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CASESIAN: A knowledge-based system using statistical and experiential perspectives for improving the knowledge sharing in the medical prescription process

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ABSTRACT

Knowledge sharing is crucial for better patient care in the healthcare industry, but it is challenging for physicians to exchange their clinical insights and practice experiences, particularly with regard to the issuing of prescriptions for medicine. The aim of our study is to facilitate knowledge sharing and information exchange in this area by means of a knowledge-based system. We propose a knowledge-based system, CASESIAN, to automatically model each physician's prescription experience. This is done by collecting as many as possible instances of when the physician has issued a prescription. These occasions will be analyzed from a statistical perspective to form a reciprocal interactive knowledge sharing process for the issuing of medical prescriptions which we will call the prescription process. With the help of the prescription data in medical organizations, the knowledge-based system employs the Bayesian Theorem to correlate the experience of peers in order to evaluate individual prescription knowledge as retrieved through the case-based reasoning technique. In addition, a system prototype was implemented in a Hong Kong medical organization to evaluate the feasibility of such an approach. Our evaluation indicates that there is a significant improvement in knowledge sharing after the adoption of the system. CASESIAN obtains a higher rating in both recall and precision measurement when compared to traditional knowledge-based system. In particular, its information retrieval is much stronger than the baseline in around 40%. Furthermore, regarding the result of the interviews, physicians agree that the system can improve the storing and sharing of medical prescription knowledge.

1. Introduction

Healthcare knowledge sharing is a crucial and promising vehicle for facilitating safer, higher quality patient care (Abidi, 2001; Morrissey, 1998; Nutkis, 1997). According to Liebowitz (1996), knowledge sharing can provide efficient and focused assessment, either by directly navigating users to the knowledge artifacts or indirectly providing peer-comparisons to help discover the relevant knowledge artifacts. The sharing of such knowledge resources is particularly valuable for physicians in the area of medical prescription, when they encounter complex and potential drug interactions. It is particular true for the medical organizations which consists of many physicians that specialized in different medical professions. In other words, if a physician practices drug therapy which is not his/her specialty; (s)he cannot provide the required standard of care (Anis, Carruthers, Carter, & Kierulf, 1996; Laurence, Bennett, & Brown, 1997).

Numerous methods have been investigated for improving the knowledge sharing process in medical prescription (Wickramasinghe, Gupta, & Sharma, 2005). In essence, the sharing platform is mostly represented in the form of research articles, forum discussions and clinical guidelines. Jabr (2007) argues that this kind of knowledge sharing process is not well constructed and that problems are still mounting. One challenge for physicians is the limited time they have available for acquiring the relevant knowledge because of the demanding nature of their work and the speed and quality of the transfer process. This acknowledges that there is a pressing and burning need to develop a new approach to facilitate time-efficient, effective knowledge sharing and information exchange for medical prescription.

As a backdrop to the above mentioned sharing considerations, knowledge-based systems (KBS) have gained increased attention in recent years both in healthcare knowledge management and in medical prescription. Most KBSs employ artificial intelligence techniques to develop a knowledge-centric healthcare system for gathering prescriptions in a knowledge repository and disseminating the knowledge to all parties for reuse and problem solving (Schmidt, Montani, Bellazzi, Portinale, & Gierl, 2001; Sim et al.,

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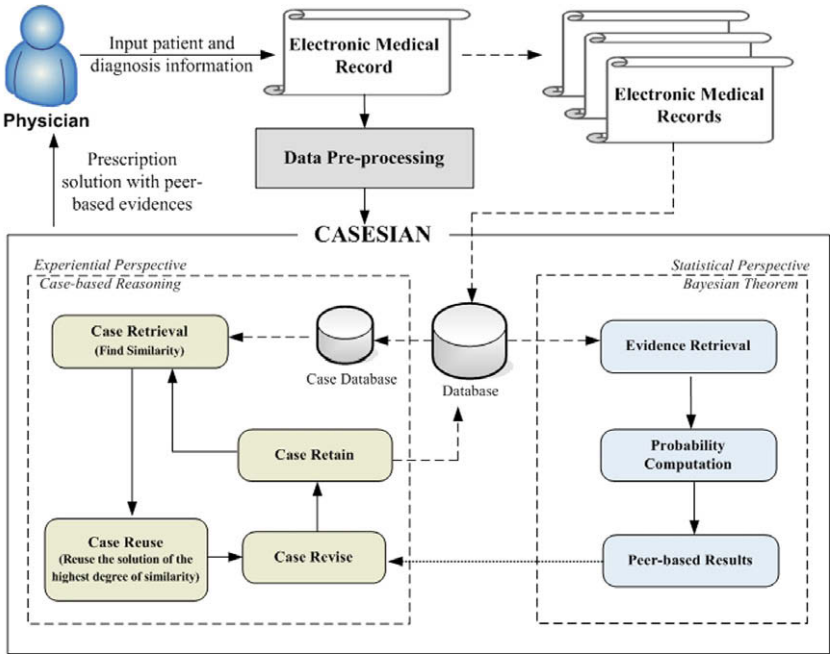

