A SERIOUS GAME FOR MULTIMODAL TRAINING OF PHYSICIAN NOVICES

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Abstract

Serious games are usually applied to cognitive learning. However, the development of recent Natural User Interfaces (NUI) enables us to use serious games for a more holistic training. This project proposes to implement an educative game that teaches medical students how to carry out a neurological examination. The purpose is to improve not only the cognitive knowledge of the young physicians but also their sensorimotor skills.

The game takes place in a virtual doctor office, which is modelled in 3D. Many possible clinical cases related to different neurologic diseases are simulated. The users are tested at two skill levels. First of all, they have to choose the right exam according to the patient's symptoms. This initial stage is used to assess the theoretical expertise of the students. If the choice is correct, the physical examination begins. In order to evaluate the motor performance, a Kinect NUI is used. Such a device allows for the natural and intuitive control of the doctor's avatar because there is a direct link between the individual's and the avatar's joints. Due to the fact that the real movements of the student are recorded with some accuracy, it is possible to gauge whether or not the medical gesture is properly applied to the virtual patient. In particular, the force and the precision of the movements are measured and compared to reference values.

After each examination immediate feedback is given, so that the learners may rectify their choices and improve the quality of their motor skills at the next training session. Overall, the objective of this software is to enable the future physicians to practice a basic medical exam on a wide scope of neurologic disorders, without any risk for the patients and through an enjoyable approach.

Keywords: Serious games, sensorimotor learning.

1 INTRODUCTION

This paper describes the development of a serious game focused on training medical students to perform some actions from a neurological examination. The main characteristic of the implemented tool is the use of Natural User Interfaces (NUI) to help the player to perform the different actions. The use of this technology is justified by increasing the player's immersion and the movement training. By raising the immersion level, it is expected to get a more effective sensorimotor learning of the examination gestures.

1.1 Neurological Examination

A neurological test is one of the most important examinations in all of clinical medicine. It is performed to localize and identify a lesion in the Central Nervous System (CNS) or Peripheral Nervous System (PNS). Since neurological diseases are characterized by conditions that may be detected only by applying specific examination techniques and logical deduction, considerable insight and experience are required to interpret the symptoms and signs observed during the evaluation [1]. Even with the availability of modern imaging techniques, it remains a critical tool in the clinical decision-making process. For the purpose of simplicity, the neurological examination is divided into several steps which are not always necessarily performed in the same order. These steps are represented in Table 1. The traditional training method of the neurologic exam relies on the application of the various tests on real patients. However, due to the fact that practising this examination on patients is limited and not always possible, the development of a simulation game can facilitate the learning process for students in neurology.

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Table 1 - Neurologic Examination overview.

Mental Status	Cranial Nerve Examination	Motor Examination	Coordination and Gait	Reflex Examination	Sensory Examination
▪ Observation ▪ Attention ▪ Frontal Lobe Function ▪ Memory ▪ Left Hemisphere Function ▪ Right Hemisphere Function	I – Olfactory II – Optic ▪ Visual Fields ▪ Visual Acuity ▪ Fundoscopy III, IV, VI – Ocular Motility V – Trigeminal VII – Facial VIII – Acoustic IX, X – Palate movement XI – Spinal Accessory XII – Hypoglossal (tongue)	▪ Observation ▪ Test for drift ▪ Testing tone ▪ Strength ▪ Finger Tapping	▪ Cerebellar testing ▪ Gait, Station and Romberg testing	▪ Deep Tendon Reflexes ▪ Superficial Reflexes ▪ Pathological Reflexes	▪ Tactile ▪ Painful ▪ Thermal ▪ Postural ▪ Vibratory

1.2 Natural User Interfaces

The latest advances in the development of computer vision, speech and audio processing, along with the development in hardware, like inexpensive cameras and sensors, has led to a growth in the research of more natural and intuitive human computer interactions, known as Natural User Interfaces. These devices enable users to interact with a computer with little to any training, which contribute to an easier and faster learning process of the applications. They usually provide a multimodal interface that allows an interaction through many different inputs such as: speech, gesture and typing, and combine them in multiple ways, increasing the user degree of freedom [2].

