Web-based Monitoring System for Home-based Rehabilitation with Stroke Patients

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Abstract

Research on developing low cost home-based rehabilitation systems aim to provide support for the rehabilitation of post stroke patients in the home environment to promote/aid functional recovery and ultimately enhance their quality of life (QoL). A web-based system has been proposed for monitoring the home-based rehabilitation and providing both therapeutic instruction and support information. The system will support specific rehabilitation interventions, provide a three-dimensional (3D) visual output and measure the effectiveness of the resulting actions undertaken by the participant. Information regarding process can be reviewed and accessed by the patient, their carers and health professionals.

1. Introduction

In the United Kingdom (UK), stroke is the largest contributing factor to severe disability, with the majority of cases linked to the elderly population. A quarter of a million people in the UK are living with long-term disability as a result of stroke, significantly affecting their independence and QoL. Current approaches used in hospitals and rehabilitation centres either require access to specialised equipment with dedicated laboratory setup, or rely on clinical observation and patient recall. Due to the cost barrier, inpatient rehabilitation length of stay for patients with stroke has been decreased and outpatient physiotherapy rehabilitation is typically only 2-3 times per week. The National Framework for Older People recommends that rehabilitation should continue until maximum recovery has been achieved [1].

Home-based rehabilitation is a provision of rehabilitation services within the domestic environment. It has the potential to provide support for the rehabilitation of post-stroke patients by accelerating full recovery thus yielding a higher QoL. The introduction of a home-based system comes with added financial benefits by reducing the burden on the National Health Service (NHS). A recent feasibility study has indicated that current technology meets the requirements of the home-based rehabilitation system both technically and financially [2]. At present there is very little feedback on the web based system due to its novel nature and recent introduction.

A web-based monitoring system, a small part of the overall home-based rehabilitation system, is currently in the design phase. This system is responsible for storing rehabilitation instructions, healthcare professionals' comments and the rehabilitation process which includes patient movement data. Those individuals in the rehabilitation chain have access to the system at any time to monitor and maintain the rehabilitation progress. Each healthcare professional will have their access restricted to those patients who fall under their jurisdiction. However

information on a patient's rehabilitation process can be shared among other healthcare professionals if and when required.

2. A home-based rehabilitation system

SMART project is funded by EPSRC EQUAL (enhance QoL) initiative. The project aims to examine the scope, effectiveness and appropriateness of systems to support home-based rehabilitation programmes for the elderly and their carers [3]. The infrastructure is shown in figure 1.

In stroke rehabilitation, patients are required to undertake basic types of exercise to accelerate recovery, these movements although not exclusive include reaching arm, sit to stand and hand to mouth. To collect, analysis and provide the patient with constructive feedback the proposed home-based rehabilitation system consists primarily of three components, a data collection system, a base station and a web based monitoring system.

2.1. Data collection System

The goal of this system is to collect and format three dimensional data relating to the position of a number of markers. These markers are predefined locations on the patient's limb which has been affected by stroke. A portable low cost device based on accelerometer technology has been proposed to achieve this goal and is currently being evaluated against a more robust commercial system namely codamotion. The accelerometer device can support wireless communication to provide an easy method of retrieving data without any obtrusive wires present while the patient is performing a specific rehabilitation task. The device itself measures three dimensional co-ordinates and any acceleration that occurs during the rehabilitation exercise.

2.2. Base station

The base station will be based on a personal computer (PC) with the principal aim of receiving movement data collected by the measurement device within the domestic home environment. The management of the movement data alongside other information will be also performed by the base station which includes the ability to upload/download any data or information to a central resource server.

2.3. Web-monitoring system

Running on a central server the web based monitoring system is initially responsible for the management of all data and information across all patients and rehabilitation experts. Secondly it provides an entry point for healthcare professionals allowing features such as decision support assistance and the opportunity to provide feedback directly to the patient.

