Three-dimensional digital projection in neurosurgical education: technical note

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Three-dimensional images have become an important tool in teaching surgical anatomy, and its didactic power is enhanced when combined with 3D surgical images and videos. This paper describes the method used by the last author (G.C.R.) since 2002 to project 3D anatomical and surgical images using a computer source. Projecting 3D images requires the superposition of 2 similar but slightly different images of the same object. The set of images, one mimicking the view of the left eye and the other mimicking the view of the right eye, constitute the stereoscopic pair and can be processed using anaglyphic or horizontal-vertical polarization of light for individual use or presentation to larger audiences. Classically, 3D projection could be obtained by using a double set of slides, projected through 2 slide projectors, each of them equipped with complementary filters, shooting over a medium that keeps light polarized (a silver screen) and having the audience wear appropriate glasses. More recently, a digital method of 3D projection has been perfected. In this method, a personal computer is used as the source of the images, which are arranged in a Microsoft PowerPoint presentation. A beam splitter device is used to connect the computer source to 2 digital, portable projectors. Filters, a silver screen, and glasses are used, similar to the classic method. Among other advantages, this method brings flexibility to 3D presentations by allowing the combination of 3D anatomical and surgical still images and videos. It eliminates the need for using film and film developing, lowering the costs of the process. In using small, powerful digital projectors, this method substitutes for the previous technology, without incurring a loss of quality, and enhances portability.

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KEY WORDS anatomy; 3D imaging; digital projection; education

THREE-DIMENSIONAL images of complex anatomical sites aid in the accurate understanding of depth during surgical procedures and have become an important tool in teaching surgical anatomy. The didactic power of a 3D presentation is enhanced when anatomical images are combined with still surgical images and videos. This paper describes the method used by the last author (G.C.R.) since 2002 to project 3D anatomical and surgical images using a computer source.

Methods

Three-dimensional digital projection involves the use of a personal computer with a dual core configuration, 4

MB of RAM or higher, or a similar Apple computer unit, running Microsoft PowerPoint 2007 or similar software, a beam splitter (Matrox DualHead 2Go, Dual Analogic Edition, Matrox Graphics Inc.), 2 digital projectors (InFocus digital projectors, Model LP70+), polarizing or anaglyphic filters (Cokin s.a.s.u.), a screen painted with aluminum (silver screen, Da-Lite Co.), and polarizing or anaglyphic glasses (Fig. 1). If images were processed using the anaglyphic method,³ complementary-color anaglyphic filters and glasses must be used. If horizontal-vertical polarization of light⁶ is chosen, horizontal-vertical filters, polarizing glasses, and a silver screen are needed. For details on 3D image acquisition, refer to previous publications of this group.^{3,6}

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FIG. 1. Photographs of the setup for digital 3D presentation. The setup for polarized 3D digital presentation involves a computer and beam splitter (A), 2 digital projectors and filters (B), a silver screen (C), and 3D glasses (D). The projector to the right side is hooked to the number 1 connection in the beam splitter box, while the projector to the left side is hooked to the number 2 connection. The beam splitter is hooked to the computer using the USB port and the RGB cable. Figure is available in color online only.

Results

Data Presentation

Anatomical and surgical stereopairs are arranged in Microsoft PowerPoint (2007 version or later) or similar presentation. The slide configuration is set to landscape, with a width of 54.1 cm and a height of 20.3 cm. The right and left images are mounted in a way to fill the slide on each side of midline and arranged in a crossing-eye disposition.⁶ The crossing-eye disposition involves placing the right image of the stereopair on the left of the screen, and the left image on the right. This type of mounting is preferred because it allows for direct viewing and mounting adjustment with no special optical aid, just by performing stereopsis. During stereopair mounting, strict attention must be paid to keeping the horizontal adjustment between the 2 pictures. This allows for comfortable viewing of the images and videos. Text and effects can also be used. They must be paired using the same criteria described above and care must be exercised when timing the effects, as they must appear simultaneously. Horizontal and vertical alignment must be adjusted at the beginning of each presentation. By starting each presentation with a pair of target slides—which consist of images displaying a series of horizontal, vertical, oblique, and curved lines—careful overlapping is always obtained. This step guarantees the stereoscopic effect during actual presentation.

Setup of the Computer and Projectors

The projectors are set up vertically or horizontally on a stable base. The setting is started with the computer switched off and the projectors should be the first units to be switched on. When using crossing-eye mounting, the projector to the right side is hooked to the number 1 con-

nection on the beam splitter box, while the projector to the left side is hooked to the number 2 connection. The beam splitter is hooked to the computer using the USB port and the RGB cable; then the computer is turned on. This allows for automatic recognition of the beam splitter device once it has been installed and correctly sets the video configurations accordingly. This precaution saves time and is especially recommended during a series of consecutive presentations.

