Medical Knowledge Management using Case-Based Reasoning Methodology

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Abstract

In medical applications, domain knowledge may be used to avoid wrong decisions, to be able to make a correct decision for strong working diagnosis and partly for therapeutic purpose. In this paper, the Case Based Reasoning methodology combined with ontology has been applied to implement case-based medical diagnostic knowledge structuring. The knowledge repository for disease-specific treatment has been developed in order to support diagnosis process, provide and share the knowledge of medical experts for diagnosis and treatment of specific disease. It has also been described that medical Knowledge Base (KB) systems are either highly specialize, lack accuracy or are just too simple. To overcome this problem of scope, a methodology for proliferating the scope and precision of the diagnostic ontology-based knowledge base is described in this paper. It also aims to understand and solve new similar problems and support similar decision making as well as share medical knowledge and treatment experiences among the medical practitioners.

1. Introduction

Knowledge and knowledge sharing became established requirements for general practitioners due to the fast growth of the internet. Knowledge is a critical resource competitive advantage of lasting competitive advantage. And knowledge is also more powerful than natural resources. Especially in medicine, the knowledge of experts does not only consist of rules, but also consists of a mixture of textbook knowledge and experience which takes into account reasoning of expert physicians.

Since there involve lots of complications, medical diagnosis from surface etiology is difficult. A general practitioner has to carefully investigate a patient's symptoms, chief complaints, and pathology examination in order to decide possible diseases. In medical field, it takes years of training and practice for a doctor to make correct decisions. The knowledge is based on the experience of human resources, and medical experience in terms of treatments, diagnosis, drug-dosing, lessons learned, the notions and explanation of physicians. In order to fulfill this need, this paper has proposed to develop medical diagnostic knowledge structuring and management realized in modeling of medical treatment for specific diseases and its reasonable descriptions.

The proposed system aims to analyze and model the professional decision performance processed by the experienced physicians to identify emanating knowledge. Then the medical diagnostic knowledge repository model has been built to store the crucial knowledge as in cases. Each concept and relation of the diagnostic knowledge memory are explained and described to build the associated domain ontology.

The rest of this paper is organized as follows. Section 2 reviews the related work. Section 3 describes why Case Based Reasoning (CBR) is suitable for this system. The overview of the proposed system is presented in section 4. Finally, in section 5, we conclude this paper and discuss the future work.

2. Related work

Knowledge is defined as "the fact or condition of knowing something with familiarity gained through experience or association". Knowledge Engineering aims to collect, analyze, structure and represent knowledge. Knowledge environments can be seen as distributed systems where physicians with different specialties share their knowhow in order to achieve their professional activities. The more efficient experience reuse and the benefit of experience sharing and reuse have become obvious with the increase use of internet and improving decision processes is obvious. Today almost all over the world people in different fields are taking advantage of sharing their experiences and reusing them for example in Knowledge Management [4] and [7], Diagnostics and Condition Based Maintenance system [5] and Health Monitoring system [6]. At the

same time the amount of low quality information and waste amount of information available reduces the value of the internet and the time employees spend on searching for the right information increases and it may extend to hours every day [2]. Also much of the information and experience available is of low quality and may even be wrong and in worst case resulting in serious accidents and costs.

A general framework of how to capture knowledge from experience described in [8]. In this article, using Case-Based Reasoning (CBR) they elaborated MUSETTE (Modelling USEs and Tasks for Tracing Experience). In similar articles, [3, 9] built and exploited project memories in product design projects with domain ontology. In [3], it described an approach to manage knowledge based on multi-agent system, the development of a knowledge engineering module integrated in a collaborative eGroupware system. It developed a formalism called RIOCK (Role Interaction Organization Competence and Knowledge) to identify the emanating Knowledge resulting from the interaction between the roles played by professional actors. [3], it presented the design of a domain ontology called OntoDesign for building and exploiting project memories in product design projects.

There are ontologies that aim to comprehensively represent domains of basic biomedical science such as anatomy, physiology and pathology and which are reusable and generalizable to meet the needs of any application requiring structured information for the particular domain.

3. Why Case based reasoning?

Especially in medicine, the knowledge of experts does not only consist of rules, but of a mixture of textbook knowledge and experience. The latter consists of cases, typical and exceptional ones, and the reasoning of physicians takes them into account. In medical knowledge based systems there are two sorts of knowledge, objective knowledge, which can be found in textbooks, and subjective knowledge, which is limited in space and time and changes frequently.

The important thing for improving decision processes, and the knowledge management across interacting organizations is to explore successful past experiences. Case-based reasoning (CBR) is a problem solving strategy which is based on the reuse of past solutions (cases) to address new problems. CBR means reasoning from experiences or "old cases" in an effort to solve problem, critique solutions, and explaining anomalous situations. A past experience is stored under the form of solved problems (cases) in a so-called "case base". When a new case comes, CBR search the similar case to identify the solution for the current one.

