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Virtual Centers and Pathways from the Brain and Spine: Immersive Stereoscopic System

Jose Luis Mosso Vazquez[1*] and Angelica Torres Morales[2]

[*1] *School of Medicine, Universidad Panamericana, Mexico*

[2] *Internal Medicine Residency Program, Mount Sinai Medical Center, Florida, USA.*

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ABSTRACT

Objective: Designing virtual centers and pathways of the brain and spine for education.
Methodology: With NVidia software we designed immersive stereoscopic software to navigate in 3D through a virtual brain and spine cords.
Results: 33 centers, 7 pathways and 20 tracts of the central nervous system (CNS) have been developed on a basic model of brain anatomy. A Cyber Brain 3D VR System was designed.
Conclusion: Education is the main objective of this program which will aloud a general understanding of the anatomy and physiology of the CNS. We are proposing for it to be used by medical students as a virtual tool and with patients for a better understanding of clinical explanations. This immersive virtual scenario is available for 3D glasses and potentially for Oculus rift + Touch.

Keywords: Brain, Virtual reality, Virtual simulator

INTRODUCTION

Surgical education

There are two different ways of seeing anatomy; one in the real and one in the virtual world. The first one includes cadaveric and animals dissection, open and endoscopic surgery, endoscopy, and robotic surgery (immersive anatomy with Da Vinci robot). Virtual anatomy includes books, e.g. Ullan, Kierman and Lopez's books [1-3], journals, image in 2D, image in 3D and augmented reality. The way people perceive the anatomy varies depending on the media in which it is displayed. All methods are necessary and at the same time complementary. The ways people learn vary from individual to individual, some learners prefer visual stimuli and feedback controllers as in an open surgery or augmented reality with total immersion in which natural or artificial feedback systems use many senses for learning.

Patient's education

More and more often patients are aware of their conditions and look for different sources to learn more about the, they get information from the internet and they review images, videos and texts about their conditions. With this technology we can facilitate to our patients the understanding of medical condition by showing them virtual scenarios. The information can include the etiology, symptoms, treatments and prognosis of their diseases and would replace the use of posters, magazines, drawings and other 2D media.

There are a lot of brain and spine cord virtual scenarios [4-6], but the particular difference between them and ours is the number of nuclei, and tracts displayed. These characteristics help to understand in. an easier way the neuroanatomy and cranial centers in the brainstem and 13 nuclei of the spine cord and ascending and descending tracts. Our design the neurophysiology, for instance, we included an amygdaline body with 6 nuclei, all hypothalamus nuclei, 12 permits the user to navigate through specific neurological pathways, look inside of the hemispheres and contemplate how the mind works. We are using this software as a complementary tool in the psychological treatment of obese patients [7-9].

Corresponding author: Jose Luis Mosso Vazquez, MD, School of Medicine, Unviersidad Panamericarana, Mexico, E-mail: jmosso@up.edu.mx

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Obesity pathophysiology includes structures such as the hypothalamus, limbic system and prefrontal cortex that affect the hunger and satiety functions.

MATERIALS AND METHODS

The basic model of the brain includes cerebral cortex with hemispheres (frontal, temporal, parietal and occipital lobes), diencephalon, midbrain, pons, cerebellum, brainstem, eyeballs, olfactory, visual nerves and ventricular system (lateral and III-IV ventricles as well as the mesencephalic duct). The NVidia GeForce GT 430 card was used as the platform. The program used to design the structures of the brain was 3D game studio; the virtual models were made on 3D Max. The following structures **(Table 1)** were obtained from 4 Neuroanatomical books.

Table 1. Structures of brain and spinal cord.

Central Nervous System	Structures: Nuclei, Tracts and Fascicles and Pathways.
1. Cerebral cortex	**Hemispheres.** Frontal, parietal, temporal occipital lobes and corpus callosum.
2. Diencephalon	**Intern capsule** **Epithalamus** **Pineal gland** **Thalamus.** Ventral nuclei (Anterior, intermedium, lateral and posterior nuclei), Lateral nuclei (Dorsal and posterior), Medial nuclei (Dorsomedial and medium line nuclei) and intralaminar nuclei, **Hypothalamus.** (Preoptic area, anterior hypothalamic area, supraoptic, paraventricular, dorsomedial, ventromedial, arcuate, tuber, mammillary body, hypothalamic posterior area. **Pituitary gland.** (Neurohypophysis and adenohypophysis). **Amygdaloidal body.** Lateral subnuclei, basolateral, basomedial, basal accessory, cortical, medial, nuclei of stria terminalis, Accumbems nucleus **Ventricles: Lateral, third and mesencephalic duct.**
3. Brainstem	**Reticular Network** Lineal nucleus Cuneiform and pedunculopontine nucleus Dorsal and ventral tegmental nucleus Central and superior nucleus Reticular oral pontine nucleus Reticular tegmental paramedian nucleus Reticular caudal pontine nucleus Pontine raphe nucleus Paramedian reticular nucleus Parvicellular reticular nucleus Raphe magnum nucleus Raphe pale nucleus Gigantocellular reticular nucleus Nucleus dark of the raphe