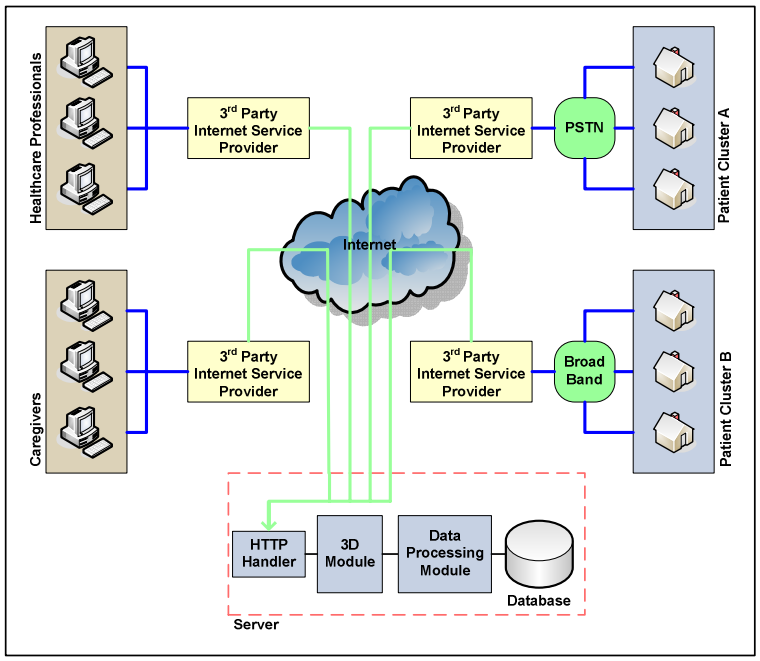

Figure 1. Infrastructure of home-based rehabilitation system

3. Web-based monitoring system

Current development has produced a web-based tool that allows the healthcare professional the ability to view the patient's rehabilitation history and provide feedback to the patient. The monitoring system offers different levels of user access – (1) health care rehabilitation professionals and (2) patients and their carers. The professionals are granted full access to all information/data relating to their patients, those patients who belong to a clinic or hospital not affiliated with the healthcare professional will be inaccessible. The professionals can provide feedback directly relating to a specific rehabilitation exercise carried out by one of his/her patients. Healthcare professionals can communicate with one another in real time through private messaging affording the healthcare professional the opportunity to clarify any issues or gain additional expertise. Patients and their primary caregiver are only granted access to their own data where by they can review the rehabilitation process and their progress by obtaining feedback from a professional.

A screen shot of the monitoring system is illustrated in Figure 2. Information is visualised according to different areas of the web based interface. The area to the left hand side contains a list of patients to whom access is granted along with the entire rehabilitation history shown as individual movement files. A search tool available towards the top of the interface can be used to find patients efficiently. The right side provides a location to display information on the patient's clinical history, rehabilitation instruction and feedback of a rehabilitation movement examined. The centered area holds a representation of a patient's rehabilitation task by rendering it in three dimensions. A toolbar is available to control playback, zoom and pan features with a secondary toolbar providing access to some decision support features. Underneath the center section a small private messaging service is available.

