

Teaching Enhancement by Using Simulated Learning Aids: Interactive 3D Animations of the 12 Pairs of Cranial Nerves in the Human Brain

Tsim, K W K¹; Li, W W S²; Chow, C C L³; Tse, C K L⁴;
Lee, H C C⁵; Kei, R T Y⁶ and Tse, M Y Y⁷

¹ botsim@ust.hk

Department of Biology,
The Hong Kong University of Science and Technology

² wanze@ust.hk

³ ctchris@ust.hk

⁴ ctcattse@ust.hk

⁵ ctchiu@ust.hk

⁶ ctross@ust.hk

⁷ ctmay@ust.hk

Center for Enhanced Learning and Teaching,
The Hong Kong University of Science and Technology

ABSTRACT

Teaching neuroanatomy is not an easy task. Students always have difficulty in learning and sometimes they even refuse to take classes that cover brain biology. The major stumbling block in teaching neurobiology more effectively is the complexity of the human nervous system. The brain of a human being, when exposed, looks rather like an enormous walnut; it is made up, like other organs, of cells, and has been mapped in minute detail. The brain is composed of many billions of neurons linked by a unique connectivity; however, the neuronal circuitry within our brain is very abstract, and even some times imaginative.

Here we have developed a series of Simulated Learning Aids (SLAs) that contains mainly visualization and simulations of the neuronal connectivity within the nervous system. Students can look at this neuronal connectivity from different angles, such as dorsal, ventral, caudal and rostral views. These different views are usually difficult to illustrate on paper or via slides that present 2D images, or even using a brain model. By using SLAs containing 3D visualizations and simulated neural pathways, students can visualize the connection of nerves between different targets and, therefore, are able to understand the topology and innervations of this connection. Besides demonstrating the SLAs in classroom, students may also access the program on-line through a WebCT course. The existence of these SLAs thus facilitates both teaching and learning of the topic inside and outside the classroom. In addition, the use of multimedia components as well as 2D and 3D computer graphics in the SLAs in illustrating the functions of neuronal circuits also help students learn neurobiology in a fast and enjoyable way.

The 12 pairs of cranial nerves in the brain stem are used here for illustration. These cranial nerves are very important in controlling the muscles of the face, mouth, eyes and neck, and their neuronal connectivity is a complex one. Using computer graphics, the neuronal connectivity of the cranial nerves is demonstrated from different angles. Additionally, the functional aspects, motor or sensory, of these nerves are illustrated by a uniform storyboard.

Keywords

3D animations, learning aids, cranial nerves, human brain

THE ANATOMICAL STRUCTURE OF THE BRAIN

The brain of a human being, when exposed, looks rather like an enormous walnut; it weighs about three or three and a half pounds and is made up, like other organs, of cells. Unlike a walnut, it has been mapped in minute detail; even the apparently random surface corrugations by which we all recognize the brain have names. The wrinkled outside of the cerebrum (brain) is the cortex (bark) and is divided into gyri (ridges) and sulci (valleys). The small, ridged projection at the back is the cerebellum (little brain). The major components of the brain are nerve cells (neurons), which, unlike other cells in the human body, send out many fibers or perform processes. Some, the dendrites, receive signals from other cells; others, the axons, which usually also branch, are the message senders; they may be as short as a tenth of a millimeter, or as much as a meter long. On average, each neuron is in contact with about 1,000 other nerve cells. The brain itself is made up of about 1,000,000,000,000 (one trillion) nerve cells. A nerve cell passes information along its fibers in the form of electrical signals, but the message passes to the next cell, at a synapse, in chemical form.

