Stereoscopic Visualization of Scientific and Medical Content

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1. Introduction

As we enter a more sophisticated world, it is apparent that many students today are faced with increasingly complex subjects. How best to inform these students is a challenge for educators. One approach we have taken to engage students is to present materials on a stereoscopic display system. With this system, we are able to describe complex concepts of health and science in a more visually appealing manner. We have adapted commercially available hardware and software, and developed a production pipeline that caters to stereo movie production. These movies form the cornerstone of a curriculum that appeals to student's natural curiosity more than traditional teaching methods with similar content.

2. Composition

The complex terms and concepts associated with the subjects of health and science intimidate many students. Learning health and science for the typical student is often not fun, and teaching these subjects can be frustrating. Many students are intimidated by the complicated terms and concepts. Over the years, educators have searched for different mechanisms that will make these subjects more appealing for students. The world of science lends itself to technologies that will help describe complex functions and often indescribable interactions to those who wish to be enlightened on such subjects. To this end, our experience echoes the cliché: "a picture is worth a thousand words." Indeed, artistic illustrations, visualizations, and computer generated animation have played a significant role in helping both professional scientists and novice science students to understand all disciplines of science. The development and use of the stereoscopic display system now provides us with yet another medium in which to present our visions of science.

The rich visuals and immersive environment of stereoscopic displays allows students the opportunity to perceive the complex content in a way that engages the student more fully. It is our mission to help students learn by bridging the gap between artist and scientist, and delivering a learning experience that is both scientifically accurate and artistically appealing to the student. We hope that learning using stereoscopic display introduces a "wow factor" that helps students assimilate information at a higher rate than traditional learning.

The stereoscopic display medium is now in use at the Ruth Lilly Health Education Center (RLHEC) (Peebles) in Indianapolis, Indiana where it helps to educate over 80,000 students annually. One of the theaters at the center has been outfitted with a permanent stereoscopic installation that allows students the opportunity to view selected pieces of curriculum in stereo. The stereoscopic display is helping to revolutionize traditionally difficult subject matter for students K-12. Content created by the research team at the IUPUI School of Informatics has been implemented to fit into the curriculum of the RLHEC.

The stereoscopic computer generated content that has been created for the RLHEC, includes subjects such as "The Cell," "The Circulatory System," "The Nervous System," "The Immune System," "The Respiratory System" and "What is Cancer?" These custom animations are produced under the direction of the center's curriculum committee and designed specifically to be integrated into the RLHEC's programs. A large part of our mission is to develop a story and not to just show the science without a good narrative.

Computer generated content created for other clients utilizing the stereoscopic technology has been used to educate audiences on subjects such as the simulation of hip and knee replacement surgery, the effects of diabetic retinopathy, and simulations of real world data of biological macro-molecules. These programs have been especially significant to specific audiences since the subjects did not have traditional learning media associated with them or were particularly difficult subjects to comprehend. The stereoscopic programs created were instrumental in allowing audiences the chance to discover these new subjects in a manner that allowed them a unique learning experience.

In addition to stereoscopic computer generated animations, stereo video footage has been produced of "Total Knee Replacement Surgery." This intricate and complex surgery is performed thousands of times a year around the world, yet learning the procedure is a time consuming and difficult process. Recording the surgeries with high definition cameras in a stereo configuration and using a customized post-production pipeline allows us to create a piece of high quality and unique medical educational material that provides surgeons a detailed movie of the exacting surgical procedure.

3. Methods

The content of a movie is established through traditional production meetings with the clients in which their needs are determined. In the case of the Ruth Lilly Health Education Center, the production team from the School of Informatics meets with the curriculum committee to determine the subject, the audience, the length of the program, and any special considerations. Pre-production consists of thorough research on the subject using traditional textbooks, journals, and internet resources. On many scientific subjects, a vast and sometimes conflicting quantity of views and information are available. Thus, it is often necessary to not only conduct extensive research, but to have that final information to be checked for accuracy by an expert scientist or review panel in the subject area. A preliminary script is written and approved by the client. Often the script needs to be changed to age appropriate language by the RLHEC so that the narrative content speaks directly to the target audience. Storyboards of the visual content are prepared from the approved script and then approved by the client. Pre-visualization then commences on the project. Using Alias Maya, models are created, animated, textured, and lighting and other effects are provided. Low resolution renderings or playblasts are created to show the animation along with high resolution stills. These are put into an animatic with scratch narration to synchronize the entire movie. This low resolution animatic is then submitted to the client. Upon final approval of the animatic pre-visualization by the client, production rendering begins.

To create computer generated animations, we have been using Alias Maya to create the frames. All modeling, texturing, lighting, and animation are done as would normally be done to create a standard 2D animation. Traditional movies are generally animated using a one camera viewpoint. For our stereoscopic animations, a stereo camera rig has been specially created to simulate the ocular separation of two eyes and give two slightly offset views with which to render (Figure1).