CBR is often used where experts find it hard to articulate their thought processes when solving problems. There are two styles of CBR 1) problem solving style that can support a variety of tasks including planning, diagnosis, and design 2) Interpretive style that is useful for situation classification. In medicine, CBR has mainly been applied for diagnostic and partly therapeutic purposes.

Central tasks that all CBR methods have to deal with are [1]: to identify the current problem situation, find a past case similar to the new one, use that case to suggest a solution to the current problem, evaluate the proposed solution, and update the system by learning from this experience. How this is done, what part of the process that is focused, what type of problems that drives the methods, etc. varies considerably, however.

There are the two main tasks for the CBR process. The first one is ***retrieval*** which is the search for the calculation of most similar cases. If the case base is rather small, a sequential calculation is possible. Otherwise faster non-sequential indexing or classification algorithms or Nearest Neighbor match should be applied.

The second task is the ***adaptation*** (reuse and revise) which means a modification of solutions of former similar cases to fit for a current one. If there is no difference between the current and the similar cases, a simple solution is to be transferred. Sometimes, only few substitutions are needed, but the adaptation is a very complicated process.

4. System overview

The whole process of structuring therapy knowledge base is possible to capitalize diagnostic experience in medical domain. In this system, for a single case, a variety of different performances from the different experienced therapists have to be gathered into the therapy memory. Indeed the therapy memory is a memory of knowledge and information acquired and produced during the realization of the previous diagnosis. Thus, therapy memory constitutes a basis for knowledge capitalization and reuse. Not like other recommender systems or decision making systems, all possible standard ways derived from the memory for a given similar case will be shown to the user. So, any general practitioner can keep an eye on these ways and reuse these professional experiences in the past similar treatments from the therapy memory. These processes are managed by using ontological concepts. This architecture can be seen in figure 1. In this figure, a new case may be either symptoms or patient's record.

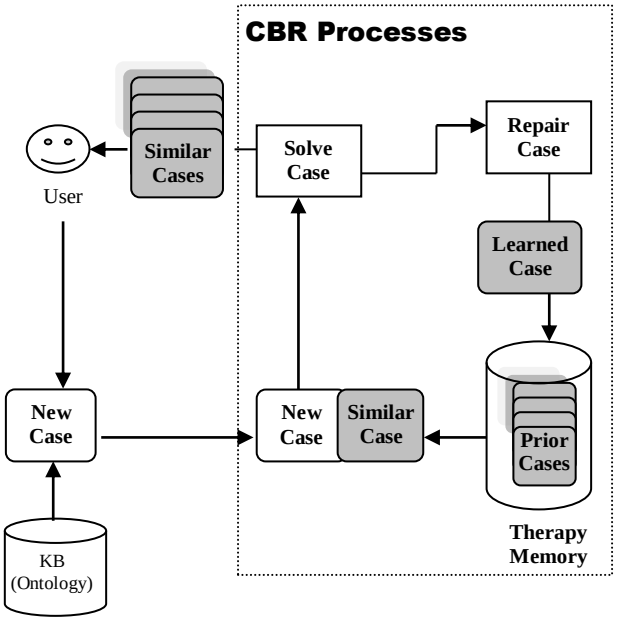

Figure 1. Overview of the system architecture

In multidisciplinary medical services, Case-Based Reasoning systems require good case representations. When multiple disorder cases must be stored in the same case memory, a highly flexible representation is required. The use of ontologies can provide a top level formal description on case structure, and the capability of reasoning. We have proposed case representation ontology for medical domains, covering aspects related to the flexibility of case structure. Finally, the system shows the possible benefit of the proposal by presenting a case-retrieval system based on the ontology for specific disease.

Diagnostic knowledge concerns the way in which a diagnosis is performed and it is distinguished in two types, procedural diagnostic knowledge and heuristic diagnostic knowledge. The later knowledge type as like the previous diagnosed case derived from the memory will be displayed to the user. So, to support decision making, any medical practitioner can obtain these past cases and reuse these professional experiences in the past similar treatments from the knowledge repository.

The possibilities for improving decision processes, and the knowledge management across interacting organizations is to explore successful past experiences. Case-based reasoning (CBR) is a problem solving strategy which is based on the reuse of past solutions (cases) to address new problems. Ontology is a means to facilitate sharing and reuse of bodies of knowledge across organizations and applications on the basis of a well-defined and precise semantics for concepts and terms. This work presents a proposal aimed at knowledge reuse, during the decision activities by means of interwoven concepts from the knowledge management, CBR and ontology research. This blended approach presents an ontological case construction for CBR systems as theoretical and empirical support for knowledge sharing. We obtain a formal characterization of a case by means of an ontological description of particular cases.