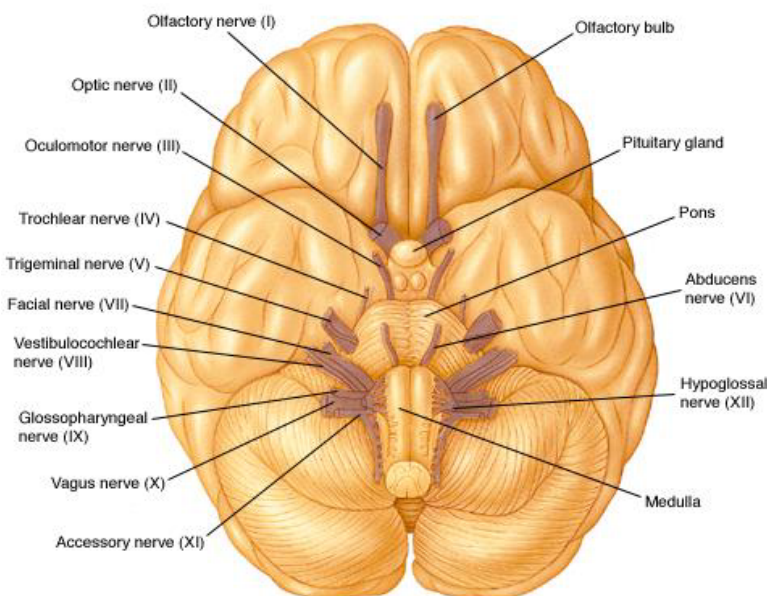


Figure 1. The 12 pairs of cranial nerves of the brain in rostrocaudal sequence

Located in the brain stem, the 12 pairs of cranial nerves are numbered in rostrocaudal sequence (Fig. 1). The cranial nerves have three functions: (1) they provide the motor and general sensory innervation of the skin, muscle, and joints in the head and neck; (2) they mediate vision, hearing, olfaction, and taste; and (3) they carry the parasympathetic innervation of autonomic ganglia that control visceral functions, such as breathing, heart rate, blood pressure, coughing and swallowing. Some of them are purely motor, others purely sensory, and the rest are mixed.

PROBLEMS IN TEACHING BRAIN ANATOMY

In the course BISC 224 Introduction to Neurobiology taught at HKUST, studying neural connectivity is one of the major parts in the syllabus. Although this course has been taught for the last six years, problems in teaching neural connectivity effectively are frequently encountered and present a major obstacle to the effective learning of this subject. The sheer complexity of the anatomical structure of the brain hinders the learning process of the students. Students always have difficulty in learning and sometimes they even refuse to take classes that cover brain biology. The brain is composed of many billions of neurons with unique connectivity among them; however, the neuronal circuitry within the brain is very abstract, and even sometimes imaginative. The only solution to this type of learning process is to ask students to memorize all the facts. In our experience over the last few years, students have never been able to fully understand brain anatomy in its entirety.

VISUALIZATION AND SIMULATIONS OF NEURONAL CONNECTIVITY IN CRANIAL NERVES

A series of Simulated Learning Aids (SLAs) that contains mainly visualization and simulations of neuronal connectivity within the nervous system has been developed. Students can now look at neuronal connectivity from different angles, such as dorsal, ventral, caudal and rostral views. In the initial phase of the study, the 12 pairs of cranial nerves localized in the brain stem have been chosen for demonstration. By using the SLAs that contain 3D visualizations and simulated neural pathways, students can visualize the connections of nerves between different targets and, therefore, they are able to understand the topology and the innervations of these connections. In these 12 pairs of nerves, the originality of the nerve, the activation of the nerve signaling and the targeted sites are presented and illustrated by the 3D visualizations.

The core component of the SLAs is constructed using Flash, which is a versatile authoring tool for creating highly interactive instructional materials. The SLAs are composed of modular reusable blocks. Each block is responsible for storing texts, images or animations. The main interface acts as the container to hold these separated blocks together and present them in a hierarchical structure (Fig. 2).