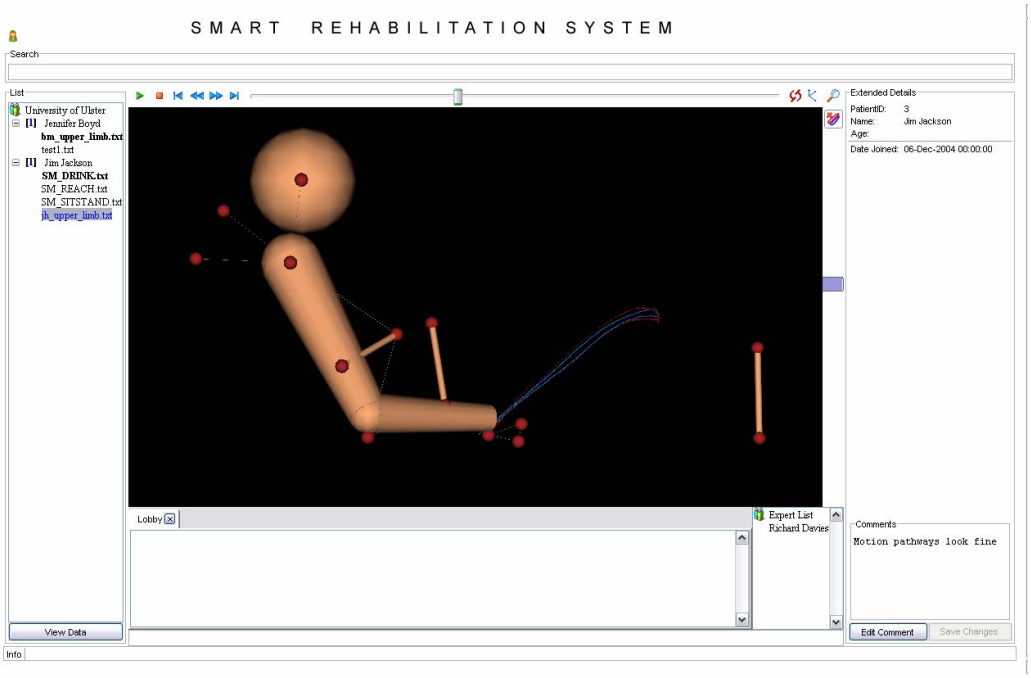

Figure 2. Web-based monitoring system

The system consists primarily of four modules namely a backend database module, decision support module, communication module and a 3D rendering module. Figure 3 illustrates how the four modules are structured together to represent the web based software.

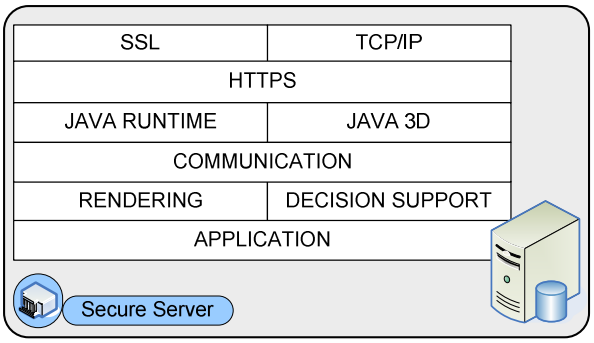

Figure 3. Server software layers

3.1 Database module

The database stores patient's personal information, clinical history, rehabilitation instruction, feedback, and the features extracted from the rehabilitation movement examined and any discussion between professionals will also be stored as a log file. Any editing of information such as the feedback or comments field will automatically lock the database until editing has been completed upon which the database will be unlocked.

3.2 Decision support module

The decision support module provides analysis of kinetics and/or kinematics in relation to a specific rehabilitation task carried out by the patient. Various measurements will be carried out to quantify and assess the rehabilitation process. These include but are not limited to the

distance of reach in the arm reaching task, the pathway of movement and the number of cycles of a particular movement. A comparison of these assessments between two separate tasks performed can be used as a measure of the effectiveness of the rehabilitation and help the professionals adjust the protocol. The private messaging consultancy tool can really be viewed as an extension to the decision support module as it provides the opportunity for a decision support from another professional.

3.3 Communication module

This module provides the necessary underlining functionality to glue the entire system together; this includes obtaining data from a patient's home and reading information from the database. Without this low level module the information would not flow correctly and efficiently between the stakeholders and thus result in a poorly run system. The communication module keeps track of those professionals who are logged in and alerts the private messaging tool so that it may include those professionals in the listings. Any private message sent between professionals is also managed by this module.

3.4 3D movement rendering model

Presenting the rehabilitation exercises in a three dimensional environment provides the opportunity to allow patients to monitor their own progress by reviewing the movements. The patient can adjust his/her movements by comparing their own exercise to a template. This patient empowerment works well for simple and obvious adjustments however for more complex decisions a rehabilitation professional's intervention is needed.

Many of the rehabilitation systems currently available in laboratory environment only provide stick diagram visualisation which can be difficult to interpret. The main aim of developing the three dimensional rendering module is to improve upon the stick diagram easing the level of interpretation.

Figure 2 illustrates a rendition of a reaching task. The data is obtained from a codamotion tracking system available from Charnwood. The reaching arm task involves the patient reaching out for an object which is situated in front of them but is just out of reach.

