OPTIMISED MULTIMEDIA APPLICATION FOR IMPROVED MEDICAL VISUALISATION

Salsabeel F. M. Alfalah
David K. Harrison
Vassilis Charissis
Dorothy Evans

Glasgow Caledonian University
School of Engineering and Built Environment
Cowcaddens Road
Glasgow, G4 0BA, UK
Salsabeel.Alfalah@gcu.ac.uk

ABSTRACT

Efficient delivery of healthcare has become increasingly dependent on a broad range of medical data, which includes different media types. The use of technology in the medical field is rising rapidly, while the method of storing and visualising medical data has not altered that much, leaving health professionals to deal with fragmented patient data which consumes time and affects decision-making.

This paper shows how health professionals can manage sizeable quantities of information and different data types so they can improve medical treatment, patient care, medical diagnosis and the development of future treatment improvements for research purposes.

A 'work in progress' project presented here deals with medical data. This paper provides a detailed study of the problem of having fragmented medical data, and the proposed solution which is having a medical record and a toolbox/software interface to assist health professionals in storing and visualising data.

Keywords: Multimedia, Medical, Visualisation.

1 INTRODUCTION

Due to the variety and complexity of the software, hardware, and data types used in the medical field, current methodologies are both time-consuming and limited in-depth analysis for use by health professionals and it often involves alternating among different applications to view the data. Having different media types which need to be viewed at the same time without having a single interface makes it difficult for both the health professional and the viewer, as it wastes precious time in trying to link data and has the potential to cause confusion.

This work investigates multimedia output from medical software and assists in the display and understanding of the data. In particular, it seeks to integrate different types of media (Graphs, Imagery, Patient records, Text files, and Spreadsheets among other) and considers methods to display these in a single application to manage, share and visualise multimedia data. The provision of the patient record in a digital format has many advantages: improvement of quality of care, fast and easy access to the records, without the need to prepare the file of the patient in advance of each visit, easy navigation through the data due to having the option to query, and data presentation are better for educational and research purposes.

2 BACKGROUND

Computers are no longer used solely as terminals to access and manipulate documents, data, and browsing the internet. The gap between the users and the computer is reduced through time in all fields as in

medical visualisation which helps in many issues such as: ease of diagnosis, therapy, surgery planning, and producing reports all of which improve decision making (Ward et al. 2008; Sakellariou et al. 2011). The idea of integrating different data types to create a multimedia medical record is not new, the solution for presenting patients' data is to build a multimedia view of the medical records consisting of integrating different data types from multiple databases and then presenting the integrated multimedia view of the patient record to the health professionals in a meaningful and useful way.

2.1   The Need for a Multimedia Medical Record

Computer patient records are typically composed of textual data, multimedia data such as images, audio and video have been more difficult to store and visualise, but the need for integrating multimedia data is now arising as the patient's data is becoming fragmented and important data may be scattered along with multiple repositories. This fragmentation of patients' records is making it difficult for health professionals to obtain the integrated view that is essential for decision-making and research purposes. The solution is having an electronic medical record which means: storing the patient's data in a single repository by entering data directly or integrating data from different repositories and having management tools to control authorised users, database search and edit patients' data.

Having a computer-based patient record has many benefits, Ratib (1994) pointed out some benefits of having a computerised patient record that handles integrated multimedia data (images, text, sound, and any related data that constitutes the medical record) which will offer users the chance to browse through these data and visualise them in a better way. Brussee et al. (2005) suggest how multimedia can be used in a useful way in healthcare. Patient data can be shared, discussed and processed by clinicians involved with a patient. Also, more highlight is put on protecting the privacy of patients which allows clinicians to sustain responsibility for their patient data.

Dayhoff et al. (1991) discussed how an automated system that combines different media types such as patients' images and text data will provide clinicians with a more complete view of the patient's data. They proposed a model for software integration, instead of having a Separate Image Management and Communication Systems (IMACS) which does not include communication with the Hospital Information Systems (HIS) or Departmental Information System (DIS). This means that regardless of the data values or data types, it will be stored in the same database system and used by clinicians. Also, a single representation for patient records, models, and images which are maintained in a multimedia database system was introduced by Dionisio et al. (1996).