One of the most interesting benefits, resulting from the application of motion tracking devices, in games is the improvement of the immersion level of a player, compared to the traditional handheld controllers. Immersion is one of the most powerful experiences of gaming, that even gamers cannot themselves clearly explain. It takes in consideration realism, trough the combination between sound, light, kinematics and other senses. The perfect sensorimotor correlations between the user's avatar and the individual induce a feeling of telepresence into the virtual environment [3]. Since NUI eliminate the input devices by turning the user into one, there is an invisibility of the controls (also, known in ergonomics as control transparency), which is essential for total immersion taking place [4].

The gaming industry became the main backer of the NUI development, and some of the next steps of NUI research are likely to be through gamming applications [5]. The Microsoft approach, with the Kinect, allows people to interact with games with their bodies in a natural way. The Kinect sensor incorporates several advanced sensing hardware, such as, a depth sensor, a colour camera and a four-microphone array, which provides: full-body 3D motion capture, facial recognition and voice recognition capabilities [6].

With its wide availability and low cost, Kinect's impact has extended far beyond the gaming industry and today, many researchers from different areas are leveraging the sensing technology to develop creative new ways to interact with machines and to perform other tasks[1], such as: hand-gesture recognition, body biometrics estimations (e.g. weight, gender, or height), 3D surface reconstruction, and a variety of healthcare applications [6].

1.3 Serious Games in Healthcare Education

Although there is not a clear way for defining the term, a serious game normally refers to applications that combine a utilitarian scenario with an entertaining element that derives directly from videogames.

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[1] More examples at: http://www.kinecthacks.com/ and http://mashable.com/2012/06/29/entrepreneurs-kinect-technology-innovative/

They can also be referred as games that do not have entertainment, enjoyment or fun as their primary purpose [7]. One of the main applications of serious games is education. The use of serious games in this area became common, and nowadays many graduate and post-graduate courses have computerized simulations and serious games deeply integrated into their syllabus [8].

Healthcare is one of the main areas of application of serious games. There are many applications not only for rehabilitation, but also for education and training. Many studies support the application of game-based education on the healthcare area, and some authors say they can be a good support compared with traditional methods and can benefit the advantage of the technology use, to create appropriate environments and to get users to engage in a more rapid therapy [9][10]. Simulation based games for training physician novices present many advantages, such as the enhancement of knowledge, psychomotor skills and decision making [11].

Immersion is also a key variable for the success of a training game. Some authors claim that the immersive experience is a critical element for training in the healthcare area, utilizing serious games. The degree of immersion achieved represents an excellent starting point for serious game design professionals to leverage appropriated methodologies that creates the rich context of realism that serious games aspire to have [12].

2 METHODS

The development of the serious game was made according to the following steps: 1) assessment of the application area of the game; 2) definition of the target audience; 3) game design; 4) implementation of the prototype solution.

2.1 Area of application

The first step of the development consisted in finding a proper area of application for the game, which makes use of the most relevant types of user interfaces for training. The application in medical training was the main goal from the beginning. The neurological assessment was chosen because this physical examination has a comprehensive set of different manoeuvres, which allows not only testing the theoretical knowledge of the student/player, but also his/her motor skills.

2.2 Target Audience

The targeted audience for the developed game are undergraduate medical students, attending a neurology course. The main purpose of this tool is to assist the students to train the practical part of the course.

2.3 Game Design

The game consists in a simulation game, in order to explore the various interfaces and enhance the training success. The game takes place in a 3D virtual medical office (Fig. 1), where a doctor, who represents the player, executes the various actions related to the exam on the patient. The player goal is to perform the exam having immediate feedback that indicates if the gesture was correctly applied.

Each test from the neurologic exam is considered at different level, with different mechanics. The difference in mechanics can be an adaptive perspective, a difference in the player gestures and ultimately a different goal for each level. This distinction of mechanics for the different levels contributes for a higher efficiency of the training, given that each test can have profound differences of goals and execution. When it is possible, the first person view is used to grant a higher level of telepresence for the player.

Figure 1 - Doctor's office overview (in-game).

2.4 Implementation

To test the system dynamics of the game interaction, a prototype of the game was developed. It consists of two complete levels of the game.