Markers were placed on the subjects head, neck, shoulder, elbow, wrist and hand with two wands, one on the upper arm and one on the lower arm. The markers are represented by spheres with any limbs shown as conical cylinders producing a more realistic look. The rendering module provides a number of controls to manipulate the data. These include playing, pausing, skipping frame by frame, zooming, panning and viewing the data from different perpectives i.e. axial, coronal and sagittal. In figure 2 the pathway of the wrist marker is calculated using the decision support module and is visualised using a series of thin cylinders.

4. Experimentation and Summary

Using data generated by the codamotion system the rendering module of the SMART rehabilitation system was validated. Firstly the data was rendered using the codamotion system then using the rendered using the SMART rehabilitation system and the two outputs compared. The comparison was made by comparing markers positions in a single frame for both systems.

A second set of data was collected from the proposed home based-rehabilitation device. A single device was placed on the wrist to detect its position with the position of the elbow being computed. This resulted in a simple two column data set and was rendered using the SMART rehabilitation system to ensure that there were no irregularities present. A screen shot of the two markers, wrist and elbow on a single frame is shown in figure 3.

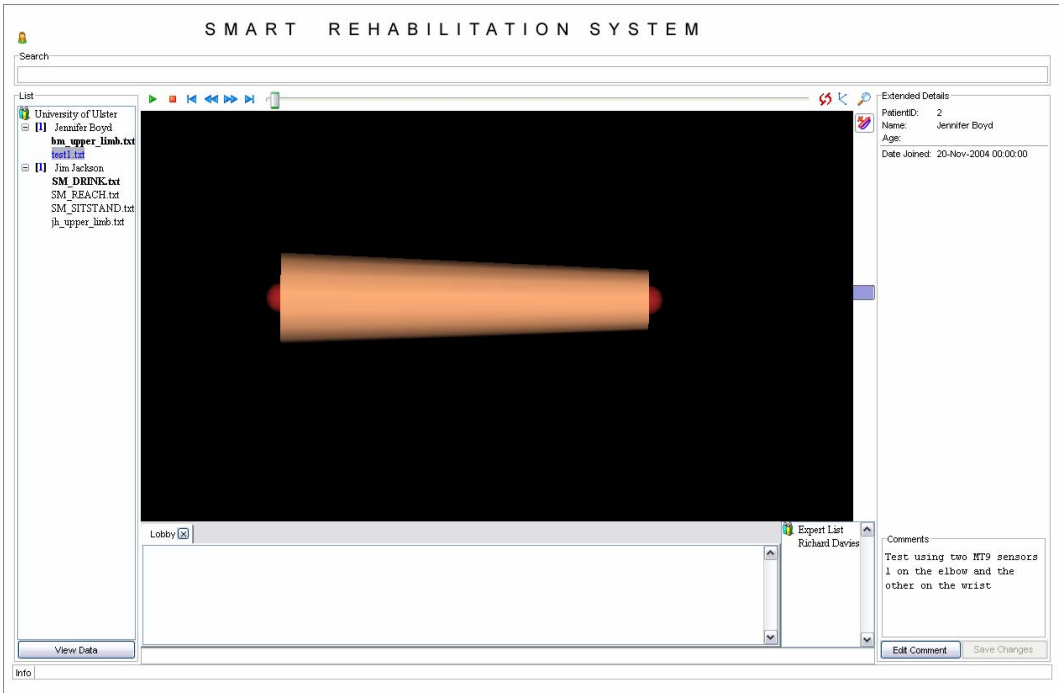

Figure 3. Web based monitoring system showing accelerometer test data

In summary, the web-monitoring provides an important platform in the home based rehabilitation system. Patients and their carers, and rehabilitation professionals can access and review the information regarding rehabilitation process and adjust their movement during rehab. However, the project is still progressing, further work should be carried on the improvement of the 3D render module and the development of decision support module and communication module. The home base station side of monitoring system is current under developing and the clinical trial is due to start in late 2005.

5. Acknowledgments

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6. References

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[3] http://hsc.shu.ac.uk/smart/.