Medical decisions rely on the patient record thus an analysis of similar cases and access to related information. The need for having an option to obtain specific information, such as having a query, search and customising option is preferable. Some work has been carried out in this area; Degoulet et al. (1995) indicated the importance of having a multimedia workstation for clinicians, integrated into a network architecture, which will be the connection to spread and integrate health information systems. This workstation will allow the user to view the patient record as a single unit while information is scattered among different servers. Adding to that the benefit of having search query options will help access similar patient cases from existing databases.

2.2   Web Applications and Multimedia Medical Records

A plurality of different systems is currently employed to present medical records based predominantly on web or desktop applications. Each has its own advantages and disadvantages. The Internet has evolved as a network which allows collaboration between distant health professionals using different computer systems. There are many benefits of using Web tools: no need to have a particular computer system in order to have a medical record system tied to it, and regardless of the type of machine upon which the record is stored an authenticated user is allowed to access the patient record, giving the opportunity to authorised people to enter anytime, anywhere to the system, allows secure access with different privileges to patient

records, and helps in obtaining benefit from other experts in the field from different countries (reduces the cost of experts travelling to the same site or transferring the documents to them).

In this area, Halamka et al. (1999) demonstrated the importance of using the World Wide Web to merge heterogeneous clinical data across several institutions and their project provides a design for World Wide Web-based retrieval of electronic medical records from various data sources. It provides a virtual consolidation of the medical records at heterogeneous institutions which may differ in legacy systems, vocabularies, and even in the completeness of clinical information. Zhang et al. (2005) developed a web-based system to interactively present electronic patient records such as images, graphics, structure reports and treatment records, for intranet and internet medical applications.

There are computer systems that offer online consultation and manage patients' clinical records; as an example, Santoni et al. (1995) report on the results of the Pilot Project at the Radiation Therapy Department of Florence for managing the storage and retrieval of different and complicated data types. Another example of a web-based system that can be accessed through the internet/intranet is Lim et al. (2006) who introduces GP-Soft, which manages patients' data; it provides tools to handle prescription writing, medication, and patient billing. It also provides communication tools that will allow General Practitioners (GP) to carry out collaboration and discussion.

3   CURRENT PROBLEM

Health professionals are often aggravated by the complex software and multimedia generated from current techniques for storing and visualising the complex and varied multimedia medical data. As they have sometimes to view an image, video, spreadsheets, and text files at the same time, it is difficult without having a single interface, as the health professional has to switch between different applications to view the data. Visualising different data types from various applications and trying to link data does waste a great deal of time and causes confusion for the viewer.

This work is focusing on current techniques for storing and visualising the complex and varied multimedia source data generated in the process of clinical gait analysis. Gait is the way of moving the body from one point to another. There are many ways to move the body; the most common way is walking, but also humans can run, skip, etc.

Definition 1 Gait is defined by Kirtley (2006) "*as any method of locomotion characterised by periods of loading and unloading of the limbs. This includes running, hopping, skipping, swimming, cycling and walking. The latter is the most frequently used gait, providing independence and used for many of the activities for daily living*". Gait may be affected if a person is injured or suffers from diseases that may lead to biomechanical abnormalities such as unusual or uncontrollable walk patterns while the body is trying to find ways of compensating for the problem. An analysis must be undertaken to facilitate treating the patient. Here arises the importance of gait analysis which is the method used to assess the way of movement manifest directly whilst treating patients, or indirectly in medical diagnosis and development of future treatment improvements as in gait analysis research.

Definition 2 Gait analysis, defined by Whittle (2007) "as *the systematic study of human walking, using the eye and brain of experienced observers, augmented by instrumentation for measuring body movements, body mechanics and the activity of the muscles*".

Gait analysis is carried out by health professionals, and there are different methods for the analysis process, ranging from using no equipment at all to the need for more complicated equipment. In simple cases, the health professional can simply watch the way that the patient moves, either by letting the patient walk or run on a treadmill. In more specialist settings careful assessment of the running or walking style needed for the walking cycle may be recorded using a video recorder which gives extra options such as slow-motion and pausing frames. In more advanced methods, 2D and 3D measurements can be performed using complex equipment and software.

Using any of these methods requires health professionals to work with a variety of data types. The problem is that there is no current system to: store patients' data in a single repository, visualise all need-

ed information in one interface without the need to switch between different applications, give an option to obtain specific information by searching or querying patients' data, and generate reports depending on predetermined criteria for quality control.

