A thoroughly approach to upper limb rehabilitation using serious games for intensive group physical therapy or individual biofeedback training

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Abstract

Several studies have shown that game-based rehabilitation is a viable option to improve the treatment of patients with physical disabilities. Even though many games are built focusing on rehabilitation, the majority does not present a broad study about the right approach on the many types of existing conditions and also the physiological and medical implications of this games in the patient's treatments. The actual level of integration between Unity and the body-tracking device supported by Microsoft Kinect, has provided a solid tool to build a serious game focusing the rehabilitation paradigm. This work presents the steps and foundation regarding the subject to build a serious game with focus in rehabilitation of the upper limb, more specifically of those patients with hemiplegia or hemiparesis, with the use of biofeedback analysis to evaluate the patient's development. It also shows the possibility of the multiplayer perspective into the rehabilitation treatment to help with the learning phase and bring motivation to the gaming experience.

Keywords: physical rehabilitation, hemiplegia, hemiparesis, long-term care, natural user interfaces, serious games.

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1. Introduction

Hemiplegia is a disorder of the patient's body in which the lateral half your body is paralyzed or partially full. It is usually the result of a stroke, but may also provoke conditions affecting the spine or brain hemispheres. Hemiplegia therefore triggers loss of functional autonomy generated by a dependency on the patient to perform activities of daily life autonomously.

The normal treatment of hemiplegia is limited to periods of heat and cold therapies and electrodes, as well as some medicines. Within some weeks, patients usually present severe neurological sequelae such as motor disorder. It is the most limiting and serious of all types of central nervous system conditions that are known not only for the dramatic effect (e.g. overwhelmingly sequelae) such as cognitive loss, visual loss, speech and hearing, but also severe motion disorders.

The general approach to circumvent such disease is limited by the high disability it generates in the patient. Since it can be a congenital and/or acquired disorder, which is largely affecting the cerebral cortex, little progress can be observed in the short and medium term, even when the patient gets involved in a physical rehabilitation program.

Rehabilitation helps the patient to achieve or regain the capacity that lacks or has lost after an accident, illness or age-related deterioration. The main goal is to give autonomy and quality of life. Physical therapists help these patients and therefore seek and offer all the options available to retrieve their quality of life. Technical aids, from the simplest to the most advanced technology are some of these options. For both activities of daily living such as communication, sport or leisure, the latter is noteworthy today and mainstream as video games.

Physical therapy patients and/or victims of accidents, injuries and spills are submitted for several months to repetitive exercise sessions for rehabilitation, relying almost entirely on aid and monitoring of the physical therapist. The exercises should be monitored and evaluated regularly in order to measure the patient's progress in treatment. The rise of technologies interact with the patient via sensors detect movements of low cost enable the creation of software to support physical therapy.

Natural User Interfaces (NUI) represents a current concept that deals with the interaction between human beings and electronic devices using the five senses. Through the identification of gestures, voice commands, expressions and bodily movements or detection of human body parts such as face, hand or joints, new games have incorporated this technology. Natural interaction has gained popularity with the introduction of gesture-oriented games and exergames. One particular technology that has become a successful NUI device is the Microsoft Kinect[1]. Kinect is a low-cost, consumer-packaged depth camera with integrated skeleton tracking. Depth-camera-based gestures can facilitate interaction with the Internet on keyboard and mouse free and/or multi-user technologies such as lTV sets. Skeleton tracking is the processing of depth image data to establish the positions of various skeleton joints on a human form.

[1] http://www.xbox.com/en-US/KINECT

This work proposes the development of a system to aid the therapist in assessing the quality and efficiency of the treatment and encourages patients through the use of a serious game with emphasis on the characteristics of multiplayer games, which uses quantitative measures to rank results, using existing interfaces for human-computer interaction.

The organization of this paper is as follows. Section II makes a review about the literature that addresses the works regarding the use of natural interface hardware for rehabilitation. Section III presents a introductory review on hemiplegia, hemiparesis and the gaming influence on the matter. Section IV shows the framework and tools used in order to create the game. Section V Expands the concept of Biofeedback and the influence of Mirror-Neuron on the patients recovery. Also explains the influence of the multiplayer perspective on the game and the risks for the patient about the poorly executed gaming. The concluding section quickly exposes the final considerations.

2. Related Work

Games have long been used as a means of health promotion. Gamification, a growing trend in health promotion, is showing that fun, social experiences can dramatically improve and change people's behavior. New, inexpensive, motion-based game technologies such as the Wii and Kinect have enabled new ways of applying games to health.

