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Intelligent Decision Support System for Retrieval of Patient's Information

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***Abstract*— The majority of healthcare workers in hospitals continue to record, access and update important patient information using paper charts. Disparate patient data (clinical information, laboratory results and medical imagery) is entered by different caregivers and stored at different locations around the hospital. This is a cumbersome, time consuming process that can result in critical medical errors such as documents being mislaid or prescriptions being misinterpreted due to illegible handwriting. Hospitals everywhere are moving to integrate health data sources using Electronic Health Record (EHR) systems as well as taking advantage of the flexibility and speed of wireless computing to improve the quality and reduce the cost of healthcare. We are developing a mobile application that allows doctors to efficiently access accurate real-time patient information at the point-of-care. The system can assist caregivers in automatically searching through very large repositories of previous patient cases as increasingly large hospital databases are making manual searches of such information unfeasible. The system performs computational prognosis by providing decision support for pre-screening of medical diagnosis. A presenting patient's symptoms can be input to a portable device and the application can quickly retrieve the most similar profiles with known diagnoses from large databases which can be used to compare treatments, diagnosis, test results and other information.**

***Keywords* — System description, Image retrieval, Annotational tools for building patient profiles, Case retrieval, Evaluation**

I. INTRODUCTION

Healthcare technology is entering a new evolutionary phase. The medical community has an obligation to the public to provide the safest, most effective healthcare possible. This is evermore achievable with the use of portable electronic devices and new medical applications that can be delivered over wireless networks. Caregivers equipped with mobile computers now have levels of interaction at the bedside not possible with paper charts and can leverage accurate real-time patient information at the point-of-care to make decisions and take actions more efficiently. Electronic Health Record systems allow disparate patient information often entered by different caregivers to be stored together as encapsulated patient cases in medical databases. Using portable devices such as Personal Digital Assistants (PDA's) and Tablet PC's, all caregivers can access vital patient information as well as other resources including drug references, relevant medical imagery and online medical encyclopedias directly at the bedside. In addition to Electronic Health Records, the advent of new wireless technologies is providing many new and exciting opportunities. Healthcare providers may now move freely in hospital buildings with constant access to real-time vital patient information. Electronic Health Record systems also play an important role in long-term healthcare. We propose an innovative application that allows doctors to efficiently input, query, update, analyze and compare electronic patient records including associated medical imagery (e.g. X-Rays) on any mobile or desktop device. Our integrated EHR system can be used wirelessly by caregivers at different locations in the hospital setting to record and input all important patient data, including clinical information, up-to-date status reports, laboratory results, medication and medical imagery. The type of functionality provided in the application includes a Graphical User Interface (GUI) where caregivers can input and record all patient information in a straightforward manner and multimedia annotation tools for medical imagery to support Communication and collaboration between different caregivers. These annotations and other patient data can be used to support retrieval of patient case histories for comparison of diagnoses and treatment procedures and effective integration of image data with other patient information both within a database and within an adaptive Graphical User Interface.

II. SYSTEM DESCRIPTION

The system is based on three-tier architecture: client, server and database. There are two primary client components: a desktop application that is used by radiologists and a mobile component that is used by physicians. The radiologist employs a suite of image processing tools provided by the desktop application to annotate any images they have just acquired with relevant notes and information regarding the patient's condition. The system can be queried to display previously annotated patient images from a knowledge base of previous patient profiles for comparative studies to aid with more effective medical diagnosis and treatment. Once an interaction with a patient is complete the current patient's images are added to their profile in a central repository and the images and/or their annotations can be updated at a later date either by the radiologist or another doctor examining the patient. Physicians can use the mobile application on a Personal Digital Assistant (PDA) or a Tablet PC to retrieve and 131 view patient profiles and to quickly enter information about patient progress into electronic charts in real-time. The PDA allows physicians to view textual abstractions of current patient data as well as other patient case histories and allows for improved mobility due to its reduced size and weight. The Tablet PC provides a more comprehensive user interface and additional functionality

such as the ability to view and annotate medical imagery due to the larger screen size and higher processing power. All of the information for each patient is stored as an integrated patient profile in a database. All interactions with the patient profile by healthcare workers are recorded by the system and the profile is updated accordingly. Both the PDA and the Tablet PC can be used wirelessly at different locations around the hospital or in other situations where such facilities are not normally available (e.g. in an ambulance).They may also be used to access other resources such as online drug references or medical encyclopedias. The mobile devices may also be used to query the central repository of patient profiles with information specific to a particular illness to retrieve similar patient case histories that may help with a diagnosis by providing comparative assistance.