As these professionals may have a variable computing background to sort these different data files and visualise them in a useful way and also due to the time constraint they may not have enough time to search for extra tools in the software packages that they use. The authors consider that a method of storing, accessing and custom visualising the data generated would be of great benefit and will simplify the analysis of gait as data will be used more productively.

4   PROPOSED SOLUTION

Using multimedia applications for gait analysis visualisation offers a potential solution for the problem caused by having different data types. Some of these benefits are: efficient time management and focusing on patient care so gaining improved feedback. This will also aid research and teaching of the subject.

Computer support will also help in the research process, as all the data will be located in a database and the viewing process is easier. This will enhance the data presenting process for teaching, giving feedback to the patient and conferencing purposes. Furthermore, integrating a 'query' option would make the search and localisation of certain information easier and producing reports will lead to better decision-making and quality control.

This work will investigate the multimedia output from the medical software used for gait analysis and assist in the display and understanding of the data. This work considers different types of media (Graphs, Images, Videos, Text files, Spreadsheets, etc.) and the methods used to display these in a single application to manage, share and visualise multimedia data.

Replacing the current methodology of presenting data by having a single interface to visualise the different media types will be valuable regarding saving time and being more accurate (having a database which has the patients' medical records and users' data), Human-Computer Interface (HCI) (taking into consideration easy navigation options, readable text, search, help and user-friendly design), protecting the privacy of patients (having different authentications, so not all users are allowed access to the patient's information), security, and precision (having an automated system for saving, retrieving, and presenting information will be more accurate). Additionally, producing reports will help in decision-making and quality control.

Following, Kendall and Kendall (2005) steps for system development, the software development process for this work investigates the following: identify problems and objectives, determine requirements, analyse system needs, system design, development, system testing, implementation and evaluation.

5   PROPOSED SYSTEM REQUIREMENTS

The first phase of the software development process is to identify problems and objectives. Determining system requirements involves interacting directly with users in different ways such as: interviews, sampling and investigating data, and questionnaires (Kendall and Kendall 2005). Practical steps for this work will start by observing the process of gait analysis in the laboratory, in order to know how the procedure of the analysis goes. Then system requirements will be defined by determining the problem from the end-users (health professionals) through interviews and questionnaires.

In order to define the main problem, the used file types, the expectation from the application, the best way to visualise the data, determine the data set to work on, and define the users' accounts and privileges, interviews will be conducted with health professionals.

After interviewing health professionals a preliminary design for the database, users' privileges, and application's screens will be put in a template. The template will be presented in several presentations for the health professionals in order to take their feedback and edit the information provided according to their needs until the final agreement on system requirements is reached.

5.1   System Design

A preliminary design of transforming the detailed requirements into a complete detailed system which focuses on how to deliver the required functionality will be defined in this process. System design will be initiated by determining the data set and the users of the system. The design process is split into two main phases: website and database design.

5.1.1   Website Design

Website building goes through these stages: define website's users and audience, determine site's purpose, plan the structure of the site, and define how the media will be presented (Lengel 2002).

The users and the audience of the website must be defined in order to know what they are looking for, how they think, and what their expectations are. For this work, the users will be the health professionals at Glasgow Caledonian University (GCU), the audience are people who may be interested to know more about the gait analysis either patients or researchers in the same field.

After knowing the site's users, the purpose of the site must be defined clearly as to identify the usability objectives. Adhering to the above this work aims to improve storing and visualisation of medical data with particular interest in the gait analysis data. The proposed project seeks to integrate different types of media in a single database and display them in an interface.

The structure and the layout of the website will be defined based on the suggestions and feedback of the preliminary investigation of the end user's audience.

And for media presentation, understanding the media types and how to present them will be undertaken. Taking in consideration HCI characteristics while choosing the website colours and navigating through WebPages.

5.1.2 Database Design

Storing data is a commonly used process, yet the issue of storing and acquiring this complex information (i.e. gait analysis) through a simple and time-efficient system is currently not resolved. Here arises the importance of a database, which provides a direct way of retrieving the knowledge that already exists in huge sets of data, and providing it to the interested users. **Definition 3** Database is described by Petersen (2002) as *a collection of related data elements / a collection of related data tables or entities.*

In particular, an interface that provides the options to retrieve, query, view and print data will be connected with the database. For this work the database will consist of users' and patients' data, the medical record has two types of data, data that is entered directly by the health professional and the output from the software used for gait analysis which will be uploaded to the record. In this process all the fields that need to be added or uploaded to the patient's record will be defined, the same process also applies for the system users' data and accounts.