Health care has also seen some early innovative uses of gamification, leading to the research and design of health games and behavioral health strategies. Many researchers have successfully employed the Kinect to aid in balance rehabilitation and hemiplegia [You et al. 2005; Golomb et al. 2010; Huber et al. 2008; Perry et al. 2011].

Recently, researchers have created tools designed for use by therapists in a variety of settings. A new programming tool called PlayWrite was designed to enable mental health professionals to create social simulations for use in mental health settings [Coyle et al. 2010]. To improve the communication between physical therapists and patients, requirements for an authoring tool to enable therapists to create exercise animations for home viewing were produced [Dodge et al. 2009].

The development of an application targeted to patients with motor disabilities called Kinerehab is described in [11]. It uses the Kinect sensor to evaluate and estimate the biomechanics of fundamental movements. Furthermore, a framework for media adaptation in task-oriented neuromotor rehabilitation based on biofeedback [Huang et al. 2006; Huang 2011].

In this work, the game difficulty is often annotated by physical therapists in the beginning of the therapy session. Thus, when the patient fails to continue to play, engagement in the therapy and motivation to continue decrease. One can mention the lack of techniques allowing the reusability of game elements in the game framework. This is solved by using object oriented techniques as well as software reuse to lower the development costs, while introducing variability in therapeutic activities that can also improve patient's motivation.

3 Hemiplegia, Hemiparesis and Serious Games

3.1 Hemiplegia and Hemiparesis

Hemiplegia is a disorder of the body of the patient when the lateral half of his body is paralyzed; It is usually the result of a stroke, but may also provoke pathologies affecting the spine or brain hemispheres. Cerebral palsy can also affect one hemisphere, resulting in a limitation of functions. This does not necessarily cause paralysis but spasms. Cerebral palsy in which it is also the only symptom may be called hemiplegia [Maggiorini et al. 2012; Marston and Smith 2012].

According to part of the brain is affected, the lesions override motion and sensitivity of the opposite half of the body. Depending on the hemisphere brain affected, besides paralysis are diminished other functions, as hearing, vision, speech and reasoning ability. This disease can affect both sexes at any age, but is more common in the elderly. The most common cause is cerebrovascular accident (arterial thrombosis, or cerebral hemorrhage), which interrupts blood flow in a region of brain, resulting in necrosis or death of brain tissue corresponding to the affected area [Rahman et al. 2013].

Hemiplegia whose development is gradual, may indicate the presence of a brain tumor, for gradually increasing pressure exerted on the cerebral hemisphere where it develops, preventing its function. This injury can be caused by meningitis, severe seizures, causing breathing difficulties, or by head trauma.

The symptoms includes muscle paralysis caused by the inability to control certain muscles of the destroyed area of the brain, although not damaged, become rigid and can atrophy from lack of use. This is what causes the characteristic stiffness, called spasticity. The disease primarily affects voluntary muscles to the involuntary ones.

Hemiplegia has three phases in its evolution:

- Stroke: apoplectic;
- Stabilization: It happens to stroke patients that presents mental, temporal and spatial confusion, and may have aphasia, especially if the lesion is in the left hemisphere of brain (in people who are right-handed, because left-handed have hemispheres reversed).
- Recovery: It is one in which the patient progresses relative to an improvement according to the causative hemiplegia.

Hemiplegia is similar to hemiparesis, but the latter is considered less severe, since its strength is reduced.

3.2 Rehabilitation of the Hemiplegic Patient

Physical therapy is an integral part of the treatment of hemiplegia and it can get many benefits like improving facial appearance, mobility members, facilitating the floor and make the individual more independent in their daily activity. To achieve these goals one can perform various physical therapy techniques, exercise balls, resistance, mirrors, weights, trampolines and all that is necessary to improve the physical and mental capacity of the patient. However, care must be taken in relation to movement restrictions caused by joint and muscle pain related to spasticity and in this case the use of medicines, ultrasound and hot packs or ice. It is important that treatment may be performed continuously and the patient may be often stimulated to prevent muscle contractures.

In addition to the sensory or motor deficit and hemisphere in the patient with hemiplegia usually develops secondary pathological conditions such as shoulder pain, which affects 34 to 85% of hemiplegic patients [Golomb et al. 2010]. The patient's recovery constitutes a great challenge, both for the complexity of the functions lost and the high incidence of shoulder pain, resulting in a negative impact on the rehabilitation process.