III. IMAGE RETRIEVAL

The majority of current medical image retrieval techniques retrieve images by similarity of appearance, using low-level features such as shapes or by natural language. The biggest problem arising from these techniques is the so-called semantic gap -the mismatch between the capabilities of the retrieval system and user needs. In order to bridge this gap our application aims to unite information about underlying visual data with more high-level concepts. For example, capturing a measure of the human expertise and proficiency involved in making a diagnosis from an X-Ray us to relevant image allows information was selected. (e.g. the highlighting a particular body organ) and also how it was employed in the context of that specific diagnosis (e.g. inferred from an added annotation). The approach allows us to capture and reuse best practice techniques. Using our application, the caregiver can retrieve relevant patient imagery by entering relevant patient data and by clicking on the "Search Patient Images" button on the interface depicted in Figure1. The user can adjust the weights of the relevant search fields by using the slider bars to indicate which of the parameters are most relevant. For example a radiologist may be viewing an X-Ray image and may be having difficulty in diagnosing the problem from the particular image. The X-Ray however may remind him of a similar image he viewed previously and he may remember some of the details of the previous patient.

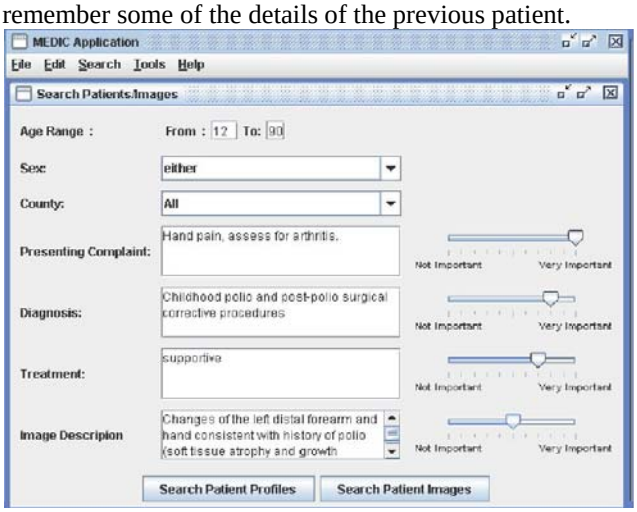

Fig.1. Search for Patient Information and medical imagery

In this scenario the radiologist could input the details of the previous patient as search parameters to the application. The application will then filter out this patient's profile as well as any similar profiles from the EHRS. The radiologist can then compare the current image to images from these previous case histories to try to find any similarities. If any of the similar images had been annotated while those patients were being diagnosed the radiologist may study these notes for extra information regarding the specific injury or illness.

IV. ANNOTATION TOOLS FOR BUILDING PATIENT PROFILES

The annotation tools provided by the application are used by radiologists to annotate medical imagery with relevant diagnostic information. When a radiologist takes a patient X-Ray or scan the image can be displayed in the screen depicted in Figure 2. Using the tools provided the radiologist can annotate the image in an appropriate fashion while diagnosing the patient. By providing an interface such as this one we have achieved the goal of capturing important contextual patient/diagnostic information by situating intelligent support for gathering it inside a flexible environment. This information is collected implicitly to shield the radiographer from the burden of explicit knowledge engineering. From their perspective, the image interaction tools support them in carrying out their task (e.g., a radiologist producing a report on the current patient) by making it easier for them to select and highlight relevant features, to store insights and to summarize aspects of their work progress. We have developed tools for direct image manipulation, including filters, transformation, highlighting, sketching and post-it type tools. The user can add media annotations to images as a whole or to particular highlighted image aspects. Currently, the system supports annotation by text audio and video.

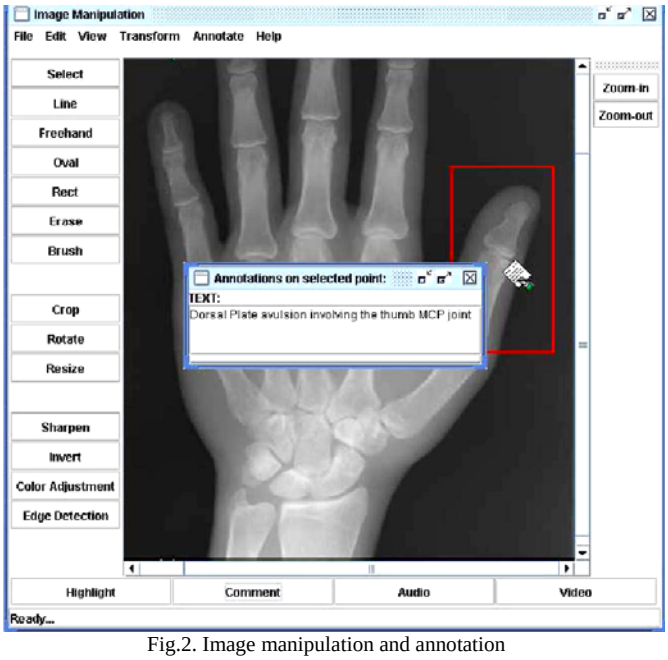

Fig.2. Image manipulation and annotation

All textual, audio and video annotations can be previewed before being incorporated as part of the knowledge base, and once recorded they can be saved and uploaded to the image as a knowledge parcel associated with the patient in

question. The system also supports annotation by cut, copy and paste between a given image and other images in the dataset, as well as any application that supports clipboard functionality. Once the radiologist has finished interacting with the medical imagery their entire work process is stored along with all the other patient data as an encapsulated patient profile in the knowledge base.

