The Videogame Technologies for a Neuroscience Program

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Abstract
In this paper we present the advances corresponding to the implementation of a laboratory of technologies for neuronal rehabilitation using videogames technologies. In this laboratory we develop interactive technologies (videogames, virtual reality material, specialized devices, etc.) to be used and introduced in the Neuroscience bachelor's degree program, which will be offered by Universidad Nacional Autónoma de México in brief.
Some of the projects developed and under development in this laboratory correspond to the bachelor thesis of some computer and electrical engineering students of the Engineering School. In particular, we present videogames based on the Unity game development platform, integrating some devices such as kinect, leap motion, oculus rift, data gloves and others. Some the devices were developed by us, such as a data glove. Additionally we are developing virtual scenes using Google cardboard as material to be used by the students for phobias treatment, considering almost any student has a smartphone.
We can say in this laboratory we have integrated and coordinated a group of engineering students according their skills, which work together making easy the development of their projects that will be employed in the courses of the Neuroscience program.

Keywords: Virtual Reality, Videogames, Interactive Technologies

Introduction

A group of professors, researchers and directives of the Universidad Nacional Autónoma de México (UNAM) have worked in the creation of a bachelor's neurosciences program.

The neuroscience program is an original and novel proposition in Mexico, where are involved different entities such as the Medicine, Psychology and Sciences Schools, the Cell Physiology and Neurobiology Institutes.

The program gives answer to social, economical and cultural questions, related to the actual research and dynamics of the mental health public attention. This bachelor program was previously created in USA and Canada due the necessity of neuroscientists, which have professionally developed in basic, clinic and technological fields.

At present, students who wish to study neuroscience in México invest a lot of time in their training and education, because most of the neuroscientists come from medicine, psychology, biology and biomedicine programs or similar. Once the students have finished the bachelor's program, they begin a doctoral program, and even a postdoctoral stay. At the end, Mexican neuroscientists invest between 10 and 12 years in their training.

The neuroscience program is directed to involve bachelor students in this area, focused in the research and the knowledge of the areas that belong to neurosciences.

The expectation of the neuroscience program is to be as successful as other programs at the UNAM, such as the Basic Biomedical Research Bachelor Program, where 57% of the graduated actually are researchers in Mexico, and the others work in basic research abroad.

The neuroscience program offers an interdisciplinary background in the basic sciences related to neurosciences; the mathematical knowledge necessary to study neural networks, find solutions to different problems, model, obtain quantitative answers to biological, behavioral and neurological phenomena, and also for the interpretation of the research results.

The program also introduces the students, early in their training, in clinic areas related to neurological diseases and addictions, the use of different diagnostic techniques and the employ of information and communication technologies (ICT) for neural rehabilitation. In this way, the graduates of this program could be integrated in multidisciplinary research groups or continue their studies in applied research.

In particular, for the use of ICT, it was necessary to set up a laboratory where these technologies were developed. The laboratory was established in the Cell Physiology Institute and begins to work in 2013.

In this paper we present the advances corresponding to the implementation of this laboratory, where are developed interactive technologies consisted of videogames, virtual reality material, specialized devices, etc.

The Competency-based Neuroscience Program

The Neuroscience program considers five knowledge areas for an integral and interdisciplinary training of the students.

1. Basic Sciences. Provides the concepts and fundaments of neurosciences, strengthen the scientific thinking and encourage the logical reasoning, which allow to understand, from a physical and chemical perspective, the cellular and molecular organization, also the structure and functions of the living beings. Also provides the mathematical knowledge to extrapolate the mathematical thinking to biological problems.

2. Neurobiology. This area provides the knowledge of the central nervous system (CNS) from an integral point of view. Also provides key elements to understand the principal cellular processes linked to the acquisition, storage and recovering of information, just like the most common pathophysiologic processes that affect the CNS.

3. Behavioral Sciences. Provides the knowledge about the relationship between structures, the functioning of the CNS and the cognitive-behavioral processes as the perception, attention, learning, speech, memory and awareness. This area provides tools to analyze the neuronal lesions and their cognitive-behavioral correlation.

4. Humanistic Area. Provides the fundaments for an ethic reflection considering the social, economical, scientific and political everyday changes, which allows the student to develop a creative and reflective thinking and a critical vision of the scientific knowledge and the research when they are carried out in humans and animals.

5. Instrumentation. This field of knowledge provides to the students the skills for mastering the laboratory techniques and to apply the principles of the scientific method in their research. The student will use different instruments such as behavioral tests, electrical activity record of muscles and the central nervous system, and will make its interpretation during the clinic activities. He will be familiar with technological devices through systemic protocols that include the ethical handle of instruments, computational models, materials and reagents. The student will develop the skills to apply and use different techniques and instruments in the search of solutions to neurological problems and he will approach to the translational research.

The interaction of the student with different knowledge areas models its profile as a professional qualified to continue postgraduate studies and strengthen the research in neurosciences, acquiring the desired competences to incorporate in different health groups and the neurological rehabilitation.