	Lateral reticular nucleus Ventral reticular nucleus Lateral reticular nucleus **Cranial nerves** O Terminal nerve (Olfactory and nasal vomer nerve) I Olfactory (Anterior olfactory nucleus) II Optic (Ganglion cells of retina) III Oculomotor (Oculomotor nucleus, Edinger-Westphal nucleus) IV Trochlear. (Trochlear nucleus) V Trigeminal. (Principal sensory trigeminal nucleus, spinal trigeminal nucleus, mesencephalic trigeminal nucleus, trigeminal motor nucleus) VI Abducens (Abducens nucleus) VII Facial (Facial nucleus, solitary nucleus, superior salivary nucleus) VIII Vestibulocochlear (Vestibular nuclei, cochlear nuclei) IX Glossopharyngeal (Nucleus ambiguous, inferior salivary nucleus, solitary nucleus) X Vagus (Nucleus ambiguous, dorsal motor vagal nucleus, solitary tract nucleus) XI Spinal accessory (Nucleus ambiguous, spinal accessory nucleus) XII Hypoglossal. (Hypoglossal nucleus) **Cardiorespiratory nuclei.** Apneustic and pneumogastric nucleus (Pon) Cardiac and respiratory nuclei: Dorsal Respiratory Group and Ventral respiratory Group Cephalic nucleus, Botzinger, Pre-Botzinger and caudal nucleus. **Fourth duct.**
4. Cerebellum	Two hemispheres
5 Spinal Cord	**Spine nerves** 8 Cervical nerves 10 Thoracic nerves 5 Lumbar nerves 5 Sacral nerves 3 Coccygeal nerves **Nuclei of spinal nerves** Posterior horn Vertex Nucleus 1 Posteromarginal nucleus Nucleus 2 gelatinous substance Head Nucleus 3 Proper sensory nucleus

	Base
	Nucleus 4 Posterior thoracic nucleus or column of Clarke, intermediate zone
	Nucleus 5 Intermediate lateral (sympathetic and parasympathetic) nuclei
	Nucleus 6 Intermediate medial nucleus
	Nucleus 7 Centralis Substantia intermedia
	Anterior horn
	Medial
	Nucleus 8 Medial posteromedial nucleus
	Nucleus 9 Medial anteromedial nucleus
	Lateral
	Nucleus 10 Anterolateral nucleus
	Nucleus 11 Posterolateral nucleus.
	Nucleus 12 Retroposterolateral nucleus
	Central
	Nucleus 13 Cord, phrenic and lumbosacral nuclei.
	Tracts and fascicules
	Motor and descending (efferent) pathways
	Pyramidal tracts
	Lateral corticospinal tract
	Anterior corticospinal tract
	Extrapyramidal tracts
	Rubrospinal tract
	Reticulospinal tract
	Olivospinal tract
	Vestibulospinal tract
	Sensory and ascending (afferent) pathways
	Dorsal column medial lemniscus system
	Gracilis fasciculus
	Cuneate fasciculus
	Spinocerebellar tract
	Posterior spinocerebellar tract (dorsal)
	Anterior spinocerebellar tract (ventral)
	Anterolateral system
	Lateral spinothalamic tract
	Anterior spinothalamic tract
	Spinal duct.

We used a PC processor with Intel Core i5-760 2.8 GHz, Windows 7 Home Premium de 64 bits. Memory SDRAM DDR3 4 GB, a hard disc 500 GB SATA II 7200 RPM. Logitech LS11 stereo sound 2.0 and a sound card Genius SM-Value 5.1 channel. User can display the images on a screen, wall or use Head Mounted Display eMagin with a Benq 3D active shutter glasses for DLP link ready projector (Projector benq MX710/MX711/MX762ST series, supported timing for HMDI [HDCP] input with 1024 × 768 XGA resolution and 3200 lumens).

There is a virtual keyboard **(Figure 1)** to move the brain on the screen, there are 5 arrows to move up, down, right and left the screen, and another one to zoom in. Six bars to make solid or transparent the following structures: right hemisphere, left hemisphere, corpus callosum, ventricles, diencephalon, midbrain, pons, cerebellum, brainstem, thalamus, cranial nerves, and basal ganglia. Another bars located to the right of the screen permits users to run pathways including the olfactory, visual, limbic, amygdaloid body, accumbens nucleus, prefrontal and limbic, reticular network, pineal, hypothalamus and lateral spinothalamic tract. On any type of display the brain can be seen in colors or only in white, is possible to dissect and disappear superficial structures to recognize deeper ones **(Figure 2 and Table 2)**.

