (2000) KM construction are conditioned, though not determined, by the problem domain. A general-purpose 6-phased procedure for outputting a KM during the knowledge conceptualization process is given below.

Phase 1: Identify the main goal of the system. Generally, the purpose of the knowledge based systems (KBS) or ES is to make a decision on a concept and, more particularly, on a property or attribute of that concept, which we have termed the (main) goal property. Therefore, the above main goal should have already been decided, as it is essential for drawing up the KM. The attribute or goal property in a medical diagnostics system, for example, would be the disease suffered by the patient and a prescription presented by doctor.

Phase 2: Design the goal decision block. To extract a graphical representation of KM, in this phase, draw a rectangle around the property, specifying to which concept it belongs, using the property/concept form, and the possible values of that property. In the example of the medical diagnostics systems, the possible values would be the names of the diseases that are to be diagnosed by the system. Figure 1 shows an example of how to represent the properties in the KM.

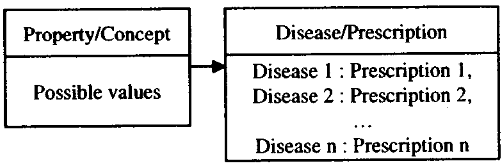

Figure 1 Property representation in the KM

Phase 3: Add the properties for inferring or calculating the goal decision. After the design of goal decision block, place the properties inside boxes around the goal decision. The relation with the goal property is expressed by means of an arrow that will start from the property used to infer or calculate the goal decision. The number of values of the source property of the arrow is specified on this arrow. If the number of values is 1, no specification is required. Each attribute around the goal decision must be involved in inferring the value of this decision. However, there is no need to infer the all attributes at the same time. Because of most human expert could deal with only a small number of attributes simultaneously. If a lot of attributes are used to infer the value of the goal decision, domain expert will probably calculate the value of some intermediate attributes in order to infer the goal decision. Then, the number of attributes around the goal decision could be reduced by introducing intermediate attributes.

Phase 4: Extend the KM. If there were more additional information to infer the decision goal, the properties used to infer the values of each property have to be added.

Phase 5: Repeat phase 4 until none of the *peripheral* properties are inferred, that is, they are taken from external sources such as user input, sensors, files, database, and other external or internal changes.

Phase 6: Check the knowledge reflected in the KM. These checks come under two categories. First, checks related to the validation of the knowledge reflected in the KM with domain expert. Second, checks related to the verification of the KM against the static and dynamic models generated during the synthesis stage.

To combine the KM with RDB, in this study, we extended the Gómez et al.'s (2000) KM construction process to 9-phased process. Then, we called this process as dynamic knowledge map (DKM) construction process. Additional processes for DKM are given below.

Phase 7: Frame-based RDB table construction. After the check for KM, transformed the KM into frame-based RDB table forms.

Phase 8: Add the inference rules into frame-based RDB table. This phase is critical difference with Gómez et al.'s (2000) KM construction. To infer the properties or calculate the goal decision, we added the each inference rule into frame-based RDB table.

Phase 9: Relate the RDB tables. To confirm the relationships among each node in KM, connect the RDB tables with RDB relationship facilities.

Figure 2 shows an example of how to represent the properties in our proposed DKM.

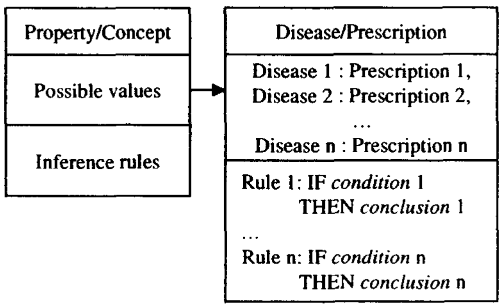

Figure 2 Property representation in the DKM

3. Example of DKM construction

In this section, we propose a practical application of the DKM to give a better understanding of how DKMs are built and used. The example is part of a real medical expert's knowledge and illustrates how the DKM is drawn up from the static and dynamic models. Figure 3 shows the example of our proposed DKM.

In contrast to Gómez et al.'s (2000) KM construction, our proposed mechanism DKM has several advantages.

First, each RDB table has its inference rules. Therefore, there is no need to construct a huge rule base.

Second, it is very easy to add and revise the DKM and its knowledge through the graphical user interface supposed by RDB management systems (RDBMS).

Third, on the basis of our proposed mechanism, ES has no need to have special inference engine. Because of every inference is performed by each RDB table respectively.