The neurosciences program considers three stages:

Basic stage. Corresponds to semesters one to three, where the courses are related to basic sciences, such as mathematics, physics, biology and chemistry, which provide to

the students the fundamental tools in their professional training, and the knowledge that establishes the platform for the analysis and comprehension of the CNS.

Intermediate stage. Corresponds to semesters four to six with courses that offer a panorama of evolutionary neurobiology and development, neuropathology, neuroplasticity, neurobiology of the behavior and addictions, neuropharmacology, neuroimmunoendocrinology, the introduction to neurological rehabilitation, and fundaments of neuroimaging. In this stage, computational modeling and virtual reality for rehabilitation are introduced. The students begin their professional practices being in touch with different aspects of the professional life in real scenarios, including basic, clinic or applied research. If the student focus its practices in basic research, it will be inserted in laboratories of schools and institutes; in case of clinic research, it will attend hospitals and health institutes to make protocols of applied research under the direction of doctors or neuropsychologists; and in the technological case he will be inserted in research centers as the Cell Physiology Institute where the laboratory of technologies for neurorehabilitation was established.

Advanced stage. Corresponds to last two semesters. The activities program includes the continuation of professional practices. The student will decide the optional courses to take for its specialization.

Laboratory of Technologies for Neurorehabilitation

The first scientific works concerning to neurotechnologies were performed 50 years ago, but the most important advances appear until this century. Neurotechnology presents a high potential in the enhance of human activities, involving technologies in areas such as neural rehabilitation, diagnostic and neural monitoring, and other combinations of neurological and biomedical knowledge with engineering technologies.

In 2012 our workgroup begins to explore the advances in the area of interactive technologies for neuronal rehabilitation, and we find a few o them in hospitals where they employed videogames as a reinforcement tool for conventional therapies (see References section). However, such videogames were directed to healthy people and they are not suitable for people with a disability. Actually, we can find projects focused in similar objectives those delimited for our laboratory.

The aim of the laboratory is the development of interactive technologies for the new neuroscience program at UNAM: systems integrating position and motion sensors with computer programs (videogames), some of them connected to Internet, other to be executed stand-alone.

The fast growing of interactive projects for rehabilitation is a sign that we were introducing in a new field of technology development with a promising benefit for patients with some kind of disability. And most important, these technologies can be connected to Internet expanding their application field and services.

We define some lines of technological development to follow in the laboratory: videogames, virtual reality and devices for neurorehabilitation. In videogames development we integrate commercial devices such as leap motion, kinect, infrared

frames and data gloves. In particular, we have developed a data glove based on Arduino because the commercial one does not fit our requirements. In virtual reality projects we are working with the Oculus Rift and Google Cardboard.

The final idea is all software and hardware we develop was available for students of the neuroscience program, in an Internet server of the UNAM or in the laboratory.

Finally, an additional aspect of the laboratory is considered a space attended by engineering students to carry out their bachelor thesis, where always there are interesting topics for them.

The Advances

The first prototypes we have developed using the Unity SDK and other specialized SDK (for leap motion, oculus rift, Google cardboard, etc.) are:

1. Charlie´s escape. This videogame can be used with the leap motion or data glove (commercial or developed by us) devices. There are two rehabilitation positions defined for the hand: open and close. The aim of the game is Charlie walks if the hand is close and jumps if it is open, avoiding some obstacles. The patient must repeat the action (open and close) some previously programmed times, rest some seconds and continue until complete the exercise. Figure 1 presents a screen of the game.

Figure 1: Videogame for hand rehabilitation using leap motion or date gloves.

2. Penal Madness. This videogame is used with the kinect 360 device. There was defined a set of 14 positions for the arm. The aim is the goalkeeper (the user) stops the balls that will go to the targets that are appearing during the exercises. Figure 2 shows a snapshot of the game.

Figure 2: Videogame for arm rehabilitation using kinect 360.

3. The sandwich. This videogame is for hand rehabilitation using a data glove. We consider five position or finger touches. The aim is to prepare a sandwich where each ingredient is selected according the finger that is touching the thumb. Figure 3 shows a snapshot of the game.

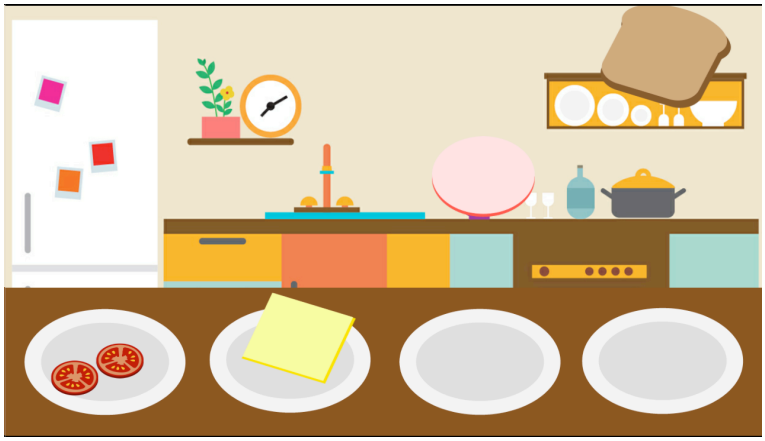

Figure 3: Videogame for hand/fingers rehabilitation using data glove.

