Developing a collaborative knowledge system for Cancer Diseases

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***Abstract*— As the number of clinical guidelines and rules for effective management of cancer therapy is rapidly increasing decision support systems are more and more required. To this direction, in this paper, we present a collaborative knowledge management system for cancer diseases leading to decision support and intelligent diagnosis. Clinicians can specify a variety of knowledge rules in a collaborative fashion. Then, those rules are applied on top of patient data collected within a personal health record. The generated knowledge is formulated as a free text and returned back to the clinicians to support them and enhance the communication with their patients.**

Keywords:Collaborative Systems, Decision Support, Uncertainty

I. Introduction

Multiple studies have shown that treatment related to cancer therapy is suboptimal. The constantly increasing number of tumor markers and the advances on diagnosis, screening, prediction and treatment monitoring makes it hard to follow for clinicians who struggle to keep up with myriad complex and rapidly changing cancer treatment regimens, and time shortages.

Our goal is actually to provide valuable knowledge back to the clinicians generated using the knowledge rules specified collaboratively from a group of health providers. Those rules can have uncertainty factors (probabilities) similar to real life. In addition, those rules are specified using a controlled English vocabulary that correspond directly to the available patient data. As such the generated rules can be effectively executed based on these available data and the results are returned back to the clinicians using natural language.

Although in the literature there are several tools, frameworks and methodologies to support modelling, collection and execution of clinical guidelines and similar rules [1], the collaborative aspect of our system, the controlled natural language it adopts for user input and communication and the direct link with existing patient data make it unique. However, we have to note that this only a preliminary version of our system that should be further developed, properly evaluated and enhanced.

This paper is structured as follows: In Section 2 we present the system architecture and we highlight the main components of the systems. Then in Section 3 we conclude this paper and present directions for future work.

II. System Architecture

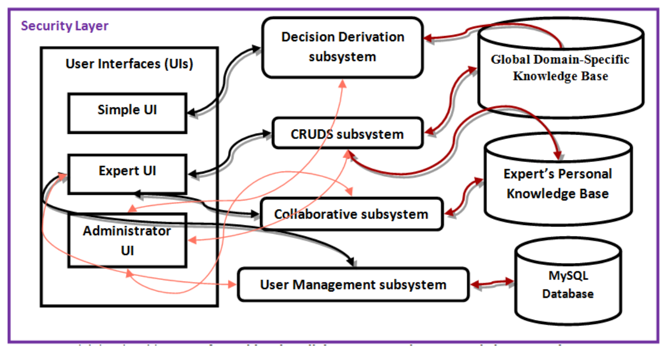

Figure 1. The high-level system architecture

Next we describe system architecture. This is shown in Figure 1 and consists of three layers. The data layer, the Application Layer and the GUI. The application layer of the system has been developed using SWI-Prolog mainly to its reasoning abilities [2] and the front-end using HTML and JavaScript. Bellow we will explain in detail each one of those layers:

A. The database layer

The data layer includes in essence three databases. The first one includes patient data such as medications, allergies, procedures, laboratory results and problems. The data come directly from a Personal Health Record System, the iPHR system [3], a system used by patients to monitor and to keep track their individual health status. All data there are annotated using SNOMED-CT ontology in order to enable interoperability. Each patient using this system can share his/her data with other patients, family members or clinicians. As such the data shared with a specific clinician can be used as input for decision support.

Besides this, the knowledge base includes multiple rules that are generated, stored and elaborated by the clinicians in their personal Knowledge base. As the rules reach a mature form they are shared with all experts within the Global Domain-Specific Knowledge base and can be collaboratively developed. An example rule is shown in Figure 2 describing a rule for identifying neoplasms, usually backache caused by metastases. After each rule, a confidence level is provided depicting diagnosis' probability (-note that there can be rules that we don't know their confidence level).