This painful condition has diverse etiology that may be associated with subluxation scapulohumeral, shoulder capsulitis, impingement syndrome, complex regional pain syndrome, bicipital tendonitis, neuropathy, brachial plexus traction, spasticity, mobilization of the paralyzed upper limb around the range of motion (ROM) ROM limitation, soft tissue lesions, central pain, or the union of these factors [Wiemeyer and Hardy 2013].

Hemiplegia usually takes a while to recover. There are two facets in treating the condition. Check further progress of underlying condition rehabilitation and control of disability. Hemiplegia is often non-progressive and many available measures make coping with it less stressful to the person affected as well as to health care providers.

This paper addresses the ROM and body positioning. For shoulder disorders, impairments most commonly measured include ROM and positioning. Disability includes activity limitations and participation restrictions that are often best measured by self-report questionnaires. Activity limitations can also be assessed by performance-based tests in the serious game prototype.

3.3 Serious Games in the Rehabilitation Sphere

Games have been a powerful tool for learning behaviors and attitudes necessary for the efficient sociocultural performance. In today's digital society that role is played by video games. Video games provide gamers with abilities and skills and facilitate learning complex processes effectively. In addition, video games have been used to improve the educational processes and training. The group of games designed to meet these objectives referred to as serious games, are used to train personnel in the area of health, security, education, and industry. Serious games that involve interaction and simulation have been designed to aid the recovery of patients with chronic or terminal illnesses.

Among the distinctive features, a serious game may address:

- education, training, and understanding of complex processes;
- some sort of virtual reality. This favors the identification of the player with the area of reality that is being represented in the virtual environment;
- a virtual environment in which you are allowed for a safe practice.

Serious games, that engage users and contribute to achieving well-defined and more significant purposes than pure entertainment, have considerably increased their capabilities in recent years. A serious game is defined as a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives [Wiemeyer and Hardy 2013]. Nowadays the development and use of serious games as part of rehabilitation programs of patients suffering from motor and/or cognitive deficiencies is growing. Results from studies show that patients' motivation when using these game-based tools increases, comparatively with traditional therapy approaches.

Usually it is not easy to challenge patients to train sufficiently, and to keep fulfilling the therapy objectives. Especially when the rehabilitation process is long, hard or boring, many patients loose motivation very fast. By providing treatment in the form of games, therapists can motivate patients much better. The games make the patients forget about the fact they are just getting treatment and give them something to focus on. The games challenge patients to set themselves goals and to work hard to win.

Undergoing rehabilitation through physiotherapy exercises plays a vital role in maintaining and regaining the physical strength of patients who suffer from physical impairments due to accidents or ageing. However, this repetitive and regular process can be boring over a long time and often causes the subject to lose interest in performing the required exercises. The exergaming approach tries to alleviate such problems by integrating physical exercise into a virtual gaming environment. We aim to create an interactive and intelligent rehabilitation exergaming system called RehabMe by exploiting Natural User Interface (NUI) devices such as the Xbox Kinect and openspace3D game engine. RehabMe aims to sustain patients' interest in performing exercises through immersive and interactive gameplays while carrying out an embedded

assessment (of both quantitative and qualitative measures) of rehabilitation progress.

4. The Development Framework

4.1 The Microsoft Kinect

The Kinect is a device for recognizing movements. The device has depth and color cameras, infrared sensor, which is used for motion detection as well as microphones for voice recognition.

It was created by Microsoft partnership with Israeli company PrimeSense, a company dedicated to the development of computer vision and 3D camera technology. Initially created for Microsoft XBOX 360 game console, the Kinect was released together with Microsoft Kinect SDK. The SDK provides the compact set of tools needed to the software development stage on a Microsoft Windows platform.

The Kinect is characterized by the recognition of player's joints. This brings many possibilities for creating different games where there is the need for interaction with controls.

4.2 Unity Game Engine

Graphics engines are very important for the development of games, as they are responsible for organizing and facilitating the game creation process, such as creating objects, terrains and environments, add textures, control physical elements like bumps, wind and water interactions between elements of the games graphics as well as light, shadows and smoke.

During game development, a decision was made to use the Unity 3D engine in connection with Kinect SDK. Unity is a game engine created by Unity Technologies. It is currently used in the creation of 3D games for various platforms such as video games and smartphones. It consists of a developmental editor and design beyond the Monodevelop, a code editor to develop the scripts that are used by the objects of the games.

