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ORIGINAL PAPER

Designing and Implementation of Retina Image Drawing System and Automatic Report Generation from Retina Examinations

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ABSTRACT

Introduction: Electronic medical records as one of major parts of electronic health records is an important application of Medical Informatics. EMR includes different types of data, Graphical items being one of these data types. To this end, a standard structure for storing and recovering and finally exchanging this data type is required. In order to standardize information items in this research, UMLS standard is used. In this research, graphical information from fondues designing in retina surgery forms is used for the task of implementation. **Implementation:** Three-layer software architecture is used for implementation of this system, which includes user interface, data base access and business logic. XML database is used for storing and exchanging of data. User interface is designed by the means of Adobe Flash. Also in the user interface for eye examinations, appropriate icons compatible with current pathologies in retina examinations are considered and UMLS codes are used for standardizations purposes. **Results:** As this project is independently implemented in Adobe Flash, it can be run in most of electronic patient records software. For evaluation purposes of this research, an EMR system for eye clinics is used. Tree structure is used for data entry and finally a text report based on the entered data will be generated. By storing graphical items in this software editing and searching in medical concepts and also comparing features will be available. **Conclusion:** One of the data items that we encounter in various medical records is graphical data. In order to cover the patient's complete electronic medical records, the Electronic Implementation of this information is important. For this purpose, graphical items in retina surgery forms were used and finally a software application for drawing retina picture was developed. Also, XML files were used for the purpose of storing valuable medical data from the pictures, and also UMLS were applied for the standardization purpose. The developed software is currently being used in some of eye clinics in Iran.

Key words: Electronic patient records, graphical information, the retina, extensible markup language.

1. INTRODUCTION

Increasing advances in the field of medical sciences as well as increased awareness and expectations of customers turned health service provider organizations to customer-oriented and competitive environments (1). For this reason, Health service provider organizations plan for improving the quality of services along with cost-effectiveness criteria for the purpose of expanding and continuation of their activities. Such a measure will not be possible without timely access to quality information (2, 3). Because of essential limitations of paper records, it is not possible to establish proper communication between health service providers, and also process data and convert to usable information. Also timely access to this information would not be possible. Therefore, paper records could not support crucial needs for information in health provider organizations (4). For this reason, moving toward computer information systems began in 1970s, with the ultimate goal of such systems to access electronic health record (5).

In fact, Electronic Health Record (EHR) is all information collected or confirmed by health providers throughout a person's life and is accessible in different places. Despite the potential benefits of electronic health records, it has some limitations and obstacles in the implementation phase which includes cost, technical, standardization, behavioural attitude and organizational limitations. Some researches show that behavioural attitude limita-

tion and resistance to change play a more crucial role than any other limitations (7, 9). Therefore, access to electronic health records needs large investment in the infrastructures and important changes in health provider organizations. Also it requires users to participate and accept the system (8). Currently in Iran, there have been disorganized activities in the field of hospital information systems, and different products in clinics, physician offices and pharmacies. Most of these products are used as financial information system by the customers and the ability and need to share information in these systems are less considered (10).

Electronic medical records as one of major parts of electronic health records is an important application of Medical Informatics. An EMR is able to store all information about health services provided for the patient and organize them, Link clinical observations data, provide health care information and medical prescriptions to each other, and also makes it possible to manipulate and edit information. It also allows authorized personnel in different treatment centers to concurrently access patient's medical records and also connects to other information systems and clinical alarm systems. On the other hand it provides a standard structure for storage, searching and correcting the exchanging of information which is required. Unified Medical Language System (UMLS) was founded by United States National Library of Medicine in 1986 which was an effort to establish an international medical ontology and it is in fact a correct response to the demand for the creation of international homogeneous and multipurpose vocabulary databases. The approach of this system is integrating of various biomedical terminology systems in different languages to create a biomedical ontology in order to prevent obstacles and limitations of exchanging and linking terminologies in structural, contextual or semantic view between various sources of medical terminology at the international level. Therefore, The Unified Medical Language System provides a unifying paradigm by establishing semantic links between equivalent medical entities which is used in various textures for several purposes (14).

The Unified Medical Language System hyper terminology is an extensive, multipurpose, Multilanguage and comprehensive knowledge base of controlled vocabularies which contains information about medicine and health and their various names and also the relationships between them. This hyper vocabulary is formed from multiple electronic versions of vocabularies, different classification schemes, a variety of codes, checklists for terminology used in health care, biostatistics, cataloging and indexing of biomedical literature and also related researches in the field of healthcare (15). One of the data items that we encounter in various medical records is graphical data. In this project, it is tried to implement tools for designing graphical information of fondues in retina surgery records. Fondues reference design provides excellent information to monitor the patient's clinical procedures and also helps to analysis the surgery plan. As it is shown in Figure 1.1. retina image is comprised of three concentric circles. The outer circle is the image of anterior region and the inner circle represents the neural network of eye center. This image consists of twelve radiuses which represents twelve hours and the exact location of graphical data can be obtained by these twelve hours and sectors connected to them.

