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A hybrid knowledge-based approach to supporting the medical prescription for general practitioners: Real case in a Hong Kong medical center

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ABSTRACT

Objective: With the increased complexity and uncertainty in drug information, issuing medical prescriptions has become a vexing issue. As many as 240,000 medicines are available on the market, so this paper proposes a novel approach to the issuing of medical prescriptions. The proposed process will provide general practitioners (GPs) with medication advice and suggest a range of medicines for specific medical conditions by taking into consideration the collective pattern as well as the individual preferences of physicians' prescription decisions.

Methods and material: A hybrid approach is described that uses a combination of case-based reasoning (CBR) and Bayesian reasoning. In the CBR process, all the previous knowledge retrieved via similarity measures is made available for the reference of physicians as to what medicines have been prescribed (to a particular patient) in the past. After obtaining the results from CBR, Bayesian reasoning is then applied to model the prescription experience of all physicians within the organization. By comparing the two sets of results, more refined recommendations on a range of medicines are suggested along with the ranking for each recommendation.

Results: To validate the proposed approach, a Hong Kong medical center was selected as a testing site. Through application of the hybrid approach in the medical center for a period of one month, the results demonstrated that the approach produced satisfactory performance in terms of user satisfaction, ease of use, flexibility and effectiveness. In addition, the proposed approach yields better results and a faster learning rate than when either CBR or Bayesian reasoning are applied alone.

Conclusion: Even with the help of a decision support system, the current approach to anticipating what drugs are to be prescribed is not flexible enough to cater for individual preferences of GPs, and provides little support for managing complex and dynamic changes in drug information. Therefore, with the increase in the amount of information about drugs, it is extremely difficult for physicians to write a good prescription. By integrating CBR and Bayesian reasoning, the general practitioners' prescription practices can be retrieved and compared with the collective prescription experience as modeled by probabilistic reasoning. As a result, physicians can select the drugs which are supported by informed evidential decisions. That is, they can take into consideration the pattern of decisions made by other physicians in similar cases.

1. Introduction

Medical prescription is facing the challenge of increased complexity and uncertainty from the very great increase in information on new drugs. Nowadays numerous new drugs are being developed and launched to treat new diseases. With the growing amounts of information, medical prescriptions made by physicians have become a contentious issue. This is particularly true from the general practitioners' (GPs) perspective. The explosive growth of data requires them to learn and remember many details so they can prescribe the right medication, in the right amount, for the right patient. The possible approaches to dealing with this problem are by means of electronic medical records (EMR) [1–5] and clinical decision support systems (CDSS) [6–10]. Through knowledge discovery from these disciplines of medical informatics, the medical prescription process can be facilitated and hence the quality of prescription decisions can be improved [46].

However, decision support for medical prescription provided by the existing medical informatics disciplines lacks flexibility in selecting and delivering relevant drug choices to physicians. The existing medical prescription support system can only assist medical experts in providing a better understanding of the problem in-hand by pooling the diagnostic experience of many physicians

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[2,11,12]. In this way, these approaches are limited to suggesting drugs based on diagnosis classification. The advice is far too vague to meet the real needs of therapeutic situations. To improve this situation, capturing specific knowledge from past medical cases can generate substantial and relevant knowledge in support of the prescription process of GPs.

In each diagnostic process, previous knowledge stored in medical records is important to physicians for making prescription decisions [39]. Case-based reasoning (CBR), a well-known problem solving technique that is capable for retrieving the most relevant cases that are most similar to the problems being diagnosed [45], is used to represent the prescription knowledge accumulated from specific situations. It is noted that drug recommendations extracted from the most relevant cases may not be appropriate for the problem at hand, Bayesian reasoning that discovers the general prescription patterns of physicians is thus employed to fine tune the medical prescription options, based on what medication is probably the most suitable, given a certain diagnosis and certain symptoms. These are distinct techniques, each with its own strengths and limitations. To the authors' knowledge, they are also seldom integrated together, particularly in the prescription domain. In other words, a "micro-view" of specific knowledge (modeled by CBR) and a "macro-view" of general knowledge (represented by Bayesian reasoning) are formulated and are leveraged using each other's strengths.

This paper proposes a hybrid knowledge-based approach to support medical prescription (HKSMP), as a complement to the existing statistical approach proposed in [2]. HKSMP incorporates CBR and Bayesian reasoning approaches in helping physicians to perform flexible prescription, in providing medication advice, and anticipating a range of medicine for the physicians. Furthermore, HKSMP is the first model that has attempted to handle the prescription solution by considering both specific knowledge and general knowledge. A case study in a Hong Kong medical center is presented to illustrate the implementation of the proposed system and to validate the practicability in a real world application.