4. Dance-arm. This videogame uses the kinect 360. The user must move one of its arms (the one in rehabilitation) from left to right or vice versa and the character, which is dancing, moves according the trajectory of the arm. Figure 4 shows a snapshot of the game.

5. Mexico City Airport. This 3D scenario of the terminal 2 of the Mexico City airport was developed to use with Google cardboard. It is intended for phobia to fly treatments. The user arrives to the terminal and walks inside it until reach its seat in the airplane. Figure 5 shows a view of the airport scenario.

Figure 4: Videogame for arm rehabilitation using the kinect.

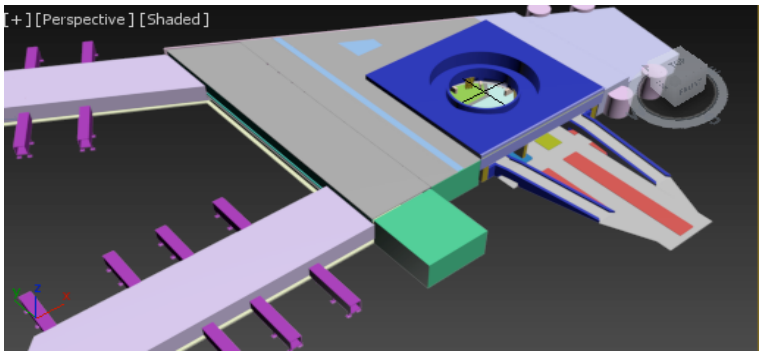

Figure 5: 3D scenario for the Google cardboard.

6. Dataglove for videogames. We developed a data glove for hand and finger rehabilitation. It is based in the arduino nano board, we are including three flexors to detect when the hand is contracting and notify to the patient via the videogame. Figure 6 shows the data glove.

Figure 6: Data glove for neuronal rehabilitation videogames.

7. VR for neurorehabilitation. We developed a VR system for ocular and head/neck rehabilitation that includes three different scenes of a certain size each case. In this system, when the user puts on the Oculus Rift, appears a view with a menu to select the scene to use for the rehabilitation. In case the patient cannot select the scene, other people can help to choose it using the mouse. Figure 7 shows the first scene, which is a planet moving around the space. Previously to start to move, a 3D arrow appears indicating the sense of the movement of the planet. Figure 8 shows the second scene, which is a macaw flying in a jungle. Finally, Figure 9 shows the third scene, a turtle swimming in the sea.

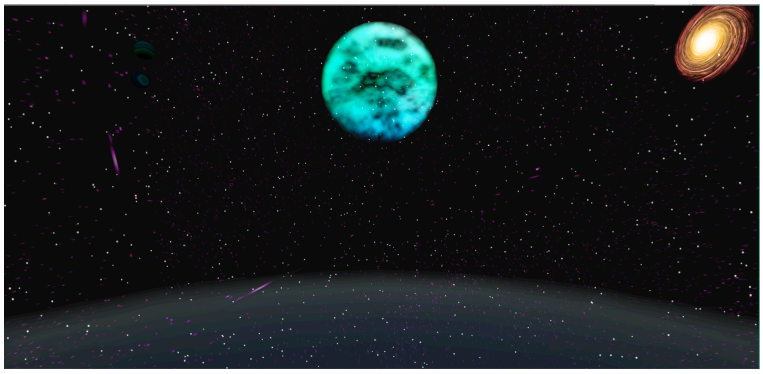

Figure 7: Planet and galaxy scene

Figure 8: Macaw and jungle scene

Figure 9: Turtle and deep-sea scene

This VR system can be employed for gradual motor rehabilitation therapy and it suggests to begin with an ocular rehabilitation, followed by the head/neck recovery and then the arms, hands, and so on.

Conclusions

We have presented the advances corresponding to the interactive materials we have developed in the laboratory of technologies for neurorehabilitation, this laboratory is relatively new and was sited in the Cell Physiology Institute of the UNAM.

The objective of the laboratory is to accept students from a Bachelor's Neuroscience Program, which will be offered by the UNAM. The laboratory. Also, set up a server where most of the materials will be available for students, in special those were there is not necessary a specialized device (i.e. the oculus rift), but a smartphone or non-expensive commercial devices. In this way, the students could uses these materials at classroom or at home depending the course they are taking.

The laboratory also has been a place where engineering students attend to develop their bachelor thesis, receiving the guide and advices of professors and researches of the Institute.

The developed materials are based in Unity SDK to establish a standard for computer programming. When it is necessary, particular devices are developed.

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