2.4.1 Development Tools

The different game elements were modelled using Blender and MakeHuman, two open-source 3D graphics software. During the implementation, it was necessary to achieve a certain level of realism of the game elements, especially the patient model, to make the exams as accurate as possible. To develop the game, it was used the free version of the Unity game engine, which offers a variety of tools to easily develop a game. C# was used for the scripting. The Kinect sensor was integrated by using the MS-SDK Unity wrapper, which can be found on the Unity Asset Store.

2.4.2 System Overview

A Kinect NUI is used as the main interface of the game, but the player can also use the mouse and keyboard to interact with the system (Fig. 2).

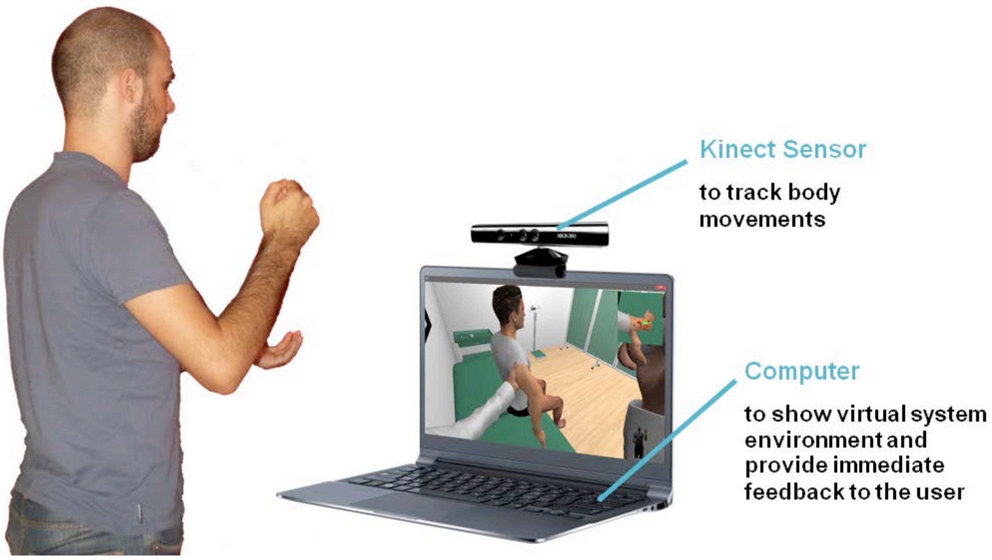

Figure 2 - System Overview.

The use of the Kinect sensor allows a natural and intuitive control of the doctor’s avatar by the player, since both the joint positions of the player and avatar are linked together. The Kinect also enables the system to accurately track the player movements and determine if the player gestures are being correctly applied.

2.4.3 Game Levels

To evaluate the player performance, two different types of errors can be detected while executing the neurological examination: diagnostic errors - in which the player does not detect the patient problem or identify a disease that the patient does not have; and execution errors – in which the player does not execute a manoeuvre as intended. For the prototype, two different levels that fully demonstrate the features of the game were created. One level evaluates the player diagnostic errors while the other evaluates the execution errors.

The first level is based on the Pupillary Reflex and the Ocular Motility assessments and evaluates the student's diagnostic errors. The pupillary responses are tested with a flashlight. The doctor starts by recording the pupil size and shape at rest, and then notes the direct and consensual response of the pupil by swinging the flashlight on each eye. The ocular motility is verified by having the patient look in all directions without moving their head, following the physician's finger (Fig. 3a). The level has two distinct parts, for each assessment. To change between parts, the user only has to hit a button that turns on and off the lights to easily watch the pupillary reflex (Fig. 3b). The player has to detect any anomaly on the eye movement. He/she controls the doctor's finger and flashlight by moving his/her own hand. After the execution of both the assessments, the student has to enter his/her diagnostic. The player's score depends on the number of correct diagnostics.