Fig. 1. Architecture of CASESIAN approach.

2001; Van Hyfte, Van Der Maas, Tjandra-Maga, & De Vries Robbe, 2001). Case-based reasoning (CBR) is one of the most prevalent knowledge extraction methods used in developing KBSs because it has a stronger explanation capability than other techniques like neural networks (Baesens, Setiono, Mues, & Vanthienen, 2003). Related work on using CBR enables physicians to share past experiences stored in the knowledge base to encounter new situations. Generally, physicians have developed their own prescription style and behaviors based on their knowledge and experience. In this situation, the problem solving is presented in a single looping process that generates a solution prescribed by the physician himself/herself previously. As a means of knowledge sharing, this approach is not suitable because physicians do not share what they know with other parties. Even though each physician has the knowledge to make the prescription, it is important for them to learn from others' experiences as well. Thus, an external method is required to enhance the sharing process between physicians, thereby supporting the peer-based comparison determined in statistical perspectives.

In this paper, we intend to construct a KBS for knowledge sharing in the medical prescription process. We propose a state-of-the-art system, CASESIAN (by combining CASE-based reasoning and the BAYESIAN theorem), that imitates physicians' prescription decision through reference to electronic medical records (EMR) database and correlate the experience of peers with the same diagnostic information during the prescription process. The system can further be used as a module to assemble other medical diagnostic systems to enhance knowledge sharing, as well as decision making in the prescription process.

2. Outline of CASESIAN

Fig. 1 shows the outline of CASESIAN developed in this study. By retrieving the knowledge from numerous medical records, it is possible to derive all prescription decisions. The main purpose of our KBS is to enhance the knowledge sharing process between physicians by taking into consideration their peer-based experiences; therefore, we adopt the CBR technique as the basis of the KBS and employ the Bayesian theorem (BT) for supporting and benchmarking the result from CBR. With the support of CBR, the most relevant cases can be retrieved and reused according to the highest degree of similarity, while the BT allows us to capture and calculate the prescription decisions based on the diagnostic experience of all the physicians within the organization.

2.1. Data pre-processing

In our KBS, all the patient demographic, treatment and administrative data (including age, sex, treatment date, symptoms, diagnosis, allergies, significant past history, referrals, payment, number and duration of sick leaves, doctor's name, clinic name, and drugs prescribed) are consolidated and stored in the data warehouse of the information system. For facilitating the knowledge sharing in the medical prescription process, a pre-processing method is used to index and extract the specific information from the data warehouse. All the irrelevant information is filtered out, while the remaining information is structured as a data mart for supporting the data analysis from both the statistical and experiential perspectives.

2.2. Construction of experiential and statistical perspectives

As discussed in Van Hyfte et al. (2001), experience plays a very important role in improving the performance of physicians in the medical prescription process. The selection of each drug dose is heavily reliant on the physician's knowledge of drugs and his/her skill of diagnosis. Even encountering the same disease, the result of prescription is different for different physicians. This is particular true as these medical experts are come from different educational background and have different diagnostic experiences. Therefore, solely considering the experiential perspective is inadequate for providing a better quality of prescription.

In CASESIAN, the statistical perspective is taken into account as an evaluation factor to enhance the prescription result in each diagnostic process. Fig. 2 shows the elements (representing statistical and experiential perspectives) employed in our system. Each physician's prescription decision is represented by the small circle