The first phase being the querying of a symptom ontology, to direct diagnostic systems to the most appropriate domain or class reference given input symptoms. Additional symptoms can then be targeted, extracted and analysed with a domain specific set of KB systems. This process allows us to forecast key symptoms, patient characteristics and increase the value of available data in decision making. In addition this approach could allow a system to dynamically correct an inappropriate domain decision.

The proposed system consists of two main components. The first component is domain ontology which is used for case structuring as standardized features. The second one is CBR module that is used to store the medical diagnostic knowledge and retrieve the most similar case according to the user‘s need and desire.

4.1 Domain ontology

This component contains case knowledge, concepts used to describe cases, taxonomy of concepts, relationships between concepts and constraints. In this case, the whole case base is not stored into the ontology. Ontology stores the information about the case attributes.

4.2 CBR module

The CBR approach represents expert knowledge as a set of cases. In this module, the processes are carried out as follow:

- a new case is matched with all the other cases of the case base;
- retrieve the most similar case (or cases) comparing the case to the library of past cases;
- reuse the retrieved case to try to solve the current problem;
- revise and adapt the proposed solution if necessary;
- retain the final solution as part of a new case.

These processes are demonstrated in figure 2.

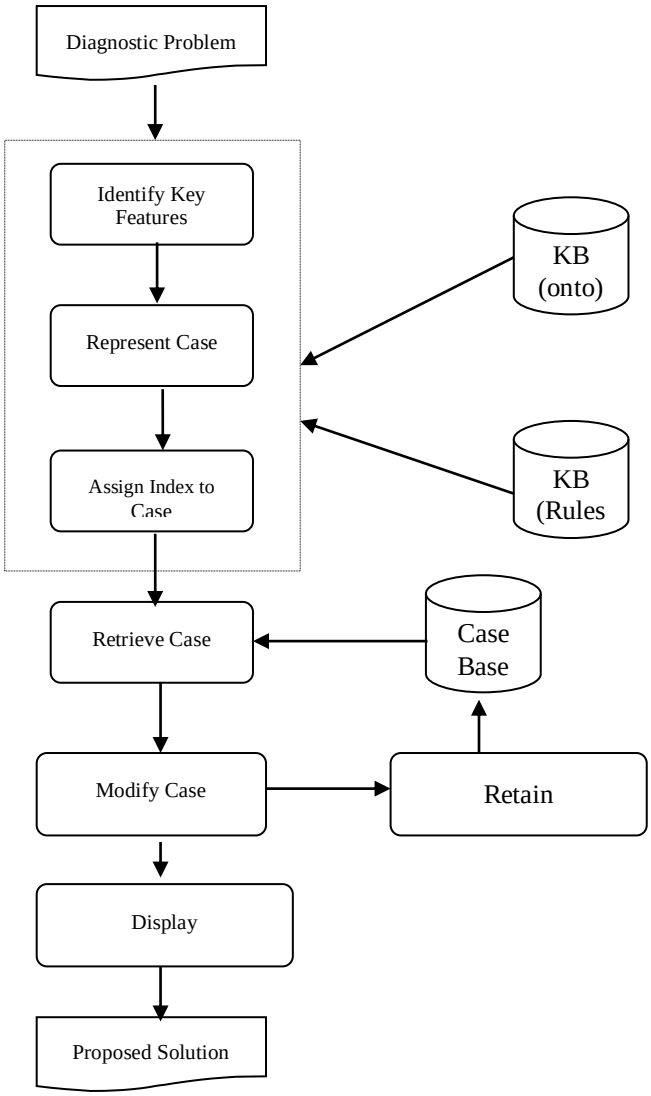

Figure 2. CBR processes using domain ontology

5. Conclusion and future work

The system described in this paper is to integrate experienced physicians' (expert) knowledge and to build a case memory and its associated medical ontology. By applying CBR approach and ontology concepts, it is to convert information of patient records and reasonable explanations of human experts into structured knowledge in case form and to re-use these knowledge in decision making for specific diseases.

This knowledge has to be built the knowledge repository called therapy memory for disease-specific treatment. The objective of this memory is to capitalize the information and knowledge gained, experimented and performed by an experienced physician during the process of physical treatment. It also aims to support in decision making for a given case, giving the all possible solutions of the past similar case from our therapy memory. The last step of this system is about the specification of concepts, attributes and their relation in order to build the ontology. The ontology provides an integrated conceptual model for sharing information.

The proposed system including domain ontology and case library will have to be implemented as my ongoing works and eventually to be applied in tele-consulting system, tele-diagnosis system, and medical recommendation in telemedicine on eGroupware system or peer to peer network or wireless network as in my future work.

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