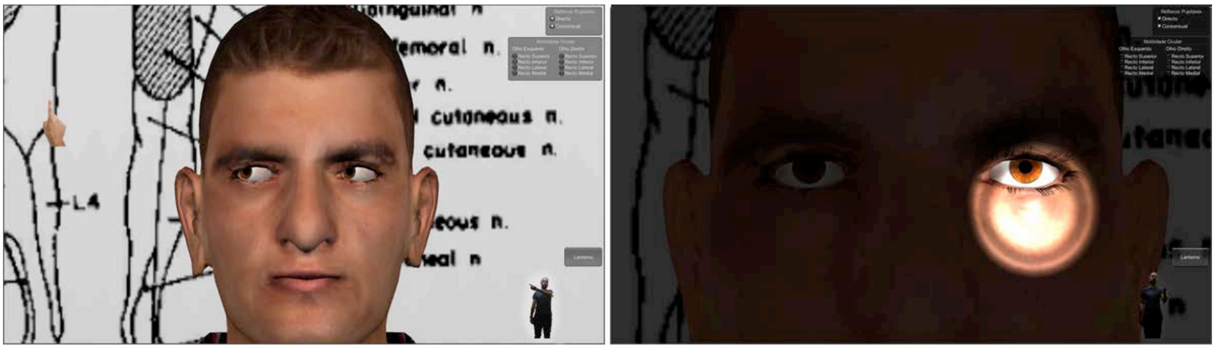

Figure 3 - First prototype level (a) Ocular Motility; (b) Pupillary reflex.

The second level, included on the prototype, aims to test the Deep Tendon Reflexes, and it is used to evaluate the student's gesture execution. On this level, the player has to check the deep tendon reflexes of the patient using impulses from the reflex hammer to stretch the muscle and tendon. Only the stimulation of a limited body area for each reflex can induce its triggering. The user controls the doctor's arms and also where he/she looks, by moving the head (Fig. 4a). He/she has to make the correct gesture to touch the patient with the hammer on the accurate anatomic structure and with the ideal force. In this level, the learner has 15 tries to trigger the patient reflex and the score is calculated depending on the number of times the reflex is triggered. During the test, the player has a real time feedback of the previous hits from a different camera, in a top perspective to give him/her another view of his/her movement. After a successful hit, an animation of the patient's avatar is triggered. When the test is finished, a hit chart is generated for the student to see where he/she hit and with how much force (Fig. 4b).

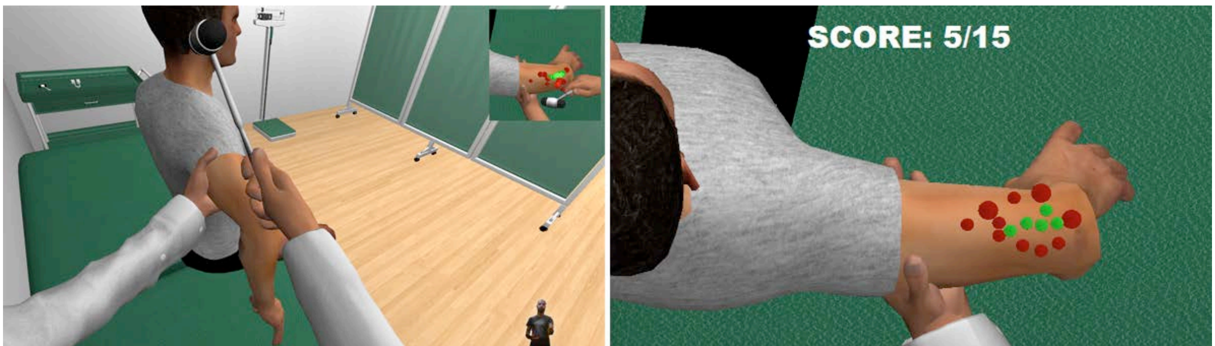

Figure 4 - Deep Tendon Reflex level (a) Overview; (b) Hit Chart.

3 CONCLUSION AND FUTURE WORK

Taking into account the advantages of using NUI in terms of learner immersion, and the effect this variable has on the success in a training game, we presented details on the development of a serious game, which benefits from the use of a multimodal interface to help medical students to perform a neurological examination.

Currently the game is a prototype, consisting of two fully implemented levels that clearly demonstrate the game potential. The existing limitations associated with this prototype are mainly related to hardware constraints, in this case, the Kinect sensor accuracy. With the next generation of the Kinect, about to be released, it will be possible to greatly improve the application.

The next stages of the game development will be the implementation of other levels with different mechanics, and a creation of a central linear narrative using clinical cases connecting all the levels. It is also intended to apply the game on medical students, taking the neurology course, to collect data from the already implemented project and feedback to use in future work.

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