R1: if Backache and History of cancer, especially of breast and prostate then Neoplasm: CF1 = 0.9
R2: if First episode of backache occurs after age 50 yr then Neoplasm: CF2 = 0.7
R3: if Weight loss then First episode of backache occurs after age 50 yr: CF3 = 0.9
R4: if First episode of backache occurs after age 50 yr and Weight loss then Neoplasm: CF9 = ?

Figure 2. Example rules

B. *The application layer*

This is the core layer of the whole platform. It includes operations for creating, reading, updating, deleting and sharing the rules (CRUDS), the user management sub-system and the subsystem supporting the collaboration process.

The decision subsystem operates using an inference engine and several generated prolog rules. The inference engine iterates over the rules that are within the specific clinician profile and they are executed for all patients or for a selected patient that has shared their data with the aforementioned clinician. The decision making engine is using an ad-hoc, but principled, uncertainty framework knows as "certainty factors" originating from the MYCIN system [4].

As such. in our application it is possible that two or more rules might draw conclusions about a parameter with different weights of evidence. In the event the certainty is less than zero the evidence is actually against the hypothesis. In order to calculate the certainty factor our system combines these weights to yield a single certainty factor similar to [4].

C. *The user interface (UI) layer*

The UI includes the interfaces for the Experts (Expert UI), the Simple Users (Simple UI) and for the Administrator (Administrator UI).

Expert are allowed to modify both the Global KB and their personal KB. An expert is allowed to update in the Global KB only the rules which have been added by him. Simple users are users who cannot create or change rules but can import their patient's medical data. The system returns a diagnostic decision which can be used mainly for consultation purposes.

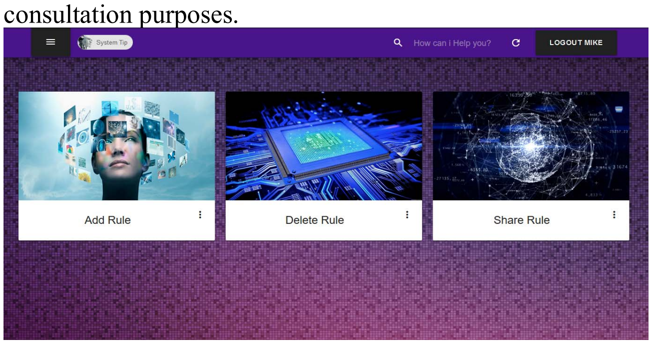

Figure 3. Managing rules

The UI for the expert includes two main parts, one for rule management and one for visualizing the decision making process. For managing the rules, an end-user is able to add new rules to delete existing ones and share rules with other clinicians. The shared rules can be collaboratively edited by a whole group of people and all decisions and updates are recorded in the knowledge base. The rules are written almost in natural language using specific terms from a specific vocabulary provided to them. This vocabulary corresponds to the available data within the patient data database.

In addition, multiple clinicians can collaborate to define a specific set of rules or to update them. A screenshot of the system is shown in in Figure 3.

An example rule is shown in Figure 2. Note that the language is English language statements using specific terms from a specific provided vocabulary and concepts from the SNOMED-CT ontology. Having all rules available and the necessary data, the end-user can select a specific patient to be checked considering one or all rules available. The diagnosis is calculated, transformed into natural language and returned to the user along with some probability value.

III. CONCLUSION

Although in the past such systems have been greatly criticized mainly due to ethical and legal issues related to the use of computers in medicine, (for example who should be held responsible if a program gives the wrong diagnosis or recommends the wrong therapy) it is evident that when used by the experts or as an educational tool could be really useful, speeding up their daily workflow and alerting them in cases that they have not a direct contact with a patient. As such we believe that the development of similar systems is really beneficial.

To this direction our future plan is to enhance the system knowledge base with more rules, present the detailed reasoning behind the system suggestion and allow the clinicians to explore alternatives. Finally, our immediate plans include a thorough evaluation of both the usability of the platform and the quality of the results.

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