Quick-Time VR™: when medical education meets virtual reality

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ABSTRACT: Learning medicine is a difficult process to undertake, partially due to the complexity of the subject and limitations of traditional methods of teaching (lectures, textbooks, laboratory and anatomical dissections). These resources have been effective for decades, even though presenting intrinsic drawbacks. Textbooks are non-interactive education tools and do not provide any three dimensional experience. Cadaver dissection is an invaluable aid to learn anatomy. It provides an immersive, interactive experience allied with an inimitable tactile feedback. However, it has several limitations, including availability of specimens, costs and a substantial time commitment. Computer based virtual reality methods may overcome these drawbacks and provide interesting alternatives for medical training. Technological advances have generated great expectations for the use of computer-based virtual reality technologies in medical education, mainly anatomy and surgery. However, these Virtual Reality tools for general medical education are expensive due to the equipment necessary to create highly detailed, immersive three-dimensional image environments with real time friendly user interactivity. The concepts of Virtual Reality methods that generate immersive environments, as well as those that create simulated objects with interactive viewing features may be contemplated by the QuickTime™ which is one of the technologies that can be successfully used for interactive, photorealistic displaying of medical images (radiological, anatomical and histological) and interaction on current generation of personal computers at a low and accessible cost. In this paper, the authors provide an overview of the Quick Time Virtual Reality methods aiming to introduce them to medical educators and illustrate their application on medical training.

KEY WORDS: Anatomy; Dissection; Histology; Education, medical; Radiology; Surgery.

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175

INTRODUCTION

Learning medicine is a difficult process to undertake, partially due to the complexity of the subject and limitations of traditional methods of teaching (lectures, textbooks, laboratory and anatomical dissections)[1,2]. These resources have been effective for decades, even though presenting intrinsic drawbacks. Textbooks are non-interactive education tools and do not provide any three dimensional (3D) experience[3]. Cadaver dissection is an invaluable aid to learn anatomy. It provides an immersive, interactive 3D experience allied with an inimitable tactile feedback. However, it has several limitations, including availability of specimens, costs and a substantial time commitment. As consequence, cadaver dissection represents a small portion of the time dedicated to global medical education[2].

Technological advances have generated great expectations for the use of computer-based virtual reality (VR) technologies in medical education, mainly anatomy and surgery[1-7]. However, these VR tools for general medical education are expensive due to the equipment necessary to create highly detailed, immersive 3D image environments with real time friendly user interactivity[1]. The concepts of Virtual Reality[8,9], methods that generate immersive environments, as well as those that create simulated objects with interactive viewing features may be contemplated by the QuickTime™ VR technology[10]. Quick Time VR (QTVR) is one of the technologies that can be successfully used for interactive, photorealistic displaying of medical images (radiological, anatomical and histological) and interaction on current generation of personal computers at a low and accessible cost[1-3,6,7]. However, most of medical educators are not familiar with QTVR methods.

OBJECTIVE

The objective of this paper is to provide an overview on these methods, introduce them to medical educators and illustrate their use on medical training.

Defining QuickTime™ And QuickTime VR

QuickTime™ (QT) is a standard set of operating system-level graphics, audio, and digital video extensions developed by Apple Computer. First released in 1992 for the Macintosh operating system, QT 1.0 primarily emphasized the handling of usual, time-based "linear" digital video and audio[1,10].

Linear video is conceptually similar to a regular movie, as classically conceived: a sequential, time-based sequence of single image frames. Linear videos play back frames at a constant pace starting with the first image finishing with the last. When a video is played back, central visual mechanisms, described physiologically as persistence of vision, permit the viewer to realize movement within the sequentially displayed frames, generating a sensation of continuity. However, one of the disadvantages of linear movies is that they do not deliver interactivity[1,10].