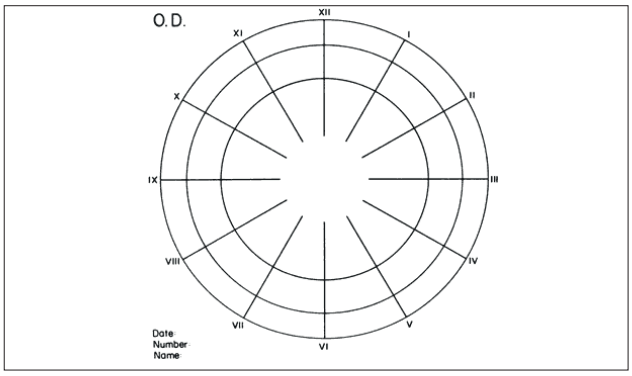

Figure 1. 1. Schema for retina graphical information

Graphical information of these forms is entered based on diagnostic information, pathology examinations and clinical operations by the physician. This information is non-editable and the extraction of medical concepts is not possible without the doctor's report.

2. IMPLEMENTATION

As mentioned above, one of the data items that we encounter in various medical records is graphical data. In order to cover the patient's complete electronic medical records, electronic implementation of this information would be very important. On the other hand providing facilities to extract valuable medical information from these images is very important which requires a standard approach to assign information to generated images. To this end, the multi-layered graphical tool for designing and placing image information is used. The first layer is a static image similar to Figure 1.1. Therefore, the basic design is a location oriented image. In the subsequent layers, graphical parameters consisting of tools and icons are in accordance with diagnostic information, pathology examination and clinical operations. On the other hand, as was proposed, standardization of medical concepts in these images to facilitate search and analytical reporting is very important. In this project, UMLS is used to unify patients' electronic records, and it is the first time that it is used to standardize graphical data records.

2.1. Program Architecture

Three-layer software architecture is used for implementation of this system, which includes user interface, data base access and business logic. Each of these layers will be described in subsequent sections.

Data Base: There are three different types of databases in this project, a database related to hospital information system, from which patients' demographic information and chief complaint could be accessed. The other one is the patient's electronic health records database which contains information about forms and their structure and any information about electronic records. Both of these databases are supported by MS SQL, The last database stores information about graphical items. Based on this information, images are saved and restored and also standard textual reports can be generated. XML database is used to store this information.

Business Logic: Asp.Net is used for the business logic programming and also Action Script is used for file business logic. The main structure of patient's electronic records in this layer was developed using ASP.Net codes and facilities for connection to the database of the program was provided.

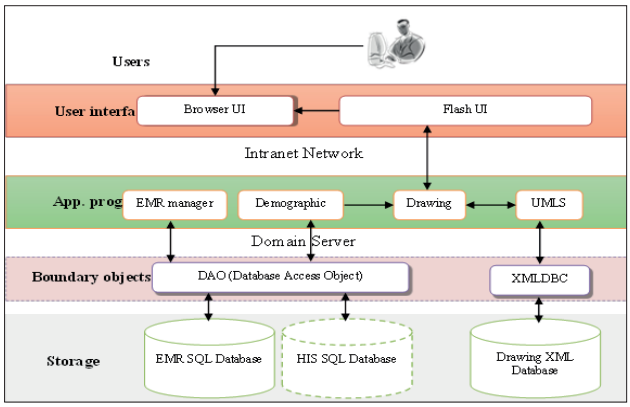

Figure 2. 1. Architecture of implementing graphical items of patient's electronic health record

Action Script codes was also used to manage and store the graphic file.

User Interface: Including HTML pages and JQuery and Adobe Flash in a logical manner. In this layer forms were created using HTML and data is managed in user level by using JQuery. Finally, in order to create graphical files, Adobe Flash files are used. Program architecture is shown in figure 2. 1. This architecture makes the program independent of EMR software and it can be used in any other software. In the subsequent sections, the program implementation and different parts of the graphical items which exist in the patient's EHR related to fondues images of retina records will be described.

