An Active Distributed Medical Advisory System

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Abstract: – For the last few decades, medical practitioners and specialists have been waiting for efficient medical advisory systems. Most of current computer-aided diagnosis systems are rather passive. Health data, a rich source of medical knowledge, often have not been used efficiently for medical treatment as well as financial management. Their accesses are very limited. This paper introduces the design of a well-structured medical advisory system based on the advanced Internet. The system is also equipped with data mining and AI techniques to make it becoming an active distributed medical advisory system.

Keywords: – Computer aided diagnosis, Distributed system, Artificial intelligence, Data mining, Web technology, Client-server model.

1. Introduction

Health data, a rich source of medical knowledge, often have not been used efficiently for medical treatment as well as financial management. They are often not nationally accessible. This is a big wasted hole in most medical and health data systems.

If patients are permitted to access their medical records, they can monitor their health statuses to cooperate in treatment, and to contribute in early detection of any abuse of health care systems.

With advances in data mining techniques, medical knowledge hidden in patients’ data can be discovered to be used in expert systems. However, in medical applications where a decision may have fatality effects, the obtained knowledge can only play a supportive role to give professionals the means to check and evaluate their judgements.

In some health care systems, people are automatically scheduled for regular general check-up sessions as well as advanced X-rays, CT (Computed Tomograph) or MRI (Magnetic Resonance Imaging) pre-scans. These images are numerous, and need a lot of human time to diagnose. However, softwares may be developed to analyse the images and sort patients into different categories depending on their severity levels, so that medical specialists can schedule their examination lists. An artificial medical expert can also be useful and efficient to give quick proposals for first-aid advice or treatments in simple but common sicknesses like headache, cold, etc.

A number of advisory systems are available for medical and educational purposes: DXPlain, Gideon, Iliad, etc. [4]. These systems store a huge amount of medical information on various diseases, but none of them really focuses on nationwide access, and especially on the capability of artificial intelligent technologies.

This paper presents the design of an active distributed medical advisory system with efficient accesses and reliable management called MEDADVIS. The system is equipped with some AI tools for data mining and image analysis to make it much more supportive and active.

The paper is organized as follows. Section 2 outlines the organisation of the MEDADVIS system with two operation layers, one in the foreground, and another in the background. The latter is expanded in Section 3. Section 4 presents some continuing work on an X-ray image analyser for lung cancer and tuberculosis (TP). The paper ends with a brief discussion.

2. MEDADVIS Organisation

MEDADVIS has been designed with careful consideration on characteristics of a distributed system, especially those of security, scalability, concurrency and tolerance. Microsoft Web services platform is an advanced technique for distributed
systems; however, many important features of a distributed system are not available yet [10], especially the security, a necessary factor for a medical data system like MEDADVIS.

MEDADVIS is organised into two layers, one for user interface based on the Web technology, the other for data analysis and management running in the background with TCP client-server models [2]. A health data system is used as the communication medium between the two layers.

Fig. 1: MEDADVIS system is organised into two layers: User interface, and Data analysis and management. They are linked together by the Health data system.

2.1. Health Data System
An efficient health data system should give both local and nationwide accesses. The MEDADVIS data system is composed of a set of data centres, each associated with a clinic. Patients’ medical records are kept at their local clinics. A central clinic has a national health data storage with backups of all local clinic data.

2.2. User Interface
Users access the MEDADVIS health data system through local clinic websites. A central website is associated with the national health data storage; however, it mainly gives access to privilege users.

MEDADVIS users are classified into four categories: visitor, patient, medical administrator and technical administrator, each with a different access privilege level, 1, 2, 3 or 4, respectively. A higher privilege user is able to perform any function available to the ones with lower privileges.

User functions with different privilege levels can be differentiated into four groups as tabulated in Table 1.