This automatic configuration sets monitor 1 at a resolution of 1024×786 , and monitor 2 is set to overlap at a resolution of 2048×786 . The presentation is then opened on the target slides, adjusting the focus of each projector, and then the lines and circles horizontally and vertically are adjusted to achieve exact overlap. Filter adjustment is performed as previously described.^{3,6}

Discussion

As surgery is performed through natural spaces or by enlarging virtual spaces existing between structures, the ideal method to teach and learn surgical anatomy involves a 3D understanding of these anatomical relationships. Three-dimensional images provide for better anatomical illustration, improve 3D comprehension, enhance an individual's familiarity with three-dimensionality itself, and favor spatially related abilities. Such qualities are basic requirements for correct neuroimaging interpretation and proper microsurgical and endoscopic surgical orientation.

Virtual environments for planning, training, and performing surgery,^{1,2,4,5,7} which are being developed through telesurgical systems, also require stereoscopic visualization and familiarity with 3D conceptualization and 3D stereoscopy. Contrary to so-called 3D computer-generated images, displayed on 2D surfaces, in which depth perception is acquired by perspective-enhancing methods and monocular clues, 3D stereoscopic images provide a real depth perception that directly mimic human vision.

Classically, 3D projection has been conducted over the years by using a double set of slides, projected through 2 slide projectors, each of them equipped with complementary filters, shooting over a medium that keeps light polarized (a silver screen), and having the audience wear appropriate glasses (Fig. 2). This paper details a method for 3D projection that involves digital dual projection, performed from a notebook computer with the aid of software that sends each image of the stereopair to a different projector, through 2 different computer video outputs (Fig. 3). This technique has been perfected and has been in use by the authors since 2002.

When compared with the traditional method using dual chromo-slide projection used by many groups in neurosurgery for more than 15 years (Fig. 2), this method presents several advantages. The possibility of using digital images avoids all the difficulties and limitations of slide mounting, and optimizes image manipulation and projection with a similar, but digital, setup. Three-dimensional anatomical and surgical still images can be combined with surgical videos, text, diagrams, and special effects, greatly enhancing the didactic power of this tool. Rearranging presentations, not using (but not excluding) slides,

FIG. 2. Photographs of a traditional 3D presentation using slide projectors. A 3D microsurgical anatomy course in Peru in 1999 is shown (A) using the traditional method of 3D presentation with slide projectors. In this method, largely used by many groups in neurosurgery for more than 15 years, 2 similar slide projectors (inset) were stacked in a vertical mounting apparatus (B). Copyright Sociedad Peruana de Neurocirugía (Peruvian Society of Neurosurgery). Published with permission. C: A silver screen, polarizing filters, and glasses were needed. Figure is available in color online only.

and storing several presentations in a compact, highly portable media are also possible. Portability is enhanced by using small, powerful digital projectors, which also result in much brighter presentations.

A different approach to separate left from right images has been developed (Omega Optical Inc.). Instead of polarization, this system uses color bandpass filtering (“wavelength multiplexing”). Each projector is equipped with a filter that passes 5 narrow band wavelengths of light spread across the optical spectrum and the exact wavelength of these narrow bands is offset between the right and left filters. The viewers use passive 3D glasses with filter lenses matching the filters. This system preserves image color and brightness, has a high extinction level (no “ghosting”), and does not require a silver screen.³ Silver screens are also dismissed when dealing with “active glasses.” These glasses are provided with shutters that rapidly alternate between the left and right images. Three-dimensional presentations using a combination of active glasses and computer monitors are becoming a common didactic tool for individual or small groups in many centers.

Although the technique of building such 3D digital presentations can be time-consuming and digital image quality is still lacking when compared with chromo-slides, practice with the method and the advances of digital technology will soon make up for these shortcomings. On the other hand, expenses with film and film developing as well as the difficulties faced nowadays in finding parts and

FIG. 3. Building and presenting a digital polarized 3D presentation. The process can be divided into 2 stages: 1) image production and 2) image presentation. In the image production stage, anatomical and surgical stereopairs are arranged in a PowerPoint presentation. The slide configuration is set to landscape, with a width of 54.1 cm and a height of 20.3 cm. The right and left images are mounted to fill the slide on each side of midline and arranged in crossing-eye disposition by placing the right image of the stereopair on the left of the screen, and the left image on the right. During stereopair mounting, strict attention must be paid to horizontal adjustment. In the image presentation stage, the setting is started with the computer switched off. The projector to the right side is hooked to the number 1 connection in the beam splitter box, while the projector to the left side is hooked to the number 2 connection. The beam splitter is hooked to the computer using the USB port and the RGB cable; then the computer is turned on. This automatic configuration sets monitor 1 at a resolution of 1024 × 786, and monitor 2 is set to overlap at a resolution of 2048 × 786. The presentation is then opened on the target slides as horizontal and vertical alignment must be adjusted at the beginning of each presentation to attain exact overlap. Filters are adjusted and glasses are worn during presentation. Figure is available in color online only.

replacements for traditional slides projectors make this method a viable substitute for a technology that has faded.

Conclusions

Three-dimensional digital projection as explained in this paper presents several advantages over traditional methods of 3D projection. It is a suitable method for neurosurgical education.

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Author Contributions

Conception and design: all authors. Acquisition of data: Martins, E Ribas, G Ribas. Analysis and interpretation of data: Martins, E Ribas, G Ribas. Drafting the article: Martins, G Ribas. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Martins. Study supervision: Rhoton, G Ribas.

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