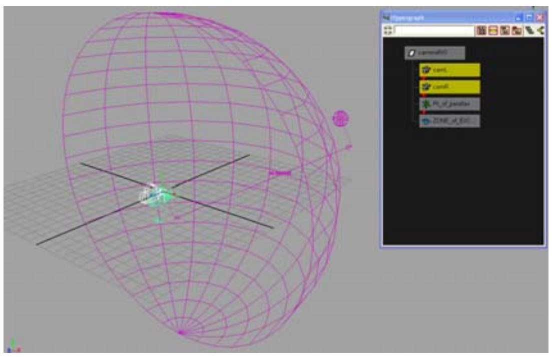

Figure 1. Stereo camera rig showing left and right cameras, zone of exclusion and point of parallax.

The separation of these two cameras determines the amount of stereo that the viewer ultimately sees in the final animation. The stereo camera rig consists of a group that has a manipulator handle that allows the rig to be transported and rotated as a standard camera. Parented to the group are the two cameras, one for each eye, the zone of exclusion and the point of parallax. All attributes of the cameras are locked with the exception that the right camera can be translated on the X axis; this function adjusts the ocular separation. The zone of exclusion, a non-renderable object, is an area in front of the cameras that helps to establish when objects are too close to the cameras to be recognizable in the stereo field. A point of parallax is also a non-renderable part of the rig and helps determine the point at which the stereo field is neutral. All objects between the zone of exclusion and the point of parallax are in negative parallax and appear to be "floating" in front of the display screen. Those objects beyond the point of parallax are in positive parallax and give the appearance of depth to the scene (Bourke). Custom expressions have been written in Maya that directly control the ocular separation distance and the distances to both the zone of exclusion and the point of parallax (Bourke).

The render output consists of two sequences of frames that correspond to each camera. The output for production renders is generally uncompressed Targas (.TGA) at a frame size of 1056 by 768 pixels for each camera. At 30 frames per second, this data can add up very quickly. For a five minute movie, this data set will be around 25 GB.

To edit these frame sequences, Adobe Premiere Pro 1.5 is used. A project is started with a frame size of 2048 by 768 pixels. This will allow the two image sequences of rendered images to be displayed side by side. Since the images were rendered at a slightly larger size, each image has an extra 32 pixels that extend off of the sides of the visible project. This allows for a final tighter stereo image. All video clips of images rendered with the left camera are assembled into one video track, transitions are created, and any title, graphics or credits are added. All of these clips are positioned to cover the left side of the display monitor window. On another video track, all of the video clips of images rendered with the right camera are assembled, synchronized with the corresponding left video track clips, and exact transitions and other assets are created to mirror the left video track. The right video clips are positioned to cover the right side of the display monitor and both right and left video clips meet each other exactly in the center of the display field. Once all of the clips have been synchronized, positioned and transitions have been made, the sequence is output as a series of bitmap (.BMP) images. Each of these images is 2048 by 768 pixels in dimension and is approximately 4.6 MB. For a typical five minute animation, this amount of data will be about 27 GB.

To convert the bitmap sequence to a playable movie, the sequence is loaded into Virtual Dub (Lee). This software will output the movie in an AVI format which will play well in the stereoscopic player. Since the pixel dimensions of the movie are so large, a suitable compression codec needs to be utilized in order for the stereoscopic player to playback the animation at a smooth and consistent rate. Typically a codec such as Xvid (Militzer) has been used. This codec was chosen to provide very few compression artifacts with smooth playback. Additionally, Virtual Dub is used to add sound as a WAV or MP3 to the video. A typical five minute AVI movie with sound will be compressed to around 140 MB.

Passive polarized light is utilized to view the content on the stereoscopic display. We are using a system that consists of a shuttle computer running Windows XP with either an nVidia Quadro FX 1100 or 1300 graphics card (nVidia) with dual outputs. These outputs are set to clone mode and send signals to two projectors. Each projector transmits through a linear polarized filter and on to a silver screen that has been specifically designed to preserve polarized light. The observer then wears glasses fitted with polarized lenses in the same orientation as the filters through which the projected images are sent through, and the images are seen in stereo. Movies are AVI format and are played with Stereoscopic Player (Wimmer).

Creating content from video sources follows the same production techniques as those utilized for computer generated animations. High definition cameras are placed on a custom rig placed on a tripod that provides a stable platform. The amount of physical separation of the cameras determines the point of parallax and zone of exclusion mathematically, as was accomplished with software for the virtual stereo camera rig. This allows the video feed from each camera to comprise one half each of the stereo field after the images are captured. Often the clips need to be scaled down to fit in the desired playback field. High definition video allows the scaling process to be performed without loss of resolution.

4. Conclusion

The use of stereoscopic displays to educate students on the complex subjects of science and health holds great promise. Traditionally, students have not been easily able to visualize concepts using standard textbooks, and stereo displays fill a role that will allow these students a greater insight to the materials that often have gone misunderstood. Often, science is portrayed by artists who may not understand the science and thus misrepresent the subject matter, or by the scientist who is not capable of rendering images of a complex nature with the artist's technical ability. The technologies used to create and display stereoscopic content are becoming increasingly economically feasible and user friendly. The end result of this situation will be to permit a more fascinating, accurate, and dynamic learning environment that can be available to anyone interested in exploring science and health.

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