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THE ROLE OF 3D SIMULATION TO AID PODIATRY DIAGNOSIS

Salsabeel F. M. Alfalah

Glasgow Caledonian University
Cowcaddens Road
Glasgow, G4 0BA, UK
Salsabeel.Alfalah@gcu.ac.uk

David K. Harrison

Glasgow Caledonian University
Cowcaddens Road
Glasgow, G4 0BA, UK
D.K.Harrison@gcu.ac.uk

Vassilis Charissis

Glasgow Caledonian University
Cowcaddens Road
Glasgow, G4 0BA, UK
Vassilis.Charissis@gcu.ac.uk

Dorothy Evans

Glasgow Caledonian University
Cowcaddens Road
Glasgow, G4 0BA, UK
Dorothy.Evans@gcu.ac.uk

ABSTRACT

An extensive amount of medical data is recorded daily from patients with walking difficulties. Due to the volume and segmentation of derived data, it is becoming increasingly difficult for health professionals to interpret the collected data and diagnose the patient's condition. The current 2D mode of interaction constrains the users' ability to obtain information in a clear and timely manner. As such it is deemed essential to develop an automated system that can extract, store and visualise in 3D the data from different sources, in order to improve 3D mental mapping, increase productivity and consequently ameliorate quality of service and management. In particular, the proposed system offers simulation capacity and Virtual-Reality visualisation experience which enhances the gait analysis process. Overall this work is concerned with the development of interactive information-visualisation software that assists medical practitioners to simplify and enhance the retrieval, visualisation and analysis of data.

Keywords: Medical Data, Visualisation, 3D Simulation, Podiatry

1 INTRODUCTION

Due to the variety and complexity of the medical data types, current methodologies for data storage, search and view are both time consuming and limited in depth of analysis. Trying to link different media types from different applications wastes precious time and has potential to cause confusion for both the viewer and the health professional.

The problem facing the health professionals is three fold. Firstly, the data storage is inadequate as a huge amount of scattered data is produced on a daily basis without having a single repository to collect and archive. Secondly, data collection and presentation is limited as there is no specialised appropriate interface to view the different media types, and in addition, not having the option to query makes the navigation difficult. Thirdly, the typical mode of data visualisation and interaction takes place using a 2D window which does not reflect the actual three dimensional information.

This project examines the database and its visualisation and aims to address these problems. Firstly, to integrate different types of media (Graphs, Imagery, Patient records, Text files, Spreadsheets etc.) in a multimedia medical record. Secondly, to consider methods to display the medical data in a single application to manage and share multimedia data. Thirdly, to integrate virtual reality and data visualisation to enhance user interaction with data and data representation whilst controlling navigation.

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, easy navigation through the data due to having the option to query, and data presentation and as a system it is better for educational and research purposes.

2 BACKGROUND

Quality improvement in health care is affected by the delivery of accurate information in the required time which depends on data storage and presentation techniques used. Medical data is a focal point for any patient-focused quality improvement program (Rogers and Joyner, 1997). The effective use of the medical data is crucial for patient care enhancement either while treating the patient or for research purposes. Technological advances have been introduced in medicine to improve quality and efficiency in the health care processes. In particular the organisation of patients data and visualisation methods, such as virtual reality techniques, enhances diagnosis capabilities by enhancing data management and analysis (Shaw et al, 2001). Additionally, previous studies indicate that provision of suitable tools that encourage patients' involvement and active management of their conditions, result in better health status and clinical outcomes (Stroetmann and Pieper, 2003), in particular in chronic disease management, such as diabetes, involving active patient monitoring of complex sets of medical observations and behaviours. Providing these patients with a highly interactive graphical user interface allowing them to navigate through their historical data results in a more accurate, complete and useful application, (Andry et al, 2009). While it is important to keep the application interface simple, easy to use and interesting to the users, it is important to provide as much relevant medical information as possible (AJMQ, 2006). All these factors should be taken into consideration while developing the software. The PREPaRe system (Personal Repository for Electronic Patient Records) is one examples of a system that provides a notion to generate easy to understand graphical data from different types of multidimensional medical data. It is an internet-based information system that is able to store, combine, process and visualize all types of medical data that are part of a Personal Electronic Medical Record (PEMR), (Tschirley et al, 2002).

Based on the aforementioned observations, the proposed system focuses in the fastest and more efficient conveyance of information and data representation for gait analysis. 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 is affected by a plethora of pathologies producing biomechanical abnormalities of the musculoskeletal structure and dysfunctional walking patterns.