5.2   Development

For this process, the practical steps of building the system will be undertaken by choosing the software needed to build this web application, which fulfils all the requirements defined by the end-users (health professionals).

5.3   System Testing and Submission

The Alpha version of the complete system will be evaluated via field trials, with the participation of the system users. The obtained numerical results and subjective feedback will be recorded and analysed, informing the development of the beta version and delivery of the system after acceptance gained by end users.

6   CONCLUSION

This paper presents a proposed solution that assists in medical data storing and visualisation which solves: medical data fragmentation along with multiple repositories, no single interface to view or search patients' data, and there are no management tools to control the data.

The proposed solution is to have patients' data stored in a medical record and presented in a single interface which simplifies the process of storing, searching and visualising medical data.

For future work, enable the system to keep up with new developments in the field, improve the optimisation of the application, simplify the system usage, expand the benefit of using it, and gain medical consultation. The future plan is to apply telemedicine to this application.

REFERENCES

Brussee R., et al., 2005. Integrated Health Log: Share Multimedia Patient Data. Multimedia and Expo IEEE International Conference, pp.1593-1596, Amsterdam, ISBN: 0-7803-9331-7.

Dayhoff R.E., Maloney D.L., Kuzmak P.M., and Shepard B.M., 1991. Integrating Medical Images into Hospital Information Systems. Journal of Digital Imaging, Vol.4, No.2, pp.87-93, DOI: 10.1007/BF03170416.

Degoulet P., Jean F.C., and Safran C., 1995. The Health Care Professional Multimedia Workstation: Development and Integration Issues. International Journal of Biomedical Computing, Vol.39, No.1, pp.119-125, PMID: 7601524.

Dionisio J.D.N., et al., 1996. A Unified Timeline Model and User Interface for Multimedia Medical Databases. Computerized Medical Imaging and Graphics, Vol.20, No.4, pp.333-346.

Halamka J.D., Osterland C., and Safran C., 1999. Careweb, A Web-Based Medical Record for an Integrated Health Care Delivery System. International Journal of Medical Informatics, Vol.54, pp.1-8, PMID: 10206425.

Kendall K. and Kendall J., 2005. Systems Analysis and Design, 6th ed. Pearson Education, Inc., ISBN: 0-13-127323-X.

Kirtley C., 2006. Clinical Gait Analysis Theory and Approach, Elsevier, ISBN: 0443100098.

Lengel J., 2002. The Web Wizard's Guide to Web Design. Pearson Education, Inc., ISBN:0-201-74562-3.

Lim C.C., Yu H. M., and Jin J. J., 2006. Web-based Multimedia GP Medical System. Proceedings of the Pan-Sydney Area Workshop On Visual Information Processing, ISBN: 1-920682-18-X.

Petersen J., 2002. Absolute Beginner's Guide to Databases. Que, ISBN: 0-7897-2569-X.

Ratib O., 1994. From Multimodality Digital Imaging to Multimedia Patient Record. Computerized Medical Imaging and Graphics, Vol. 18, No. 2, pp.59-65, PMID: 8168051.

Sakellariou S et. al. 2011, Virtual Reality Environment as Knowledge Enhancement Tool for Musculoskeletal Pathology, Human-Computer Interaction. Virtual and Mixed Reality, Lecture Notes in Computer Science (LNCS), J Schumaker, R (Ed), Vol. 6774, ISBN 978-3-642-22023-4, pp 54-63, Springer Berlin / Heidelberg.

Santoni R. and Cellai E., 1995. Technical note: Multimedia clinical records: results of a pilot project at the Radiation Therapy Department of Florence. The British Journal of Radiology, Vol.68, No.808, pp. 413-420, PMID: 7795979.

Ward B.M., et al., 2008. An evaluation of prototype VR medical training environment: Applied surgical anatomy training for malignant breast disease. Journal of Studies in Health Technology and Informatics, 132(16), pp 500-505.

Whittle M., 2007. Gait Analysis an Introduction, 4th ed. Philadelphia, Elsevier,ISBN:978-0-7506-8883-3.