Figure 1. Brain in colors and virtual keyboard on the screen.

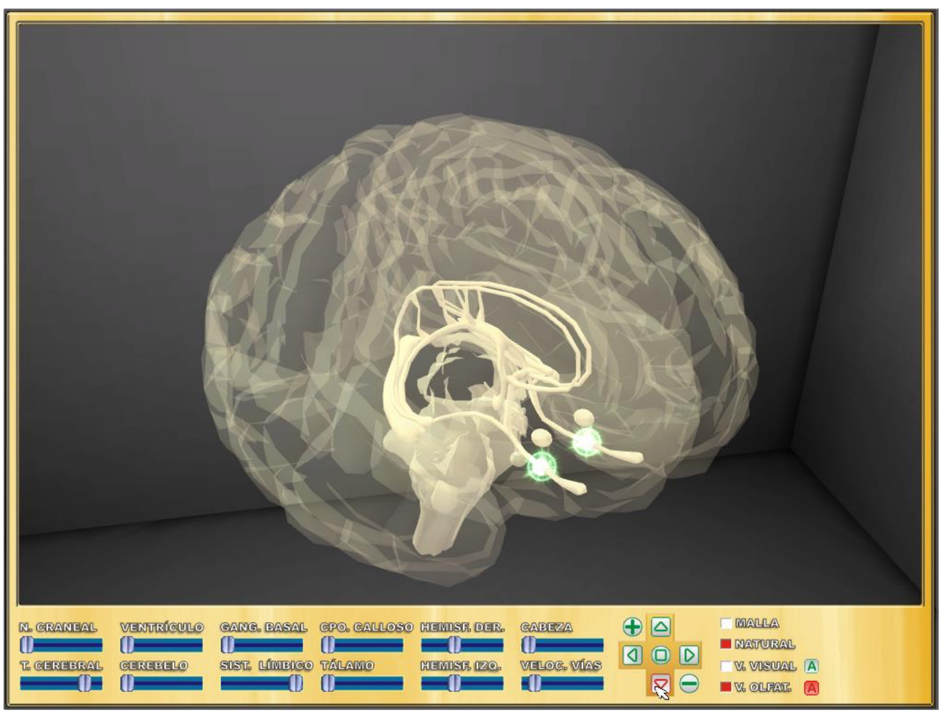

Figure 2. Brain in one color with olfactory pathway simulation.

Table 2. Pathways of the brain and spinal cord.

Central Nervous System	Pathways
	Olfactory
Hunger, appetite, satiety	Visual
Aggressiveness, sex	Amygdaloidal body
Pleasure	Accumbens nucleus
Reason, intelligence, awareness	Prefrontal-limbic
Alert	Reticular network
Circadian cycles	Pineal gland and hypothalamus
	Cardio respiratory circuit

RESULTS

A Cyber brain 3D VR System™ with a turnkey system with stereoscopic 3D visualization software was developed. Software and hardware were created, including a 3D computer, 3D projector, and the 3D glasses. **Table 1** describes the CNS structures represented in the software.

CONCLUSION

Cyber Brain 3D VR System™ includes a turnkey system with stereoscopic 3D visualization software that represents an alternative tool for medical education. However, we can suggest other applications using the system as patient's education. Neuroanatomy is so brad that goes beyond the spectrum of this project but this atlas includes the most important structures in the central nervous system. Is important to notice that anatomy perspective varies among the different authors. We propose to use this system in high school and undergraduate students as a complementary tool to neuroanatomy books, journals, webpages, and videos. In medical school, cadaver dissection facilitates learning in neuroanatomy but remains a tough subject. Our software will help solidifying students' knowledge after dissection. Actually as of today, medical students from Universidad Panamericana, School of Medicine, the top medical school in Mexico, are using this system as a complementary toolkit after cadaveric dissections. As mentioned before, patients can use this system to get a better understanding of their neurological diseases, and can aloud neurosurgeons to teach patients about their surgical procedures. This is a useful tool for psychiatrists and psychologists as well; they can explain to their patients how the mind works, what is the relationship between structures of the brain and their behavior, emotions, intelligence, memory and consciousness. Addictions and obesity are two of the most common diseases that can be explained using out system. For all the above, stereoscopic immersion, animation and simulation make learning easier, funnier and more interesting. A journey through the human brain allows all our senses to be involved in the understanding and learning process [10-18]. In future endeavors, this system could be improved with feedback tools like cyber gloves or Kinect using big screens as virtual cubes for total immersion; oculus rift + touch is the best option up today [19-21].

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