V. Case Retrieval

As the system builds up encapsulated user interactions, another type of retrieval is enabled, retrieving entire previous patient case histories. This enables a physician or radiologist to look for previous patient analyses. The caregiver can retrieve relevant patient case histories by entering the relevant patient details to the interface and by clicking on the "Search for Patient Profiles" button. As in image retrieval the user may adjust the relevance of the search fields by moving the associated slider bars. One challenge in retrieving previous case histories has been how to present an entire case history in a manner that is compact enough to allow multiple results to be viewed simultaneously. Figure 3 shows an example of our results for retrieved case histories. Each row represents a patient case history. It includes the matching percentage score between the current query and the similar patient profile. The user can click on the "Open Profile" button to view the full case history (including any medical imagery) of that patient.

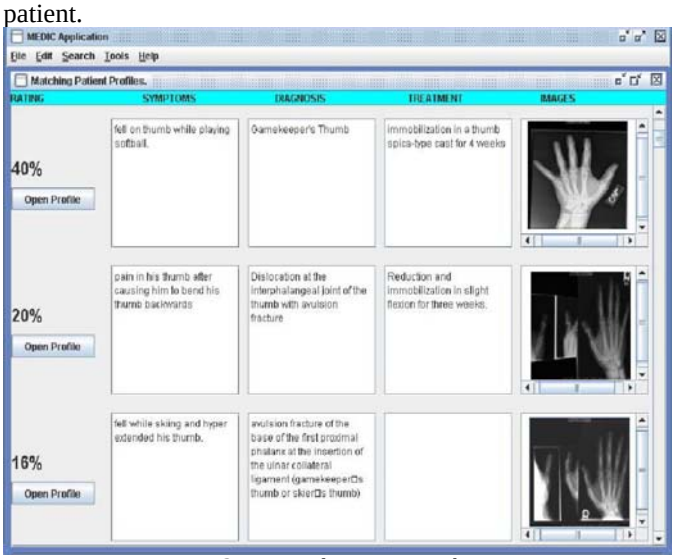

Fig.3. Retrieved previous case histories

VI. Evaluation

In an initial evaluation we have conducted testing with a dataset of 100 encapsulated patient profiles. In this preliminary evaluation we conducted experiments to test the previous patient case retrieval capabilities of the application. In this approach we were interested in showing that the system is capable of capturing and deciphering expert medical knowledge and we were aiming to show that recommendations made by the system based on similar patient data. We were also interested in demonstrating the ability of the application to facilitate effective knowledge and data sharing. The 6 selected cases were then input as search parameters to application. The information, symptoms, diagnosis and treatments for each case was entered to the system and similar cases were retrieved by pressing the "Find Similar Cases" button. The cases retrieved by the application and displayed in the results screen were then analyzed. Each returned case was marked as either "relevant" or "not relevant" to the search query. These ratings were then compared to the clusters we had outlined earlier to examine if the results were appearing in the relevant categories.

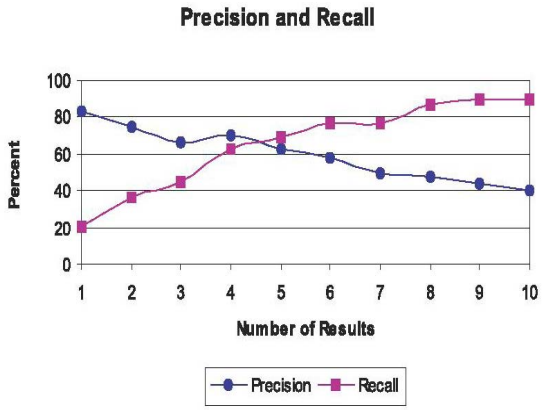

Fig.4. Precision and Recall data

This process was repeated for each of the 6 cases. In order to graph the results for our prior case retrieval algorithms we employed precision and recall metrics. Figure 4 shows the average precision and recall values for the results of the 6 queries. From the graph we observe that the system is performing case retrieval accurately. We also observe a linear increase in recall as the number of results returned increases indicating that all relevant cases are being retrieved for each query.

VII. Conclusion

The current system in hospitals where by doctors enters patient information using paper charts is cumbersome, time-consuming and does not facilitate knowledge sharing. Types of information, including imagery, are stored in different locations and valuable time is often lost trying to correlate data in order to diagnose and treat patients. This system can address such issues by providing doctors with instant access to information that will allow them to make critical decisions and prognoses with greater speed and efficiency. It facilitates knowledge sharing and supports effective communication about the most effective ways in which to treat patients by linking similar patient case histories using case-based reasoning techniques. It adds more value to imagery and image transmission by combining it with patient records to support more thorough communication, examination and diagnosis. Our initial evaluation of the system has produced very promising results. The system can effectively capture important patient information and can be successfully used retrieve similar previous patient case histories that can offer useful real-time decision support to physicians at any location in the hospital setting. We intend to conduct trials with domain experts in the near future. We intend to incorporate a facility to record relevance feedback from physicians to improve the usability of the application for the expert users.

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