HeartHealth: New Adventures in Serious Gaming *

David Monaghan, Freddie Honohan, Edmond Mitchell and Noel O'Connor
Insight Centre for Data Analytics
Dublin City University, Ireland
david.monaghan@dcu.ie

Anargyros Chatzitofis, Dimitrios Zarpalas and Petros Daras
The Centre for Research and Technology, Hellas
Thessaloniki, Greece
tofis@iti.gr

ABSTRACT

We present a novel, low-cost, interactive, exercise-based rehabilitation system. Our research involves the investigation and development of patient-centric, sensor-based rehabilitation games and surrounding technologies. HeartHealth is designed to provide a safe, personalised and fun exercise environment that could be deployed in any exercise based rehabilitation program. HeartHealth utilises a cloud-based patient information management system built on FIWARE Generic Enablers[1],and motion tracking coupled with our sophisticated motion comparison algorithms. Users can record customised exercises through a *doctors* interface and then play the rehabilitation game where they must perform a sequence of their exercises in order to complete the game scenario. Their exercises are monitored, recorded and compared by our Motion Evaluation software and real-time feedback is than given based on the users performance.

Categories and Subject Descriptors

I.4.5 [**Computing Methodologies**]: Image Processing and Computer Vision—*Reconstruction*

General Terms

Cardiovascular Disease, Rehabilitation, Serious Games

Keywords

Motion capture, 3D Vision, Exercise Rehabilitation.

1. INTRODUCTION

The significant benefits of integrating exercise into rehabilitation are well recognized for a broad range of medical conditions[2]. However, despite the known benefits of exercise, uptake and adherence are very low, especially amongst those with medical conditions such as Cardiovascular disease (under 10% - W.H.O.). Patient adherence to prescribed exercise **is crucial** in both disease prevention and rehabilitation. The development of intuitive, low-cost, personalized home-based exercise monitoring systems can help address these issues by encouraging exercise adherence through a captivating Serious Game that provides real-time feedback.

A Serious Game can be thought of as any game that has been designed for any purpose other than entertainment. Inspired by the success of video games and through their inherent ability to capture and keep a persons attention, serious games have grown into a significant research area [1]. Serious games in rehabilitation have been used for successful balance re-training, rheumatoid arthritis rehabilitation [2], rehabilitation following stroke that often necessitates upper limb rehabilitation [3]. Recently it was reported that the application of home-based exercise programs for cardiac rehabilitation carried the possibility of providing much higher adherence rates [4]. However, to date none of these systems have fully utilised a culmination of captivating story-based scenarios, intuitive human computer interaction and sophisticated motion analysis software present in our system.

2. THE HEARTHEALTH SYSTEM

2.1 Target Population

The target population group for our research are phase 4 cardiovascular disease patients who have been prescribed exercise-based rehabilitation, for which the adherence rates are low. We define Phase 4 of Cardiac Rehabilitation (CR), although the definition varies from country to country, as home or community based CR, in which patients try to sustain long-term behaviour change typically with encouragement by CR staff. Although the HeartHealth project specifically targets individuals at phase 4 CR, current work is being pursued to introduce this technology earlier in the CR process.

2.2 Use Case Scenario

Typically when a clinician sees a patient he/she prescribes a set of CR exercises, however adherence rates remain low for a variety of reasons. Four well recognised reasons are (1) there is no real motivation; exercises may be boring; exercises are not personalised, (2) patients do not train sufficiently or they perform the exercises incorrectly, (3) patients

*The HeartHealth project is supported by the European Commission under contract FP7-604691 FI-STAR.
[1]http://catalogue.fiware.org/enablers
[2]World Health Organization 2011

MM'15, MM'15, October 26-30, 2015, Brisbane, Australia
ACM 978-1-4503-3459-4/15/10
http://dx.doi.org/10.1145/2733373.2807969

Figure 1: Clockwise from the top-left: the login page; the Kinect Scanning screen where the system waits to track a user, allowing for Hands-Free navigation; the patient can select an avatar to use during the game using the timer-hand; the main menu

do not know when they should increase (progress) the degree of exercise difficulty (i.e. frequency, intensity, tempo), and (4) the clinician must rely on the patients honesty and subjective evaluation when evaluating the effectiveness of their CR program design. The HeartHealth system allows clinicians to tailor a personalised CR programme for a patient, based on their individual mobility limitations. The system than empowers the patient to take ownership of their rehabilitation journey by enabling them to keep a rehabilitation diary, recorded automatically in the game, and by providing a fun and personalised game through which they can perform their exercise rehabilitation.

2.3 System Description

HeartHealth utilises open-source computer gaming technology, called the Unity3D game engine, in order to maintain a low-cost prerogative. There are many components within the HeartHealth system but one of the core ones is the Motion Evaluation Specific Enabler (S.E.)[3]. This module was created in-house and hosted on the Fi-Star cloud. It provides highly accurate human motion evaluation by utilising a Dynamic Time Wrapping approach for comparing motion capture skeletal sequences. Our Motion Evaluation S.E. can evaluate and compare skeletal sequences from any motion capture arrangement as long as the sequences are stored in the h-anim[4] motion capture format. The HeartHealth system allows a clinician to record any required exercise motions, which are performed by a patient. These exercises then form the basis of the patients CR and are stored securely online in the patients account and are utilised during the course of game. During the game the patients motions are recorded, via a fusion of data from the Microsoft Kinect V2 and body worn accelerometers, and sent to the evaluation S.E. for comparison. The results are then used to assess the patients progress through his/her rehabilitation journey and are securely stored in their exercise diary for them to review later or for a doctor to remotely analyse. Screen shots of the HeartHealth system can be seen in fig.1 and fig. 2, and user testing with CVD patients can be seen in fig. 3.

[3]http://catalogue.fi-star.eu/enablers/motion-evaluation
[4]www.h-anim.org/

Figure 2: Clockwise from the top-left: the intro information for the warm-up scene; the warm up scene where the patient has to collect the green apples and try to avoid the red apples; the rehabilitation scene where the patient follows the trainer avatar and is given real-time feedback; the practice scene where the patient can practice their personalised exercises

.

Figure 3: User trials of the HeartHealth system at Dublin City University in Ireland and Bagdasar-Arseni Emergency Clinical Hospital in Bucharest

3. DEMONSTRATION

The demonstration will consist of a laptop with a special 3D-screen, or 3D-projector depending on space, coupled with 3D glasses. The heartHealth game will be showcased and users will be shown how to record individualised rehabilitation exercises. Then they can proceed to play through the rehabilitation game from a patients perspective. Users will need to wear the 3D glasses in order to experience the 3D effect. A non-3D version will also be available as will a *local* system in case of internet connectivity issues. A poster detailing the motivations behind and current state of our research on behaviour change coupled with low-cost home-based rehabilitation gaming technologies will also be shown.

4. REFERENCES

[1] P. Rego, et al. Serious games for rehab: A survey and a classification towards a taxonomy, Information Systems and Technologies *IEEE CISTI*, pp. 1-6, 2010.

[2] V. Metsis et al. Computer aided rehab. for patients with rheumatoid arthritis *IEE ICNC*, pp. 97-102, 2013.

[3] G. Alankus et al. Towards customizable games for stroke rehabilitation *SIGCHI*, pp. 2113-2122, 2010.

[4] D. Soares et al. Home-Based Programs and Application of New Technologies in Cardiac Rehabilitation *Int J Phys Med Rehabil*, pp.2, 2013.