2.2. Implementation of electronic design of retina

In this section, the drawing tool designed to create graphical items of fondues from eye surgery records of retina will be described. Adobe Flash was used for this purpose and a schema similar to Figure 1. 1. for both right and left eyes was built. At the button of the screen, there are some icons that let the switch between schemas of left or right eye or both of eyes. At the top of the screen, some links were provided to edit demographic information or store and retrieve the created images. In Figure 2. 2. an overview of the program schema is shown.

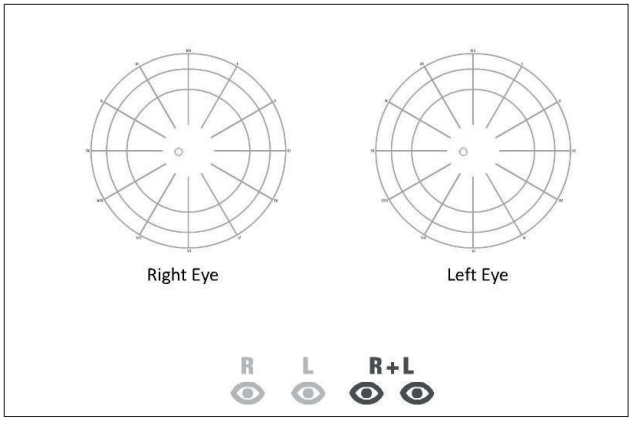

Figure 2. 2. Overview schema of eye fondues item drawing of retina

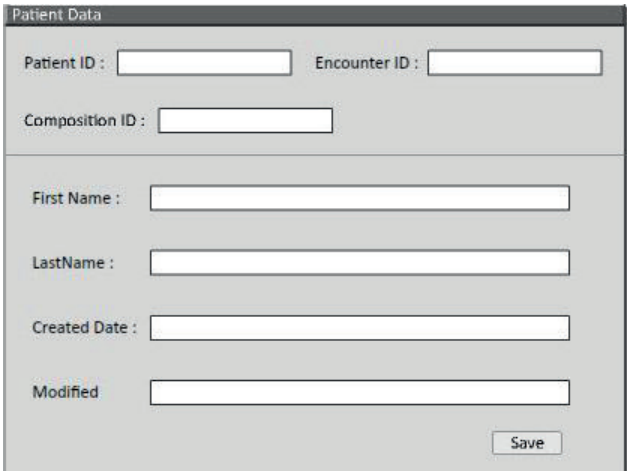

Figure 2. 3. Inputting and editing demographic information of the patient

Data fields such as patient ID, record ID, name, date of creation and modification date are available in demographic information section. This information is provided through EMR and also editing capability is available. Figure 2. 3. shows this section of the program.

By clicking each of the eye icons, the drawing tool for the physician will be enabled. Standard icons proper to pathological examinations that have their own UMLS codes are provided for eye examinations. By using drawing tools and dragging and dropping them in places considered by the physician, findings of the medical examination could be stored in the patient's medical records. These images could be retrieved later by the physician. Figure 2. 4. shows the graphical data entry screen.

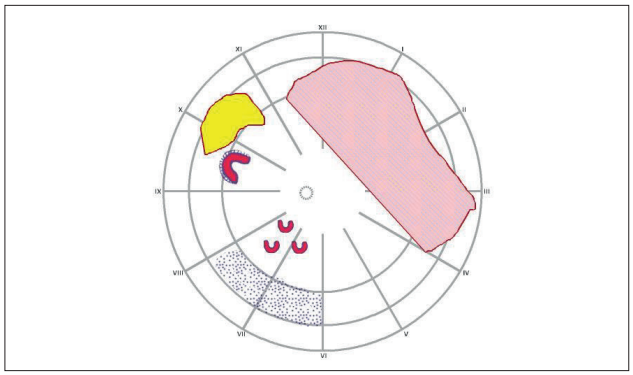

Figure 2. 4. Graphical data entry related to eye fondues design

As it is shown in Figure 2. 5. the drawing toolbar includes selection tool in order to select and move and change the size of icons and colored areas as well as a Pen tool in order to design lines. It also includes a Filling in order to select and colorize eye sectors as well as Eraser tool to erase selected areas and finally icons proper to pathologies in retina examinations. It is also possible to change the designing color.

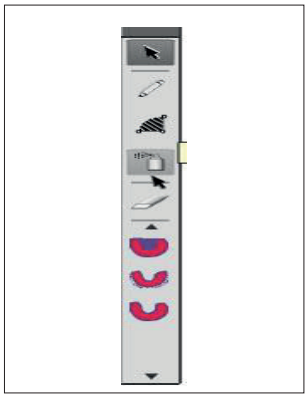

Figure 2. 5. Drawing toolbar

Finally, after drawing the images by the physician, these images could be stored by the Save icon in the program. The Saving operation generates an xml file with an appropriate name; meanwhile, the image can be retrieved by this xml file later.