Another important point of Unity is the level of compatibility with different types of languages and tools allowing developers to choose the ones that will benefit most. Unity works very well with other 3D modeling systems such as Maya, 3ds Max and Blender. The visual interface allows for manipulation of all the elements in a simple and intuitive manner, facilitating the creation of 3D applications.

Furthermore, Unity provides the user with the MonoDevelop IDE development that allows for scripts edition in C # and .NET. Scripts are a feature present in Unity that allows developers to add functions with simple codes to objects present in the scenes of the games. Unity makes use of object orientation, so each object in a scene from the game has its own properties and functions.

4.3 Bring it all Together

The interaction between the Kinect and Unity was made possible through the use of a script developed at the Entertainment Technology Center (ETC) of Carnegie Mellon University. The script comes with a test scene called *KinectSample*. It shows the various features of the plugin as well as a small sample on how to use it with objects in the scene. The script works as a new component added to the *GameObject* in the same way that other control scripts of props used by Unity. Therefore their features are the same. Variables described as public *GameObject* eg *Elbow_Left* or *Elbow_Right* represent joints that are obtained via the Kinect sensor and made available by the plugin. In the Inspector tab in Unity one can click on an added character to the scene, and add *KinectModelControllerV2.cs* *KinectPointController.cs* or script to be able to use the character as a player.

When using the script *KinectModelControllerV2.cs* one can make use of predefined skeletons called *Skinned Mesh* or *Rigged Model* in the 3D character model, which is a digital skeleton attached to a 3D mesh. The *Rigged Model* enables control of the skeleton of a character through a hierarchy that determines the connections between the parts of objects. Using the properties of the characters that have *Skinned Mesh* one can add pre-defined parts of the skeleton to the available joints for the script. This script, therefore, allows for the use of more realistic characters since the limbs and other body parts move correctly according to the player's movement.

The *KinectPointController.cs* the script allows for the use of mapped objects for each joint of the body allowing that other models of games, which do not need 3D characters, can be created. It can also be used in combination to *KinectModelControllerV2.cs* to work in the background and/or simulate collisions of objects with the characters.

The plugin is made up to two active players in the scene. Each character has its own script. In addition, several characters in the scene can be controlled from the same player. Furthermore, one can use such technique to animate the main character altogether with a simpler character, to show biofeedback results.

Moreover, the plugin has much more properties to enhance the adjustment accuracy of the movement and adjusting the position captured by the sensor to avoid errors such as smoothing, correction, prediction, jitter, and maximum deviation radius. All comes with a pre-set value that can be changed accordingly. Another interesting feature is the ability to record the movements made by the script *KinectRecorder.cs* performed during the game at kinect. The recording can later be used to animate characters.

5. The Multiplayer and Biofeedback Into Gaming

5.1 The Multiplayer Dynamic

The multiplayer dynamics is a common but essential feature found in most of the existing gaming platforms that can be easily implemented. Multiplayer approaches vary according to the needs of each game system. For instance, the players do not necessarily influence competition, cooperation or even simultaneous game modes. This is the case of MMO games, where each player can build their individual goals and, at the same time, contribute to the gaming community.

Many experts and game developers found that multiplayer mechanics can increase the engagement and motivation of the players, but empirical evidence is quite limited. While developing the game, one has to take into account the possibility of using various forms of multiplayer structure in order to make it feasible to analyze which multiplayer mode is the best choice in terms of performance and motivation. The goal is to verify whether patients engage more when facing more tasks as long as they get more points [Maggiorini et al. 2012].

According to Peng and Heish[2012], if one of the goals is motivate and engage players, a collaborative approach should be included in the project. Cooperation is one of the most important mechanisms when we want to increase motivation [Vorderer et al. 2003]. Studies show however that the competition can be either positive or negative depending on the focus of the game, such as studies with Wii Fit platform [Song et al. 2010].

5.2 Mirror Neurons

Mirror neurons belong to a class of visuo-motor neurons discovered from studies with monkeys, which are related to mouth movements and hand such as biting, tearing, pinching, catching or grasping objects and activate from the execution or notice of action. Mirror neurons allow for the act of observing the actions of other individuals, simulate what has been observed and put yourself in the position of the individual observed [Rizzolatti and Craighero 2004].