Conversely, nonlinear video is a subset of movie that allows the viewer to play back videos in a randomized and interactive way. The images may be displayed depending on the user commands and not obligatory in a linear manner, i.e. from the first (beginning) to the last frame[1,2,7]. These capabilities permit interactivity as the user may entirely manipulate the movie contents, regardless the sequence of the frames[10].

In the non-linear mode instead of playing back at a defined frame rate, users may actively control which frame of a QTVR will be displayed at a specific time. Using the personal computer mouse input, students can look into a panoramic view or to rotate a highly detailed anatomical object. Since are non linear contents, QTVR contents provide indiscriminate access control over the fourth dimension, time, in visualizing medical images[1-3,7,10].

Panoramas and objects

In the QTVR platform, movies may be displayed in two different patterns: panorama and object movies [1]. The panorama movie allowed users to pan the virtual view as much as 360° in an interactive approach usually employed to viewing landscapes, structural interiors, and modeled environments (Figure 1)[1-3,7].
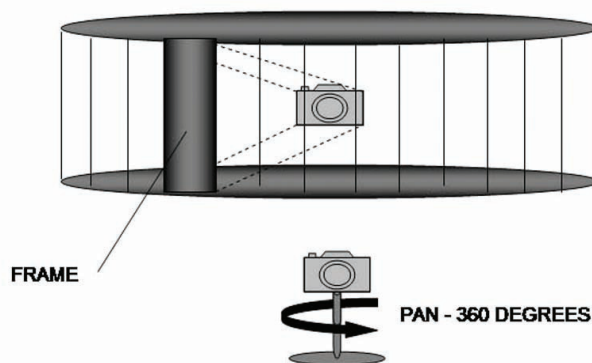

FIGURE 1. QuickTime VR panorama movie. In this type of movie, the camera spins on its own axis. Picture are taken at predefined angles, so that the entire panorama view is scanned. Each frame is displayed in a non-linear fashion. This method is well suited to simulate endoscopic procedures or depicting histological slices

In this mode, the camera spins in its own axis displaying the surrounding environment. When applied to medical education, it is well suited to visualize the interior of organic cavities in different angles and perspectives and may be used to simulate endoscopic procedures.

Conversely, the object movie allows users to appreciate 3D objects from all angles, in two different axes: vertical and horizontal (Figure 2). The camera orbits the object and rotates in predefined angles surrounding it. Then the object is the centre and it is visualized from several perspectives (Figure 2). Congruent with the format of QTVR videos, panorama and object movies are composed of a set of individual image frames, but played in a non-linear fashion[10].
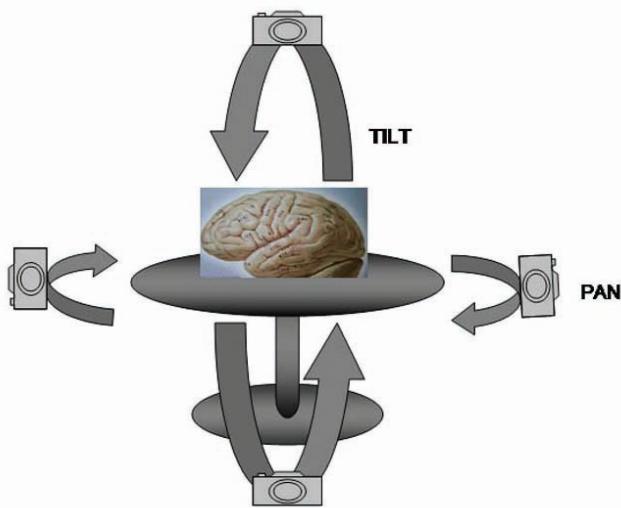

FIGURE 2. QuickTime VR object movie. The camera rotates around the anatomical specimen which is displayed under several perspectives, In this method, camera moves in two different axes: horizontal (pan) and vertical (tilt) in predefined angles. It is adequate technique to demonstrate intrinsic anatomical relationships

Each instance of a simple movie is called a node. Scenes, or complex movies, are constructed of one or more different nodes and other content. Scenes may be composed of a different combination of QTVR objects, panoramas, linear movies, still pictures, and even audio tracks. Transiting among scenes is possible by clicking defined points called "hotspots" that serve as QTVR positional information[1].