2.3. Data storage structure

Extensible Markup Language is usually used to create a standard text based structure. For this purpose, we can define

markup tags based on a set of documents that share similar features. Using these features, it is possible to save information related to images in an xml file. In addition to a significant reduction in the images storage space, it will be always possible to edit the saved images. For this purpose, a structure similar to Figure 2. 6. was designed to create the XML file and also used to save and restore graphical information.

Figure 2. 6. A sample of XML code in order to recover graphical information

The patient's demographic information will be stored in the xml file and separate tags are considered for both right and left eyes. Also for each eye, appropriate tags proper to pathological concepts are considered. Meanwhile, the type of icon and location are stored by their own tag. All of conceptual tags are standardized by standard UMLS codes and a specified range of UMLS codes are assigned to these icons. Therefore, each XML file contains all concepts available in the picture so it would be possible to generate analytical and standard textual reports from the drawn picture.

3. RESULTS

As mentioned above, this project is implemented in Adobe Flash so it has the capability to be run in any other medical software. Demographic information of the patients can be retrieved from the Hospital Information System or can be entered manually then an electronic record containing information about place, chief complaint and the physician name will be stored. Then the patient's referral form will be completed by the doctor. Different data items are considered in these forms that make it possible to have three different choices for the physician. Negative mode means that there is nothing for examination parameters or the condition is normal. The positive mode means that there is an abnormal state or the examination parameters exist. Finally, the unsigned mode means that the item is considered as unimportant for examination by the physician. These items have tree structures in the program and child nodes inherit from the father nodes in a way that positive or negative child nodes affect their father nodes or changing the state of the father node affects the state of its child nodes. Figure 3. 1. shows the tree diagram of data items and their different type of states.

Program items are defined in both textual and graphical forms. As soon as the graphical item is set as a positive screen similar to Figure 3. 1. it will be shown to the physician and make it possible to create the graphic file. The saved file can be retrieved and be edited. Finally textual report can be generated based on initial definitions and negative or positive states. A sample of generated report is shown in Figure 3. 2. In the generated report, the original image or the textual report from stored data in the xml file can be observed.

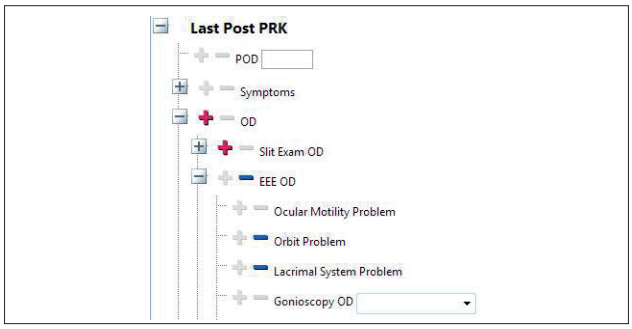

Figure 3. 1. Patient's electronic record data item in tree structure

Figure 3. 2. The final report obtained from patient information

By storing drawing item's information in the program, facilities such as editing images, searching in medical concepts and then comparing them will be available for the physician. Each user has his or her own user ID and panel in the program. In addition, the program has patient information and program management sections. In the patient information section, the user has access to the patient's medical records. There are various forms related to different parts in the patient's records that have many items with both types of text and graphical data which are unified and standardized by UMLS. Figure 3. 3. shows how the system works.

4. DISCUSSION AND CONCLUSION

It is noticeable that considering the growth of science and technology in all organizations around the world and also various problems in documenting patient's information such as loss of information, lack of timely access to patients' medical records, lack of access to patient's information in different geographical areas, and also considering high volume of requests, it is essential to replace traditional paper based with electronic records in health system. To this end, in order to remove traditional paper based systems, it is essential to provide a system to cover all data types of items. One of the data items that we encounter in various medical records is graphical data, In order to cover the patient's complete electronic medical records, Electronic Implementation of this information is important. On the other hand, providing facilities to extract valuable medical information from these images is very important which requires a standard approach to assigning information to generate images. For this purpose, graphical items in retina surgery forms are used and finally a software application for drawing retina picture is developed. Also, for the purpose of storing valuable medical data from the pictures, XML files are used and for the standardization

purposes UMLS are applied. For evaluation purposes of this research an EMR system for eye clinics is used. The developed software is currently being used in some of eye clinics in Iran. In the future, the performance of this system in these clinics will be evaluated in a research.

• Conflict of interest: none declared.

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