Diagnostic triage and gait analysis produce a multitude of data sets (i.e. functional 3D models, images, spreadsheets, text files and video media type) which can be in turn manipulated by different software and methods. For the advanced methods, 2D and 3D measurements can be recorded by using sophisticated equipment. Currently medical practitioners have to investigate all the data and compare information while accessing each individual software and interface separately. As such, this can be a hindering aspect as it is time-consuming whilst potentially resulting in confusion and frustration to the user.

3 RATIONALE

In this project, the current methods in which multimedia output is derived from various medical sources used for gait analysis (Graphs, images, videos, text files, and spreadsheets) are investigated and a novel approach of combining the existing data into a single software entity which consecutively will offer data visualisation of gait analysis with emphasis into the three-dimensional aspects of the foot and ankle section is proposed.

The data collection, archiving and prioritisation of the different types of media pose a significant obstacle in the efficient visualization and presentation of the crucial data. Currently this process is placed exclusively upon the subjective ability and capacity of the medical practitioner. To this end our

proposed system enhances the human decision making process by offering a simple, all inclusive software environment in which the user can access simultaneously more than one sources. By employing concurrent 3D and Virtual Reality (VR) visualisation methods we aim to support further the decision making process by offering a complete 3D mental model of the foot which could be further manipulated in real-time. Our interface design philosophy stemmed from the simplistic representation of data through direct manipulation interfaces and minimum alphanumeric information in the first layer of interaction as illustrated on figure 1. The second layer includes more analytical information which appears on request by the user. As such we achieve a minimum information load which enables the user to interact and interpret faster each case. Such VR visualisation methods offer significant advantages over the traditional methods of graphs and schematics (Sakellariou et al. 2009).

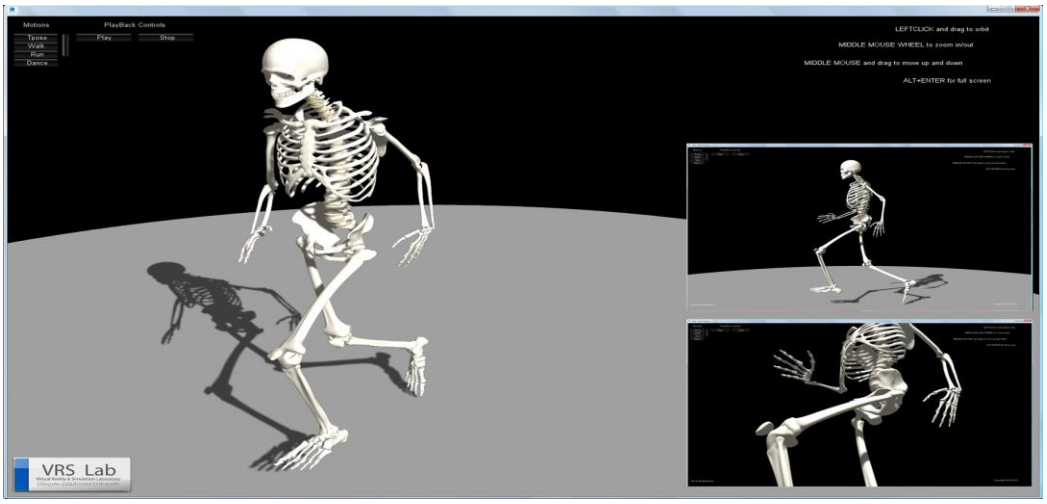

Figure 1 *Screenshot of Real-Time 3D visualisation of patients gait analysis with the use of the proposed multimedia application in the Virtual Reality and Simulation Laboratory*

4 SYSTEM IMPLEMENTATION

The first step to enhancing medical data archiving is transferring the process from paper form to an electronic form i.e. Electronic Medical Record (EMR). Optimal patient care requires accurate and up to date completeness of the EMR including all relevant media output forms as part of the record. This constitutes the Multimedia Medical Record (MMR).

In order to get the complete view and control of the patient's data, we employed 3D motion capture visualisation which provides highly precise data of human movement which can be used for empirical analysis and virtual human animation. The prototype system has been developed based on existing 3D gait analysis information provided by our motion capture suite. As currently the system is under development the incorporation of typical EMR data from other software sources have been kept to minimum as we focused mainly on the data representation and preliminary human-computer interface. The musculoskeletal information have been distilled and optimised thought the use of 3D software (Maya Autodesk). The overall data visualisation interface have utilised the Unity3D engine in which we introduced a second layer of motion-capture information which is linked to the patient's skeletal structure. Furthermore transferring patient's data from a randomly distributed form to a more organised centrally managed way of data saving and viewing. To this end we aimed to provide efficient information retrieval, and 3D data visualisation with view to reduce the search and diagnosis time.