A panorama node may be visualized as cylindrical image with the viewer's perspective located in the nodal point (center) (Figure 1). The viewpoint can be panned to the left or right, to under and above (tilt). In a complete panorama, the viewpoint can be panned through 360° (Figure 1). It is also possible to construct partial panoramas that allow less than 360° of rotation, depending upon the educator purposes[1].

In a standard panorama, the source pictures are taken at regular intervals (e.g., every 5° or 10°) as the camera rotates around its nodal point 1. Pictures are taken and are next digitally processed. Several different compression/decompression algorithms are available, including TIFF, JPEG, Motion JPEG, and MPEG. Even though QT contents can be saved without compression, their playback is usually very slow or jerky even on the fastest computers, due to the large amount of data associated with each video frame[1-3].

In the QTVR object movie, an object (e.g., an anatomical specimen) is held and rotated in space around in vertical and horizontal axes, so that the object under study can be rotated and tilted (Figure 2)[1-3]. These movements on the computer display are controlled by the user clicking down the mouse button and dragging horizontally or via a vertical click and drag. These features are appropriate for depicting structural details of anatomical specimens from almost every perspective. The student may virtually manipulate the specimen and appreciate the anatomical relationships.

QTVR object can also be used to show other properties of a specimen, including time-based changes such as intrinsic movement or levels of dissection. Another different type of object might have an automatic display of a set of image section frames (with no horizontal dragging allowed) while vertical dragging moves deeper the plane of the section. QTVR object may be also applied to interact with radiological exams, mainly magnetic resonance images.

Requirements for QuickTime and QTVR

In general, QT and QTVR will run on players with a minimum 150 MHz (or better) Pentium-class PC and on 90 MHz Macintosh Power PC machines. However, the best performance may only be obtained on systems running faster than a 266 MHz Pentium or 233 MHz PowerMac[1].

After images are obtained, panoramas, objects, and scenes can produced using inexpensive widely available QTVR authoring programs, including Apple QTVR Authoring Studio (QTVR AS), VRToolbox, Inc., and Picture Works. Alternatively, Corel Photo-Paint for the Macintosh is another bitmap graphics editor with automatic image merging features that can be used to create panoramas in QTVR movie format.