The importance of mirror neurons for this work, lies in the fact that they have demonstrated that the observation of an action of an individual is able to induce activation responsible for the execution of that same action neural circuitry enabling its execution automatically by the observer [Rizzolatti and Craighero 2004; Buccino et al. 2006].

Mirror neurons are of great interest by the physicians and physical therapists that treat patients with motor sequelae of brain damage such as hemiplegia [Buccino et al. 2006]. The sequelae of these patients may be reduced depending on the patient's condition, to some degree, through physical therapy and brain plasticity, which is the property of the nervous system that allows the development of structural changes and adjustments in affected brain regions based on experience and repeating stimulus. In other words, the contrasting brain regions that were affected take over the responsibility, thus creating an alternative to the original problem at hand [Piovesana 1999]. The brain plasticity may be related to neurogenesis that is the process of regeneration of the brain from the creation of new neurons associated with learning [Eriksson et al. 1998].

The molecules from the nervous systems that are called growth factors regulate neurogenesis. In patients with stroke, for example, new neurons migrate from the hippocampus, where they are born, to the region destroyed by lack of oxygen and try to recover it. Just a few manage to migrate, but the settling creates connections with other neurons to restore previously impaired functions [Cameron et al. 1998].

The reorganization promoted by all these changes can be observed clinically in patients, and demonstrate that an individual can recover previously developed skills slowly and gradually through the treatments, but that depends on intensive training, involving a long-term care [Buccino et al. 2006].

Scientists do not yet have the necessary knowledge about neural stem cells and neurogenesis to control the generation of new neurons to recover affected areas. However, the mirror neurons may promote accelerated in the relearning of lost motion process [Buccino et al. 2006].

By using similar characters with human beings on the screen, one can stimulate the coordination of patients as a warm-up for exercise completion. Therefore, keeping two characters in the scene may encourage the patient to see the movements of his own character, or the movements performed by the second character, referring to a physical therapist or to another patient who can perform the proposed exercise as well.

5.3 Biofeedback

Biofeedback is growing rapidly. Treatment with biofeedback allows the person to adjust their habits and reactions from visual or audible signals. This method is commonly used in physical therapy sessions to assess and guide the patient from the return of the information that is obtained through devices and sensors that can measure several physiological processes such as blood pressure, brain activity, heart rate and more. The method can be used for the treatment of various diseases such as, for example, chronic pain, cardiovascular disorders, arthritis and fibrositis [Oonagh et al. 2013].

Biofeedback is divided into some categories related to the type of disease. Dividing therefore in psychological and biomechanical biofeedback [Oonagh et al. 2013]. This paper addresses the biomechanical biofeedback since it can be bound to Kinect sensor.

5.4 Biomechanical biofeedback

The biomechanical biofeedback involves measuring the movement, posture and control forces produced by the body [Oonagh et al. 2013]. The Kinect may represent a reasonable alternative for obtaining data relevant to the analysis due to its ability to map the body's joints up to two players. The camera helps physical therapists to examine quantitatively the movement, which is far beyond the game learning aspects, working as a learning speed-up tool so that the patient can quickly grasp the meaning [Gilmore and Spaulding 2007] Based on these aspects, it was possible to use the Kinect to analyze the optimal position of the upper limbs of the patient through the joints to make the measurement of abduction and adduction as well as extension of flexion.

A small box in the sidebar shows relevant information through a biofeedback character in a skeletonized form, whereby the therapist or the patient can see the results of their movement in real time. Based on this information, both physical therapist and patient can view and analyze the treatment progress, and correct possible errors (movement error or postural deviations ones), which have occurred during the game. Physical therapists can also set dynamic aspects of the game, tailoring according to the levels of the treatment. The small box shows can be programmed to show several variables that may interfere and/or help the therapist along the game.

5.5 Risks Arising From Inadequate or Poorly Executed Exercises

During the development of this work, one of the concerns taken into consideration was the possibility that movements or positions taken by the players could adversely affect the recovery of patients. One of the requirements was to use both arms to achieve the goals, wherever possible. It is well known that the affected limb should also be used to the task at hand. Generally the motion return in the affected upper limbs can be inadequate. Therefore patients may train the affected extremity only as an auxiliary member. Consequently, the game gives patient the choice to use the two members, wich act independently to one another, to reach the goals.