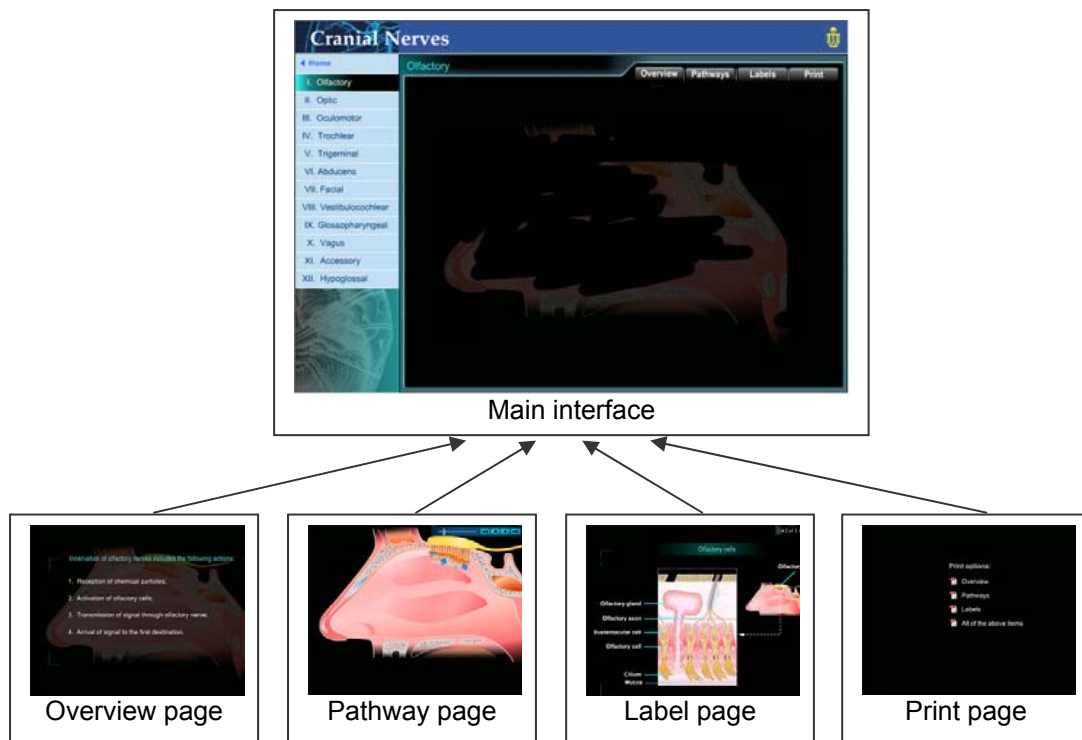


Figure 2. The SLAs are composed of modular blocks responsible for storing texts, images or animations

As regards the graphic design, most artwork is designed using Illustrator and Fireworks. They are converted into vector-based format to reduce the file size. Vector-based format also allows graphics to be resized freely without affecting the original quality. The 2D animations are created in Flash. These animations are generally small in file size and allow user interaction (Fig. 3).

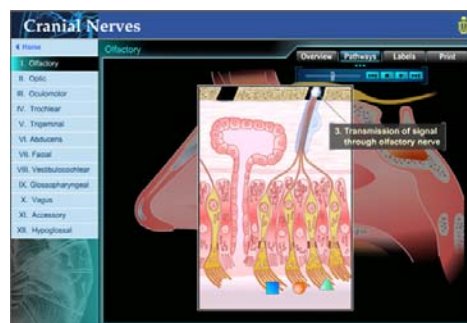


Figure 3. 2D animation of connection of cranial nerves to olfactory bulbs in a pathway page under SLA interface

3D animations are used to illustrate complicated biological structures and sequences. 3D Studio Max is used for the 3D modeling. Texture and light effects are applied to the objects to simulate the real-world counterparts (Fig. 4). Additionally, we have incorporated background music carefully selected to match the interface and animations. SoundForge is used for editing the sound clips.



Figure 4. 3D model illustrating the biological structure of the cerebrum

CONCLUSION

Neural connectivity is very difficult to understand, and is difficult to illustrate on paper or via slides that usually present only 2D images, and even using a brain model. With this new 3D animation program, neurobiology is made much more accessible. Besides demonstrating the SLAs in the classroom, students may also access the program on-line through a WebCT course. The project was started in 2002, and the establishment of the storyboard is now complete. The graphic of the 12 pairs of cranial nerves has been already built. The remaining part of the work is to streamline and fine-tune the presentation. In the summer of 2003, the SLA program was test run by a group of undergraduate students, and the response was very positive. Students like the program, and are now eager to learn more about neuroanatomy.

ACKNOWLEDGMENTS

This work was supported by Teaching Development Grants from UGC of Hong Kong (HKUST-1-E to KWKT)

REFERENCES

- Delcomyn, F. (1998). *Foundations of Neurobiology*. New York: W.H. Freeman and Company
- Kandel, E., Schwartz, J.H. and Jessell, T. (1991). *Principles of Neural Science*. London: Prentice-Hall International Inc.