Medical application examples

1. Virtual interactive histology

Partial QTVR panoramas could be used to simulate the interactivity of a light microscope slide[1]. Sequential images are captured as the microscope moves in vertical steps in order to allow proper panning on playback (Figure 3). Thus, medical students may interact with the entire histological information as if they were examining the real specimens. Hotspots may be additionally employed to change magnification, augmenting interactivity and immersion. Students and trainees may access the entire histological database from their personal computer, at home!
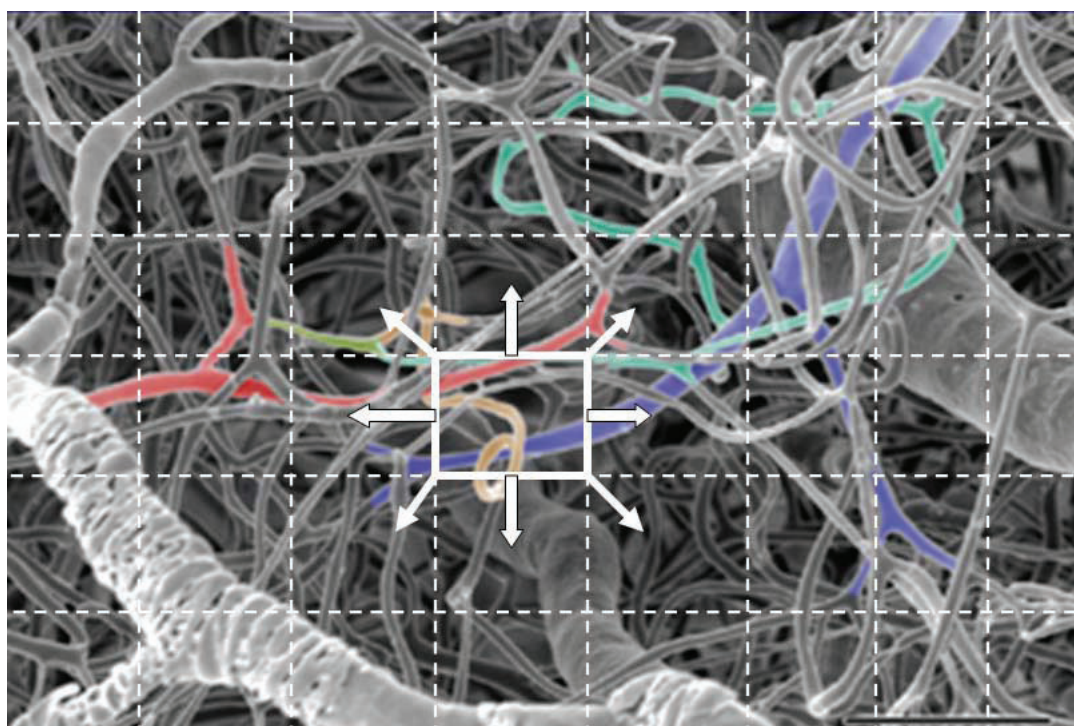

FIGURE 3. Electron microscopic photography of cerebral vasculature. Pictures are taken from different sections and each frame is considered to be an individual micrsoscopic view. Adjacent views are accessed by a simple movement of the mouse computer (arrows), simulating the movement of the microscope

Electron microscopes are expensive instruments that require training to use and mostly are unavailable for direct use by students willing to intimately explore cells. Students must learn to recognize and to understand a wide range of tissues, cells, and subcellular structures across the range of magnification. QTVR movies are resources capable of presenting cell biological structures in a way emulating a real microscope, including access to intermediary levels of magnification (Figure 2). In using QTVR, the technical knowledge necessary to handle an electron microscope is replaced by simple click of the mouse bottom[1]. Hotspots and labeling may be additionally used to improve interactivity and information.

2. Virtual anatomy

Teachers and students have long understood the usefulness of an interactive atlas and the visual and tactile experience in the real dissection laboratory[1-3,6,7,11-14]. The QTVR object format provides a practical means of simulating handling 3D anatomical specimens. Object movies offer a compelling experience in settings where real specimens are unavailable or unpractical[1-3].

Anatomical specimens may be mounted on a turntable and an object movie is obtained. Anatomic structures are then appreciated from several perspectives and anatomical relationships may be studied[15-21]. Additionally, the different steps of dissection may be displayed utilizing hotspots, from surface to the interior. Hence not only the anatomy can be revealed, but an entire virtual dissection can virtually take place on a desktop as homework. Additionally, this methodology may be employed not only for teaching but also for testing student's learning.