The remainder of the paper is organized as follows. Section 2 briefly reviews the relevant literature on common practices for medical prescription, and the application of CBR and Bayesian reasoning in the domain of interest. Section 3 illustrates the hybrid knowledge-based approach. A case study in applying this approach is elaborated in Section 4. Results are presented and discussed in Section 5. Finally, Section 6 concludes with a discussion and proposals for future research directions.

2. Research background

2.1. Electronic medical record systems and decision support systems in medical prescription

A medical prescription is a medication order form written by a qualified medical professional [3]. It serves as a medium of communication between the physician and the pharmacist/nurses to ensure that the right medication is delivered to the patient. Fig. 1 depicts the medical prescription practices among physicians, nurses, pharmacists and patients. However, with voluminous drug information (i.e. more than 240,000 prescription drugs on the market) [34], it is not easy for medical experts to be knowledgeable and familiar with the use of different drugs and with dosage instructions. Even with the same diagnosis, the medical prescription may differ from one patient to another as the patient's age and physical condition must also be taken into consideration in the prescription. This is especially the case for GPs as they are primarily responsible for providing comprehensive health care to individuals seeking medical care, and for making arrangements

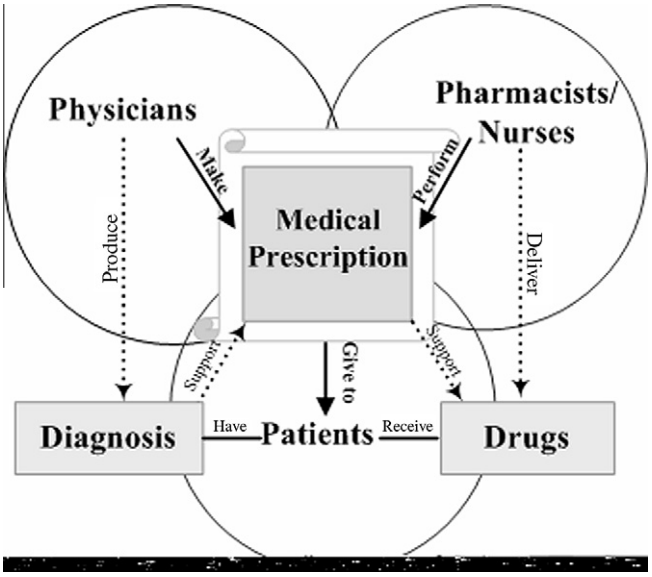

Fig. 1. Relationships between physicians, pharmacists and patients in general medical prescription practice.

for other health care personnel to provide specialist services when necessary [13]. Thus, learning about new drug information, and remembering the appropriateness and possible contradictions of a large number of drugs remain open challenges for GPs [14,15].

Many researchers have suggested that applying technology in medical practices can help GPs to stay informed about the latest development of drugs and thus can help to reduce medical errors and improve patient safety. To support the decision making process of the medical experts, electronic medical records (EMR) have been introduced to transform the traditional handwritten medical records into digital ones. Rector et al. [4] present a model for an electronic medical record system which provides a permanent, complete record of patient care and the medical decisions made. Kohane et al. [5] applied client–server technology of the World Wide Web to design national electronic medical record systems (EMRSs). Hammond et al.'s study [16] has demonstrated that using EMR not only can improve the quality of patient care and decrease medical errors, but also can result in a positive financial return on investment. With such a sound financial achievement of EMR, many researchers are focusing on how to integrate medical records with decision making tasks. Shiffman et al. [17] and Linnarsson [18] claimed that integration of EMR with a decision support system (DSS) can enhance effectiveness in ensuring patient safety. The benefits of current DSSs used in general practice include assisting doctors in performing diagnosis, disease prevention, enhancing decision making quality in the primary care consultation and in selecting appropriate dosage [19]. All these are in line with Wang et al.'s results of a 5-year study [20].

DSS always have long been used by different industries to solve different problems that range from prediction, forecasting and data classification. For example, Panda et al. [40] and Chang and Liao [41] applied soft computing techniques to predict flank wear in drills and flow time in semiconductor manufacturing factories, respectively. The application of DSS in the medical domain has been mostly developed to provide physicians with advice on either diagnosis or treatment by means of artificial intelligence (AI) and Bayesian reasoning [21]. Because of the complexity of drug information, DSS demonstrates great potential in the area of medical prescription, however, only a few publications have addressed this issue. One of the publications, proposed by Warren et al. [11], describes how drug choices can be reduced after specifying the diag-