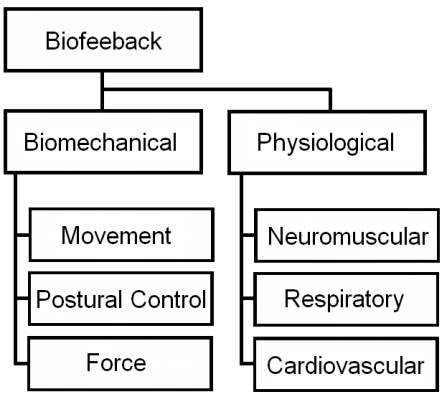

Fig. 1: The biofeedback categories [Oonagh et al. 2013].

It was observed that the proposed exercise did not reinforce the abnormal pattern of the hemiplegic patient, characterized by the impulse of improper bending of the upper limbs as well as the lateral bending of the affected arm that is too close to the body. In order to meet this requirement, the Spawn of Fruits game was designed, while pseudo-random fruits are placed in the tree in accordance with a selected distance. The game alerts the patient when its trunk is too tilted.

5.6 Game Development

For the development of this game, it was necessary a close collaboration with the rehabilitation ward of HUSM-UFSM. Through the careful observation of patients it was possible to understand and to model the routines and acquire the necessary requirements for the game metaphor. The overall objective of this game is to verify the improvement of abduction and adduction of the upper limbs of patients, in addition to analyzing the influence the motivation and the results of the multiplayer modes during the game sections.

We consider the following list of requirements described as important according to the analysis of physical therapists:

- The patient must be recognized as a character in the scene, preferably a humanoid character;
- Objectives need to be easily recognized by the patient, in this case apples are stuck to the tree;
- They need places to store objects, placed on both sides of the patient so that it can work with both arms in order to use the dominant and non-dominant arm;
- The patient must collect objects randomly, so the apples should appear in different places in the tree;
- The room must be large so that there is no interference or impediment of movement;
- Patients need to be placed in a correct position for the system to work as expected;
- The interface should be clean and well structured so that the patient and the physiotherapist can interact with it easily;
- The positions and angles on the body parts of the patient must be shown in the interface so that the therapist can correct the movement if necessary;
- Levels of difficulty may be shown, so physical therapists can adjust the game according to the level of mobility of the patient who is controlling distance between the fruit and the character height of the baskets, play time and speed of onset of fruit;

- The game needs a time counter and a counter of apples collected in order to do the comparison between the players.

A use case scenario for the game is given below.

The game starts with choosing the type of game mode to be used: single player mode and multiplayer mode, allowing collaboration or competition between two patients or a patient and a physical therapist. The duration of the game must be set.

After choosing the game mode, the physical therapist positions the patient properly so that the kinect can calibrate and recognize it. It should be placed in the appropriate distance so that your whole body to appear on the camera screen, which is also shown on the screen for the careful control of the physical therapist.

The patient starts playing the leading arm of humanoid character on screen to reach a fruit in the tree. One should then return the collected fruit to the baskets displayed by the game. The game ends when the time limit is reached. The scores are shown both to the patient and physical therapist that is, the amount of fruit collected during the game, and farthest fruit that was reached.

The physical therapist evaluates, in real time, the proper position of the upper limbs of the patient and angles through the skeleton character shown in the interface. The results of lateral and rotational and (other angles to be defined) abduction is then stored by the system for later review and comparison with results of previous matches.

Fig. 2: A use case scenario for the game created, showing the interaction that occurs when a use case is executed.

The game was developed in such a way as to include scenes, where each scene relates to a game mode. There is also a control panel where the physical therapist can control and set the goals in accordance with the treatment. The game features a single and multiplayer mode. In the single player mode, where the patient plays alone, reaping as much fruits from the tree during a certain period of time. In the multiplayer mode, the goal of the game does not change, but one may choose to have a competitive or collaborative game. In the first scenario, both participants must reap as much fruits as they can get. The winner will be the one who harvests more fruits. The second scenario is a collaborative one, where both participants must reap as much as possible to achieve a target (a selected number of fruits), which might be controlled by the physical therapist.

A main virtual class that holds all the information from menus and results controls the game. It contains the control and options of the game. The *Speed* controls the speed at which apples appear again on the scene. The *Distance Arrow* controls how far the apples on the tree should arise. *Game time* can also be set before the game begins. The *Fruit Size* option was also introduced, allowing visual impaired patients to see the apples. The *Collider* changes its size changes automatically. The *Height* controls the height of the basket to the ground.

