Developing serious games for victims of stroke

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ABSTRACT

This study introduces Serious games, which are special games planned within the “StrokeBack” project. The aim of these games is to support the rehabilitation process of stroke patients who have upper limb impairments and damaged psychomotor abilities. In this paper we will present the methodology and ideology of Serious games, and we will prove the importance and necessity of developing such tool.

1. INTRODUCTION

Each year more than 700,000 people in the United States suffer a stroke, making it the third most common cause of death, especially for older people (NINDS, 2011). Incidence in Europe is similar, about 2 million people per year. According to the World Health Organization’s data 15 million people suffer stroke worldwide each year. Although survival rate is improving, 5 million die and another 5 million remain permanently disabled (TISC, 2012). Our societies are facing a growing number of people aged at least 75, many of whom will experience impairment or disability, due to stroke. This older population will rise from 7.5% of the European population in 2003 to 14.4% in 2040, i.e., almost double. Effective rehabilitation is critical to reduce the burden of disability not only on the individuals and their families, but also on society.

Within ‘StrokeBack’, a newly started project funded by the EU, our goal is to improve the quality and rate of stroke recovery. Changes in clinical practice mean that most patients are discharged from hospital within one or two weeks; we are therefore focusing on home-based rehabilitation. There are many advantages to this approach; for example new skills are automatically transferred into daily life, improving motivation and morale. In addition, home-based therapy is less expensive. The architecture and rehabilitation cycle of the StrokeBack project can be seen on Figure 1.

Figure 1: The StrokeBack Rehabilitation Cycle.
Recovery of voluntary motor control is enhanced by many repetitions of functional exercises incorporating fine finger and whole arm movement. The aim of this part of the project is to create games that enable the patient to do these exercises ‘playfully’. The proposed games not only target recovery of sensory motor control, but to improve their logic and thinking abilities too.

We are planning to develop a few types of games, for example, a labyrinth, a free-kick game, a break the bricks game, virtual piano game etc.

2. SERIOUS GAMES

The target public of the Serious games are patients with upper limb impairments, which was caused by stroke. Because the games are controlled with a mobile phone, which the user has to hold in the damaged hand, we must assume that the patient is able to do it.

The planned games are single player games, which the patient can play with by himself/ herself. After installing and setting up the software, the patient can use it alone; the therapist won’t need to assist. This can be very convenient because the user can play at any time, and won’t need to wait for the appointment with the therapist, and this may result that the patient will play more with the games.

2.1 Architecture

The games use the architecture shown on Figure 2. The games run on a PC, which can be controlled with a mobile phone. The mobile phone is connected to the PC with WiFi, and using TCP as a connection protocol. With the phone’s accelerometer and orientation sensor the patient’s movement can be detected. This movement data is processed by the phone, and sent to the PC via WiFi.

![Figure 2: The architecture diagram of Break the Bricks.](image)

2.2 Control

The user can control the games by moving the phone, and these precise arm movements are the rehabilitation exercises. The patient holds the phone in the damaged arm’s hand, and depending on the game he/she controls the game with whole arm movements, or with flicks. The phone will detect the movement of the hand with its built-in sensors, and after processing this and converting to coordinates it sends it to the PC via WiFi. The PC will work this data and adapt it to game movements.

The patient needs concentration and the games are challenging and pleasurable. These attributes combine enjoyment with exercise, enhancing the rehabilitation process. The patient is also motivated by variations in the levels of the game, which can be raised by breaking his or her own high scores. Also an advantage of the game is that it uses the built-in accelerometer of the phone and relies on the patient’s balancing ability, so this capability can also be challenged.

There are many advantages of using a mobile phone with Android operating system. First of all mobile phones and smartphones are now widely used all over the world, so it is very easy to provide (and many of us
already has one). It’s also good to use a phone for controlling if the patient has already used one before the stroke, because it can be difficult to learn the usage of a new device (Charters, 2012a). And on the other hand, smartphones can be used for other rehabilitation purposes, so the patient won’t need to purchase one only for game therapy intention (Charters, 2012b). Another advantage compared to gesture recognition and computer vision controlled systems, where the patient has to stay and move within the range of the device, which can be very frustrating, is that the mobile phone doesn’t have any limitations like this (Rand et al, 2004).

We chose Android OS because it is independent from the mobile phone brands, so the patients won’t be restricted to use a given brand or phone type.

2.3 Development

The games are developed for the Android operating system, because this platform is frequently and widely used among mobile phones and smart phones, making it easily accessible. The mobile phone’s Android application is written in Java. The PC program is written in Qt, which is a C++ based cross-platform framework, so it can be used irrespective of the PC’s operating system or configuration. Qt is also good because it’s widely used, open source and has a great support (Summerfield, 2010).

2.4 Virtual reality

Virtual reality is very important part of the game, but not in the conventional form. The users will see a 3D environment, for example the corridors of a labyrinth, which they can move in virtually, by moving the mobile phone. In this virtual environment, they can play with games, such as a brick breaker game, a memory game, a free-kicker soccer game, or a logical pairing game. During the game, the patient’s movements are detected in 3D by the mobile phone’s built-in sensors, making movements feel more ‘real’. This feeling of reality can also motivate the user of the games to play more, and the more the patient plays, the more exercises are done, and the key of the rehabilitation are these exercises.

On the other hand, the virtual environment can be confusing and hard to understand for some patients. For this reason, we must aim for an easily understandable and usable user interface to unburden the usage of the games. This is also very important because the patient will use the software alone, and he/she needs a user-friendly environment to do this.

The patient’s movement data, high scores, the exercises practiced by the patient, the degree of the recovery and much more data will be stored in a data base. The information following from this huge set of data helps the medical attendants and stroke professionals to improve the rehabilitation process of stroke patients.

3. RESULT

Since our games are only in the developing phase, we didn’t have much opportunity to test the effectiveness of the therapy supported by them. We had some inchoate testing with two stroke patients, to see the usability and intelligibility of the half-ready software. From this experience we got much information regarding the graphical user interface, which helps us to make the games more user-friendly.

Also we searched the related literature to see the impact of rehabilitation with video games, and found that there are some approaches that prove the efficiency of rehabilitation with games. Virtual reality and other video games can significantly improve motor function in stroke patients, according to research from St. Michael's Hospital. Patients who played video games were up to five times more likely to show improvements in arm motor function compared to those who had standard therapy (St. Michael's Hospital, 2011).

4. FUTURE PLANS

After testing the games with a mobile phone, we would like to draw the conclusions, and consider using other controller devices like Microsoft Kinect or sensors attached to the patient’s arm. With these devices, more or rather different type of movements can be detected, so there is a possibility that other type of games will be needed to cover these motions.

Another plan is to make some multiplayer games, where the patient can play with other patients, or with the therapist or a caretaker person. Playing together with someone facing the same problems can be
motivating, and also playing with friends and family is fun and a good opportunity to cheer up and hearten up. For these we plan to use Microsoft Kinect as a controller device.

5. CONCLUSIONS

These games are potentially useful ways to enhance recovery of motor control following stroke, because while playing them, the patients will do small, entertaining, but important exercises. Most people like to play games, so the boring activities can be made entertaining and pleasurable.

Positive outcomes of the participation of people with disabilities in research and development of serious games have been demonstrated (Bühler, 2001; Brown et al, 2010).

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