Fourth, there are no conflicts among inference rules. Because of every DKM nodes possess his own inference rules, and its' decision depends on his own properties.

Fifth, DKM node has several inference rules within his block. Contrary to Gómez et al.'s (2000) KM, therefore, our DKM could produce multiple choices.

4. Conclusion

In this paper, we tried to show the importance of understanding and conceptualization the knowledge as a key element in proper KBS or ES development. Conceptualization is not an activity exclusively applicable to ES development. On the contrary, it is an activity performed by any human being about to solve any problem. In previous researches, therefore, many researchers tried to develop an ontology and conceptualization method to help the human expert in knowledge transformation. As a result of these researches, several accepted methods of knowledge conceptualization were introduced. Especially, KM has advantages in transforming a human knowledge to machine knowledge. Then, RDB was known as a reliable tool to represent and store the frame-based inference rules and their relationships. In this research, therefore, we extended traditional KM construction process and combined these two different knowledge

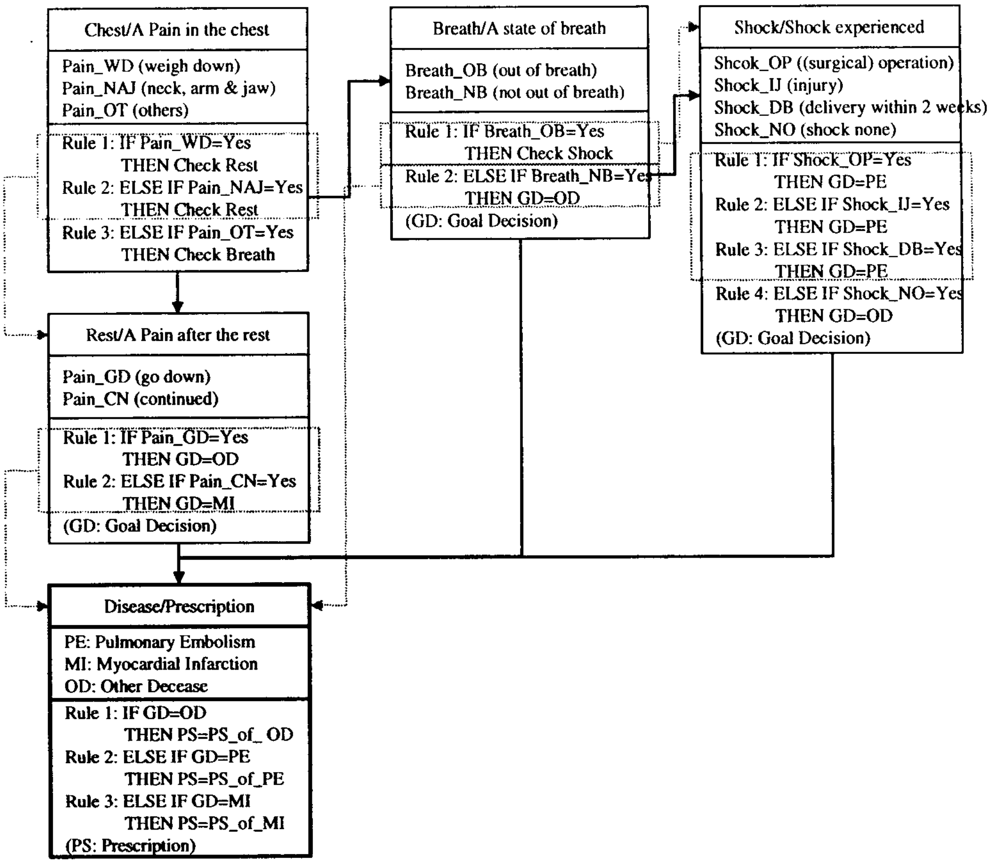

Figure 3 Representation of sub-problem in the DKM

representation tools as a dynamic knowledge map (DKM). The method could support the organizations in several ways:

- It makes expert knowledge visible to all managers and users
- It helps managers identify areas of expert knowledge requiring attention.
- It can improve the efficiency of knowledge inference and its application

The method also has advantages for the individual and for organizations specializing in education:

- It can help individuals plan their own learning when working alone in some area which requires specific domain knowledge.
- It allows an individual to see and understand a conceptualization process of knowledge and its applications.
- It can be easily applied to the educational field such as ES development or decision support systems (DSS) construction.
- It helps to concentrate effort on understanding rather than on technical implementation.

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