3. Radiological application

Magnetic resonance image (MRI) is most

frequently used to make static image sections of the body. MRI-based QTVR object movies may be very useful in assisting students to understand 3D relations and to appreciate otherwise unvisualizable dynamic changes associated with bodily functions. If an image array from an MRI scan is placed in a QTVR object a new type of visualization is generated. The object is turned into a slice (section), which can be moved around. The user is able to move the slice back and forward, directly showing relationships between sections (Figure 4). Additionally, MRI sections may interact with anatomical specimens, evidencing anatomical relationships between sections and allowing structures to be followed. Instructors can animate otherwise inanimate MRI sections and interact among axial, coronal and sagital views, allowing better appreciation of radiological features and anatomical relationships (Figure 4).
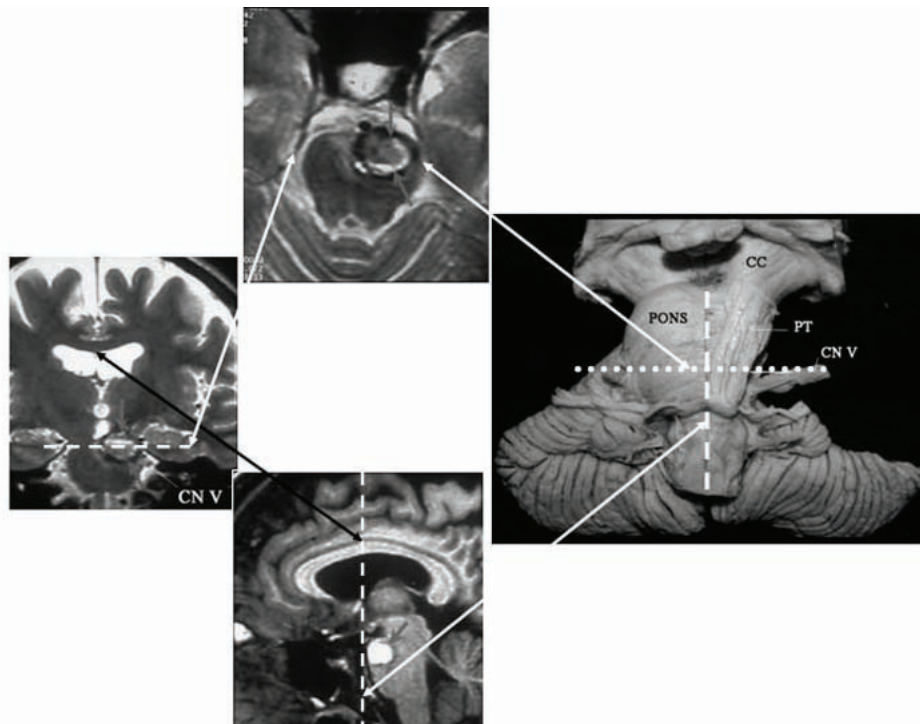

FIGURE 4. Magnetic resonance sections (axial, coronal and sagital views) of the brainstem. By clicking a predefined axis (see line) in one section the view in the other plane may be readily accessed and interact with each other (arrows). Additionally, a brainstem specimen is used to better illustrate the anatomical relationships

CONCLUSION

Medical education is evolving to a new era. Anatomic, histological and radiological specimens may be expensive to afford. Even though valuable, laboratory is difficult to maintain and massive students attendance may be unpractical. Virtual realities technologies may in some ways replace these traditional resources of learning and provide interesting alternatives, either for learning or reinforcing knowledge. Inexpensive, useful and novel visualizations can be easily created with QTVR methods in a personal computer environment. Their use should be divulgated and stimulated among medical institutions.

REFERENCES

1.   Trelease RB, Nieder GI, Dorup J, Hansen MS. Going virtual with QuickTime VR: new methods and standardized tools for interactive dynamic visualization of anatomical structures. Anat Rec, Part B, New Anat. 2000; 261:64-77.

2.   Henn JS, Lemole GM, Ferreira MAT, Gonzáles LF, Schornak M, Preul MC et al. Interactive stereoscopic virtual reality: a new tool for neurosurgical education technical note. J Neurosurg. 2002;96(1):144-9.

3.   Balogh AA, Preul MC, László K, Schornak M,

Hickman M, Deshmukh P, et al. Multilayer image grid reconstruction technology: four-dimensional interactive image reconstruction of microsurgical neuroanatomic dissections. J Neurosurg. 2006;58(2 Suppl):157-65.

4. Dunkley P. Virtual reality in medical training. Lancet. 1994;343(8907):1218.

5. Bernardo A, Preul MC, Zabramski JM, Spetzler RF. A three-dimensional interactive virtual dissection model to simulate transpetrous surgical avenues. Neurosurgery. 2003;52(3):499-505; discussion 5004-5.