<table>
<thead>
<tr>
<th>Functions</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Medical advice</td>
<td></td>
</tr>
<tr>
<td>General medical consultation</td>
<td>1</td>
</tr>
<tr>
<td>First aid advice</td>
<td>1</td>
</tr>
<tr>
<td>Online pharmacy information</td>
<td>1</td>
</tr>
<tr>
<td>2) Patient record</td>
<td></td>
</tr>
<tr>
<td>Update general personal data</td>
<td>2</td>
</tr>
<tr>
<td>View personal medical record</td>
<td>2</td>
</tr>
<tr>
<td>Check regular medical examination appointment</td>
<td>2</td>
</tr>
<tr>
<td>Make medical examination appointment with low priority</td>
<td>2</td>
</tr>
<tr>
<td>Enter self medical examination data, and seek online advices</td>
<td>2</td>
</tr>
<tr>
<td>Monitor statuses of home treatment patient</td>
<td>3</td>
</tr>
<tr>
<td>Update patients’ treatment history</td>
<td>3</td>
</tr>
<tr>
<td>3) Patient management</td>
<td></td>
</tr>
<tr>
<td>Patient registration</td>
<td>3</td>
</tr>
<tr>
<td>Patients records transfer between two local clinics</td>
<td>3</td>
</tr>
<tr>
<td>Create user accounts with Levels 2&amp;3</td>
<td>3</td>
</tr>
<tr>
<td>4) Technical management</td>
<td></td>
</tr>
<tr>
<td>Backup patients’ data</td>
<td>4</td>
</tr>
<tr>
<td>Invoke and check background operations</td>
<td>4</td>
</tr>
<tr>
<td>Create user accounts with Levels 3&amp;4</td>
<td>4</td>
</tr>
</tbody>
</table>

Users can access a local clinic website directly, or via the central, which will redirect the users to a local clinic based on the information stored in the web browser host during the last MEDADVIS access. This information is often stored in the form of web browser cookies. If the information is not available, e.g., when the host is used the first time to access MEDADVIS, the users need to supply the name of the clinic where they have registered, or to ask for a system search. In the latter case, the central website will refer to the national health data storage.
2.3. Data Analysis and Management
Patients’ medical data are analysed and managed in background operations, which contribute the intelligence and power of MEDADVIS, and some of them will be presented in the next section.

3. Background Operations
MEDADVIS background operations are built on TCP client-server models. Most of them can be achieved by administrators via web browsers. However, they can be performed more efficiently and more securely in the background.

3.1. Patients’ Data Backup
At every clinic, there is a set of TCP client and server programs that can be used for patients’ data backups. When a patient record is updated at a local clinic, an associated item, e.g., U (P), is added to the updating list of the clinic. The client program, running regularly in the background, will check the list and send the updated information to the central clinic server. With this arrangement, there is a short interval during which the two copies of a patient record are different. However, this violation in consistency is tolerable because in normal operation, the backup copy at the central storage is only used during a system search to locate the clinic at which a patient was registered.

3.2. Patients’ Record Transfer
When the transfer of a patient’s record between two local clinics is not urgent, it can be achieved more efficiently in background operations by adding an item in the transfer list at the target clinic. For example, item P@BÆA, i.e., transfer the record of patient P from Clinic B to Clinic A will be added to the transfer list of Clinic A. The client and server programs used for patients’ data backups can be also used for patients’ record transfer based on the transfer list as follows:

**Patients’ record transfer algorithm:**

a) Client A makes a TCP connection to Server B.
b) A sends a request for a transfer of patient P’s record to B.
c) B sends the requested record to A, as well as any pending updated information for backup.
d) Upon receipt of the record, A informs B that the transfer was successful, and B can delete the record from its local clinic.
e) A modifies the clinic field in the record, and adds the item U (P) to its updating list with updated fields, including pending updated information received from B.
f) Repeat Steps b) to e) for all P@BÆA transfers in the list.
g) A closes the connection to B.

3.3. Regular Examination Generation
Regular patients’ checks can be scheduled in background operations based on the availability of clinics and their professionals, as well as patients’ proposals. Once confirmed, appointments will be added to patients’ records, and some facilities like emails, phone messages, etc. will be used to inform them.

3.4. Data Mining and Intelligence Techniques
This is the power of the MEDADVIS system. Data mining and other artificial intelligent techniques such as statistics, Fuzzy Logic, Neural Networks, etc. can be used to discover knowledge hidden in patients’ medical data. The knowledge, associated with medical literature, can be used by medical professionals to check their judgments on medical examinations, as well as used to form online medical advices to MEDADVIS users.

3.5. Image Processing and Analysis
Some diseases like lung cancer or TP need to be detected when they are in early stages. Advanced X-rays, CT (Computed Tomograph) and MRI (Magnetic Resonance Imaging) are popular methods for the screening of these diseases. Although CT and MRI are more efficient than X-ray [3, 7], the latter is cheaper and generally more available. Therefore, preliminary diagnosis for lung TB and cancer, currently performed by medical professionals, is mainly based on X-ray images. This is a time-costly process, and the quantity of images to be examined is at an unmanageable level, especially in populous countries with scarce medical professionals.

In the MEDADVIS project, software facilities to analyse X-ray lung images have been developed.
The next section will report some of these developments.

