Chapter 25
Medical Case Based Reasoning Frameworks:
Current Developments and Future Directions

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ABSTRACT

Case-Based Reasoning (CBR) is one of the most suitable AI techniques for building clinical decision support systems. Medical domain complexity introduces many challenges for building these systems. Building the systems' knowledge base from the Electronic Health Record (EHR), the encoding of case-base knowledge with standard medical ontology, and the handling of vague data are examples of these challenges. Although several advantages of using CBR in medicine have been identified, there are no real systems acceptable to physicians. This systematic review examines the current state of CBR and its limitations in the medical domain, especially for diabetes mellitus. The critical evaluation of the status of diabetes CBR systems presents unique opportunities for improving these systems. The literature review covers most of the English language studies extracted from relevant databases by using search terms relating CBR, ontology, Fuzzy, and standard terminology concepts. The authors identify 38 articles published between 1999 and 15 January 2015, which represent original researches in CBR domain. The study includes 15 (39.5%) non-medical studies and 23 (60.5%) medical studies with ~22% for diabetes CBR. A list of 18 integrated evaluation metrics has been proposed and used in the analysis. The results show that the non-medical CBR systems achieved higher advances (50%) than medical systems (42.9%). In addition, the diabetes management CBR systems achieve the lowest advances (21.4%) compared to other systems. These shortages explain the question "why CBR paradigm are not fully utilized in the commercial medical systems?" As a result, there is a distinct need for more comprehensive enhancements in clinical CBR especially diabetes systems.

1. INTRODUCTION

Medical diagnosticians require many years of practice to gain the experience and analytic skills required to diagnose patients accurately. Even with many years of experience, there is no guarantee for a correct patient diagnosis. The medical domain is characterized by *contradictory information* and *constantly evolving knowledge*. As a result, it is hard to even for the most experienced diagnosticians to make the correct decisions. In order to help the physicians in this difficult task, a great amount of research on artificial intelligence (AI) in the medical domain has been conducted. The problem is complicated when chronic diseases are diagnosed. Decision making for chronic diseases is a crucial task for decision makers in healthcare because decisions need to be made accurately, quickly, and under uncertainty.

CBR is an experience management methodology for building knowledge-based systems. It has a long tradition in AI. Schank and Abelson (1977) had firstly proposed the idea of CBR. Today, it is both a recognized method for the health sciences. In the late 1980s, (Koton, 1989; Bareiss, 1989) have firstly exploited CBR in the medical domain. CBR is suitable for ill-formed, unstructured, and experience-based problems. The medical field is weak on theory and high on experience. As a result, CBR is the most appropriate AI reasoning methodology for the medical domain, but much work is still needed (Blanco et al., 2013).

The benefits of applying CBR in the medical domain have been collected by Bichindaritz and Marling (2006) and Montani (2007). CBR simulates the physician's thinking method: "I have seen a patient like this," and provides a collection of past cases that may be suitable to the current case. In other words, CBR makes "reasoning by experience." It is based on two assumptions: (1) similar problems have similar solutions and, (2) It is easier to adapt the solution to a similar problem than the solution of a less similar problem. As shown in Figure 1, Aamodt and Plaza (1994) have proposed a life cycle of CBR. This framework has four phases including RETRIEVE, REUSE, REVISE, and RETAIN. Although the case-base building and representation are not added as a separate stage in this model, it is the most critical step in the CBR life cycle (Honigl and Kung, 2014). The decisions of this step determine the quality of the subsequent steps. By considering CBR system as an expert system, its knowledge is in the form of cases, and its knowledge base is stored in a case-base.

Kolodner (1993) defines a case as "A case is a piece of knowledge in a particular context representing an experience that teaches an essential lesson to reach the goal of the reasoner". It can be seen as "the record of previous experience or problem." More formally, a case C can be viewed as a triple $\{<V: v>, <S: s>, <O: o>\}$, where v is a vector of values for the set of descriptive features V representing a problem, s is the solution selected from the solution space S, and o is the outcome (i.e., result) of the selected solution from the possible outcomes O. In medical domain, Electronic Health Record (EHR) is a good source to build the system's case-base as it stores the solved problems (Branden et al., 2011). A case can be considered as a patient record consisting of his entire medical encounters, where the *problem= patient's symptoms*, *solution= physician's diagnosis and treatment*, and *outcome= the patient's results in follow-ups*. The outcome is generally defined as changes in some of the variables in V such as the value of Fasting Plasma Glucose test or the number of hypoglycemic events, but it can in a qualitative form, e.g., a positive or negative outcome. Case-base is the collection of cases, i.e., *case base= {case^1, case^2…case^n}*, where n is the number of cases. Using EHR data as a case source solves the problem of knowledge acquisition bottleneck. However, the EHR's transactional data cannot be used directly as knowledge. A set of preparation steps must be applied to these data (El-Sappagh et al., 2014a).

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