6. Gorman PJ, Meier AH, Rawn C, Krummel TM. The future of medical education is no longer blood and guts, it is bits and byts. Am J Surg. 2000;180(5):353-6.

7. Nieder GL, Scott JN, Anderson MD. Using Quick Time virtual reality objects in computer-assisted instruction of gross anatomy: yorick-the VR Skull. Clin Anat. 2000;13(40):287-93.

8. Machado LS. Conceitos básicos da realidade virtual [monografia]. São José dos Campos: Instituto Nacional de Pesquisas Espaciais; 1995 [citado em jan. 2009]. Disponível em: http://www.lsi.usp.br/~liliane/conceito-srv.html

9. Pimentel K, Teixeira K. Virtual reality: through the new looking glass. 2nd ed. New York: McGraw-Hill; 1995.

10. Apple Developer Connection. QuickTime: Leopard guides [online]. 2009 [cited 2009 Jan]. Available from: http://developer.apple.com/documentation/Quick-Time/.

11. A.D.A.M. Interactive Atlas. [CD-ROM]. Jaipur: Techno Softwares; 2004.

12. Chao LW, Böhm GM. Projeto Homem Virtual [online]. 2003 [citado em jan. 2009]. Disponível em: http://www.projetohomemvirtual.com.br

13. Monteiro BS, Milane CO, Valdek ILL, Cunha, RMM, Machado LS. Anatomi 3D: um atlas digital baseado em realidade virtual para ensino de medicina [online].

[2006] [citado jan. 2009]. Disponível em: http://www.di.ufpb.br/liliane/publicacoes/2006_svr1.pdf.

14. Machado LS, Campos SF, Cunha, ILL, Moraes RM. Cybermed: realidade virtual para ensino médico. IF-MBE Proc. 2004;5(1):573-6.

15. Figueiredo EG, Deshmukh P, Zabramski JM, Preul MC, Crawford NR, Siwanuwatn R, et al. Quantitative anatomic study of three surgical approaches to the anterior communicating artery complex. Neurosurgery. 2005;56(2 Suppl):397-405; discussion 397-405.

16. Figueiredo EG, Zabramski JM, Deshmukh P, Crawford NR, Spetzler RF, Preul MC. Comparative analysis of anterior petrosectomy and transcavernous approaches to retrosellar and upper clival basilar artery aneurysms. Neurosurgery. 2006;58(1 Suppl):ONS13-21; discussion ONS13-21.

17. Siwanuwatn R, Deshmukh P, Figueiredo EG, Crawford NR, Spetzler RF, Preul MC. Quantitative analysis of the working area and angle of attack for the retrosigmoid, combined petrosal, and transcochlear approaches to the petroclival region. J Neurosurg. 2006;104(1):137-42.

18. Deshmukh VR, Figueiredo EG, Deshmukh P, Crawford NR, Preul MC, Spetzler RF. Quantification and comparison of telovelar and transvermian approaches to the fourth ventricle. Neurosurgery. 2006;58(4 Suppl 2):ONS-202-6; discussion ONS-206-7.

19. Figueiredo EG, Zabramski JM, Deshmukh P, Crawford NR, Preul MC, Spetzler RF. Anatomical and quantitative description of the transcavernous approach to interpeduncular and prepontine cisterns. Technical note. J Neurosurg. 2006;104(6):957-64.

20. Figueiredo EG, Deshmukh P, Zabramski JM, Preul MC, Crawford NR, Spetzler RF. The pterional-trans-sylvian approach: an analytical study. Neurosurgery. 2006;59(4 Suppl 2):ONS263-9; discussion ONS269.

21. Figueiredo EG, Deshmukh P, Zabramski JM, Preul MC, Crawford NR, Spetzler RF. The pterional-trans-sylvian approach: an analytical study. Neurosurgery. 2008;62(6 Suppl 3):1361-7.