5 DISCUSSION

An initial evaluation of the prototype system was performed in a group of ten health professionals through a qualitative method to measure their expectations of having such a system after presenting

Real-Time 3D visualisation of patients gait analysis. The experiment was recording the user responses through a set of questionnaires and was measuring three major aspects, namely: data visualisation, data storage and data manipulation. The experiment took place in the University's Virtual Reality and Simulation Laboratory. The subjective feedback was promising as the vast majority of the users (90%) suggested that the system would be appropriate and desirable for clinical environment as it is very fast, non-intrusive to the existing processes and offers a very clear explanatory data visualisation of patient's gait analysis.

In a similar fashion the users' responded positively on the efficiency of the proposed system regarding the system's ability to improve the gait analysis process in major aspects such as research results, data analysis efficiency, search-time reduction and educational value.

6 CONCLUSION

This paper presents a solution that assists in gait analysis data visualisation which resolves current issues with: medical data fragmentation along multiple repositories, lack of single interface to view or search patients' data, lack of management tools to control the data, and limitations of data view in 2D.

Storing patient's data in a medical record and presenting it in a single interface in 3D, simplifies the process of storing and searching and enhances visualisation of gait analysis data. Preliminary results of user trials are promising with positive used feedback.

Future work will focus on enabling the system to keep up with new developments in the field, optimising the application, simplifying its use and expanding the benefit of its utilisation.

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AUTHOR BIOGRAPHIES

SALSABEEL F. M. ALFALAH received a BSc degree in Computer Information Systems from the University of Jordan in 2007. Upon graduation she completed an MSc in Computer Information Systems from the University of Jordan in 2009. She next worked as a lecturer and research assistant for one year, and she has been granted a scholarship from the University of Jordan to continue her PhD studies in Glasgow Caledonian University she is currently in her second year.

DAVID K HARRISON commenced his career in 1970 as an Apprentice Engineer with Fodens Limited. He went on to complete a BSc (Hons) in Mechanical Engineering. Upon graduation he completed an MSc in Manufacturing Technology. He then joined the Microwave Division of Ferranti Ltd as the Production Engineering Manager. He next received an invitation to undertake a fully funded industry based PhD with SIMON-Vicars Ltd which was concerned with the implementation and optimisation of CADCAM within the company. David gained his PhD in 1986 from the University of Manchester. In 1994 he was promoted to Professor when he joined the Staff of the Department of Engineering at Glasgow Caledonian University. He is particularly associated with postgraduate education and has graduated 43 PhD students and acted as external examiner for over 130 at other UK Universities and internationally in Poland, Germany, China and Mauritius. He is currently Chair of the Higher Degrees Committee at Glasgow Caledonian University. David is the immediate Past President of the Institution of Engineers and Shipbuilders in Scotland, a Fellow of IET, IMechE and a Member of the BCS.

VASSILIS CHARISSIS academic background includes a BSc (Hons) in Technology of Graphics Arts and Mechanical Engineering, an MPhil in Advanced 2D/3D Motion Graphics and Virtual Prototyping and a PhD in Human Machine Interfaces and Head-Up - Display systems, the latter two from the University of Glasgow. He is awarded two patents in automotive design and engineering, regarding novel biomimetic mechanical design for off-road vehicle and he is the recipient of two international first places for prototype design and engineering in the automotive industry competitions for FIAT and Opel respectively. During his career Dr. Charissis has developed prototype vehicles and HCI systems for Alfa Romeo, Lancia, FIAT, Ford US, Suzuki US, Opel, QinetiQ, Thales, NHS, NES and Fisher Defence Submarines, amongst others. His research produced an extensive track record of international scientific publications. Currently Dr. Charissis is a Reader in HCI and director of Virtual Reality and Simulation laboratory (VRS Lab) at Glasgow Caledonian University, Department of Computing, Communications and Interactive Systems. Dr. Charissis is a member of IET, IEEE, ACM, SAE and AAAI.

DOROTHY EVANS is an experienced Project Manager and is qualified at Masters and Doctoral Level in Design Management, which she has in a number of business environments regarding product development, marketing and business development. She has had extensive experience in managing complex product design, multi-technology projects through to successful conclusion. She has experience of creating exhibition and support materials, organizing suppliers and managing clients with regard to staging high quality exhibition and dissemination experiences on a national and international level. She has also been pivotal in establishing and managing a network of Designers and Creative companies across a widespread, geographical region. Her current research activities include establishing a database for the Creative Industries in Scotland, and lecturing at postgraduate level on the MA Design Practice and Management.