The angles shown in the interface are the measures of abduction of the shoulders of the patients. Calculations are made based on the position of the joints. The shoulder angle is measured by the elbow, shoulder and pelvic tilt while the patient is measured by the bowl and neck to the ground.

The player collects the fruits by simply moving his/her hands until it touches the object on the screen. A hand collider performs the detection so fruit coordinates become hand coordinates. Once the fruit is following the character's hand, the player must bring them to the basket where another collider transfers the coordinates to the fruit basket.

Conclusion and Further Work

This paper presents a game prototype created using 3D environments and Natural User Interfaces to help physical therapists with the rehabilitation of patients with hemiplegia and hemiparesis, making use of multiplayer modes to enable the study of the effects and efficiency of such approach. At the same time, displays the relevance and importance about the inclusion of elements that ensure that the patients are performing correctly with no risks to the treatment.

Also shows the use of game engine technologies for the creation of serious games in a 3D environment. The level of integration between the Unity and Kinect through the KinectWrapper plugin made the creation of games easier. The plugin permitted that we created a game following all the requisites collected through the research and instructions of physical therapy professionals that collaborated with the creation of the game. With the level of precision, stability and adjustment presented by the plugin, the biofeedback information displayed in the screen can be adjusted to reach better results in the future.

Further work will include tests and results about the benefits and risks of the use of multiplayer modes in rehabilitation games with the use of natural use interfaces.

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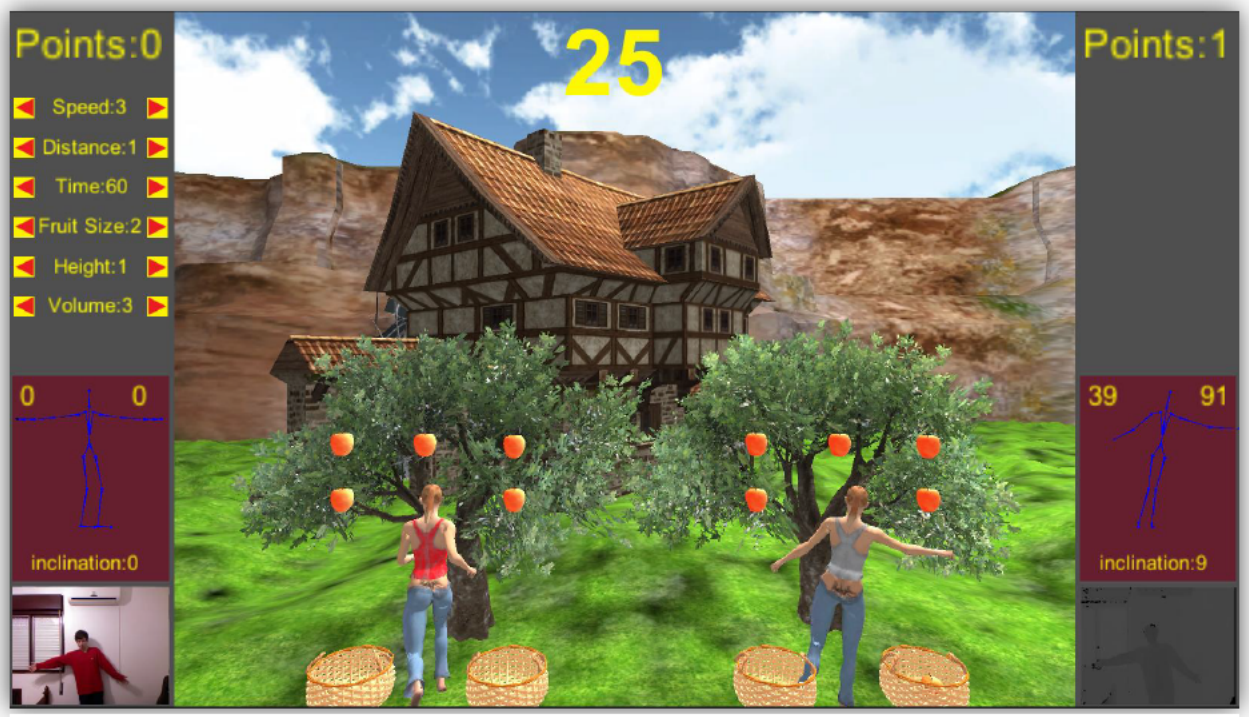

Fig. 3: The image displays the game scenario with the lateral menus that allow the use of biofeedback techniques to adjust the game in real time.

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