4. Lung X-Ray Analysis

The treatment of lung cancer and TB is easier in the early stages but very difficult in the advanced stages of the diseases. The overall 5-year survival rate for lung cancer patients increases from 14 to 49% if the disease is detected in time [1 cited in 3]. Our current work aims at the design and implementation of an automated X-ray image analyser to detect early signs of lung cancer and TB.

Fig. 2: A lung X-ray image with some small nodules, which are difficult to detect due to the presence of ribs and pulmonary arteries.

Once scanned, X-Ray images of patients’ lungs are put in clinic databases. A MEDADVIS program, running in the background, will analyse the images to classify the patients into different classes based on their disease severity. Most cancer and TB cases start with the appearance of small nodules. Nodule pixels are often brighter than the surrounding areas, but in some cases, the difference in grey levels is not significant. Furthermore, ribs and pulmonary arteries, which often have higher grey levels, also contribute to the complexity of lung tissue and make some nodules undetectable (Fig. 2 [8]). In up to 30% of cases, nodules are overlooked by radiologists on their first examinations [11], although they are visible in retrospect, especially when computer-aid diagnostic tools are used to focus radiologists’ attention on suspected areas [5].

To detect early nodules we use the following algorithm:

a) Use a pattern recognition method to isolate the lung object from the background.

b) Apply a small fixed size window –called scanning window– to every pixel inside the lung object, which has not been marked as part of suspected nodules.

c) Find the average and the maximal grey levels of the pixels within the scanning window. Select a local grey-level threshold between the average and the maximal levels.

d) Count the number of pixels that have grey levels higher than the local threshold. If the counted number is within a specific range then mark the pixel as part of a suspected nodule.

Figure 3 is the result obtained when the above algorithm was applied to the lung X-ray image in Figure 2.

We also applied the algorithm on ten lung X-rays images, and the experimental result [6] is tabulated in Table 2 with the judgement of a medical professional [9]. In the table, the column “Quality” of the “X-rays” field shows the evaluation of the examiner on the quality of the X-ray images. In the “Number of nodules” field, the column “Detected” shows the total number of nodules detected by the algorithm. The other three columns, T+ (true-positive –correctly detected nodule), F+ (false-positive –incorrectly detected nodule), and F– (false-negative –incorrectly undetected nodule), were evaluated by the medical professional. A value with (*) is probably correct. A table cell with (*) only shows
that the examiner could not make any decision due to the poor quality image; an N value means “a lot”. In summary, the preliminary experimental result shows that at least 50% of nodules were correctly detected, and at most 25% of nodules were overlooked.

We are tuning the algorithm with 100 lung cancer and TP cases collected from hospitals.

with an algorithm to detect early nodules for lung cancer and TP is very encouraging.

**Table 2:** Judgment of a medical professional on the detection of nodules obtained with the proposed algorithm on 10 lung X-rays

<table>
<thead>
<tr>
<th>X-rays</th>
<th>Number of nodules</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Detected</td>
</tr>
<tr>
<td>X0</td>
<td>Good</td>
</tr>
<tr>
<td>X1</td>
<td>Good</td>
</tr>
<tr>
<td>X2</td>
<td>Hard</td>
</tr>
<tr>
<td>X3</td>
<td>Blur</td>
</tr>
<tr>
<td>X4</td>
<td>Grain</td>
</tr>
<tr>
<td>X5</td>
<td>Grain</td>
</tr>
<tr>
<td>X6</td>
<td>Poor</td>
</tr>
<tr>
<td>X7</td>
<td>Poor</td>
</tr>
<tr>
<td>X8</td>
<td>Poor</td>
</tr>
<tr>
<td>X9</td>
<td>Poor</td>
</tr>
</tbody>
</table>

**Fig. 3:** Detection of nodules by applying a small scanning window to all pixels within the lung

**5. Discussion**

This paper presents the design of an active distributed medical advisory system for national healthcare systems. Data mining and other artificial intelligent techniques are used to make the system becoming an active and powerful expert system. The system is scalable and more advanced softwares can be easily added. The experimental result obtained

**Acknowledgement**

The MEDADVIS project is a continuing work at the School of Information Sciences and Engineering, University of Canberra.

The author is grateful to Dr. Peter Nickolls (Prince of Wales Medical Research Institute, New South Wales), Dr Warwick Lee (Bowral and District Hospital, New South Wales), Dr. Ngoc-Thach Tran (Tuberculosis Hospital, Saigon) and Dr. Quoc-Truc Nguyen (Ulcer and Cancer Hospital, Saigon) for their medical advice and X-ray images supply.

**Reference:**


