

A CLOSER LOOK AT VIRTUAL REALITY PROJECTION

OBJECTIVE:

The objective of this lab is to gain a deeper understanding of the technical details behind virtual reality projection systems. This will be accomplished through a guided tour of the BYU Virtual Reality Lab. This lab will seek to answer the following questions:

- Why are two projectors required for 3-D projection?
- Can any displayed object be projected three dimensionally, or does the system require some sort of 3-D preprocessing?
- What is the relationship between the Operating System, Video Card(s), and Projection System?
- Why do three dimensional gaming systems require special goggles, but do not require a special monitor or display device?

EQUIPMENT/SOFTWARE USED:

Hardware:

- Two DLP Projectors
- Polarized Glasses
- Polarized Projection Screen
- BYU Supercomputer Access
- Other equipment provided by the BYU Virtual Reality Lab

Software:

- All software was provided by the BYU Virtual Reality Lab

PROCEDURES:

This lab was completed by taking a guided tour of the BYU Virtual Reality Lab. The officiator presented each of the students with polarized glasses in order to properly view the three dimensional images that were displayed. The lab was equipped with two DLP projectors that were each covered by polarization material. The material was attached to the projectors at angles 90 degrees out of phase. The glasses that were provided had similar material so that one lens would only allow the image from one projector to pass, while the other lens would allow the display from the second projector to pass. This allowed for a way to project different images into each eye.

The basic concept behind this type of system is to simulate an experience that our eyes have each time when viewing a three-dimensional object. Because human eyes are slightly offset from one another, each eye sees a slightly different image than what the other eye sees. This gives the eyes the ability to see three-dimensionally, gives depth-perception, and allows the eyes to more easily focus in on a single point of origin. The images being projected onto the screen are displays of the same object, but are slightly offset from one another, similar to how the eyes are offset, in order to simulate the three dimensional view. The greater the images on the projection are offset, the more depth the image appeared to have.

The Virtual Reality Lab utilized one of BYU's supercomputers in order to produce the two images of the real-time manifold simulation. This particular virtual reality system used passive stereo display. This requires the Operating System to recognize two display outputs. The Operating System sends an identical image of the screen to both displays, thus the three-dimensional image had a 2-dimensional background and desktop. The application producing the 3-D simulation would then divide the simulation

into two slightly different displays (as described previously) and then send one to the first display output, and send the second to the other display output. Thus the projectors would display two slightly offset images, producing a three-dimensional effect.

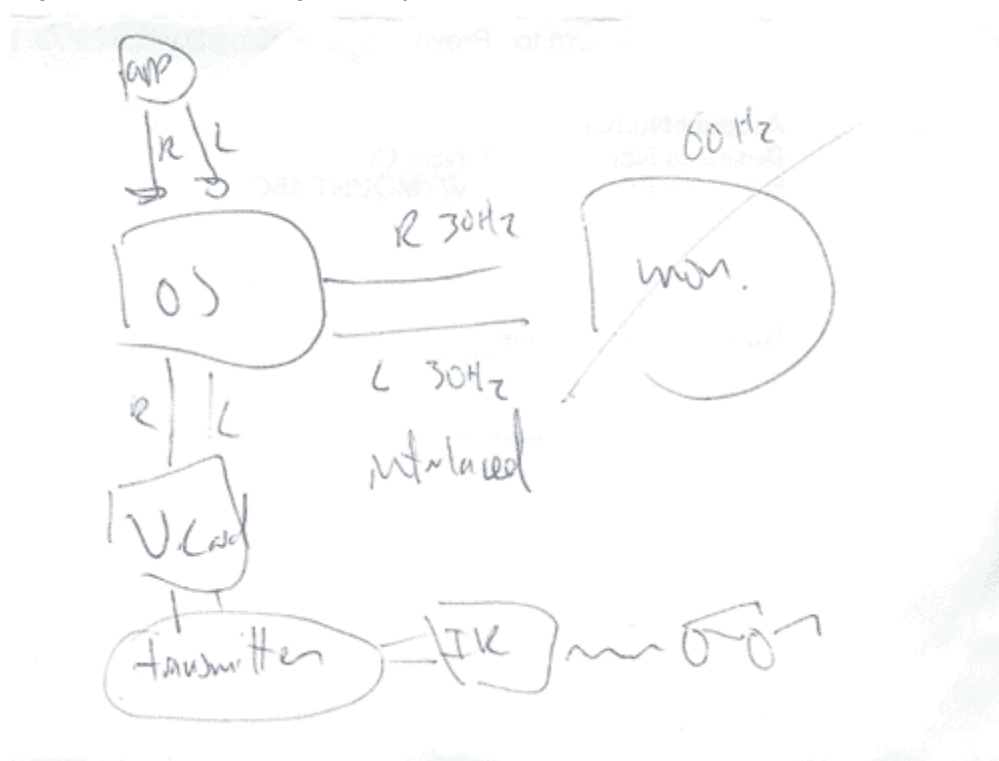
Once interesting characteristic of the projection system was that if the 3-D image was expanded so that the display went far enough right or left that the image was no longer on the display, the 3-D effect was lost completely. The lab instructor explained that this was not because the system stopped displaying the 3-D image, but rather, was because the human eye and mind would see the 2-D cut-off of the image, and would mentally render the entire image as being 2-D. Another limitation of the system is with the depth of the displayed image. The depth is controlled by the offset of the two images, and by the rendering of the application. The lab instructor demonstrated that the depth could be controlled by increasing the offset of the images. However, this depth was not infinite, and if the separation became too great, then the images would appear distorted and was actually somewhat painful for the eye to try and make sense of the image.

Upon understanding how three-dimensional projection systems function, the question was raised concerning 3-D gaming systems, and why they do not require any special type of display, but can instead be run from any ordinary computer display. This type of 3-D display system is very similar to the passive stereo system described previously, but differs in how the two images are handled by the 3-D graphics processor card. Similar to the previously described system, a 3-D game will create two offset images at the application level, and will then send those images to the Operating System. The OS will then send those images to the video card. The video card will then utilize the refresh rate of the monitor to effectively display a 3-D image. This is accomplished by alternating the images sent at each cycle of the refresh rate. For

example, if the monitor has a refresh rate of 60Hz, then each image will effectively be displayed at only 30Hz, because each cycle of the refresh rate will alternate between the two images. This makes the display look “fuzzy” or “blurry” to the viewer seeing the image. In order to then make it so that each eye only sees one of the images, special goggles are worn that receive a synchronization signal via an IR transmitter connected to the computer. This transmitter sends out a signal indicating the refresh cycles of the display. The goggles will then “turn off” the lenses alternating with each refresh cycle. The lenses of the goggles are LCD displays, which allow the goggles to either make the goggles transparent, or opaque, depending on the current being supplied to the goggles. The LCD technology allows for this cycling to occur quickly enough to keep up with the refresh rate of the monitor. Thus a 3-D image is simulated by using an ordinary computer monitor.

The following sketch, though poorly drawn, attempts to explain the relationship between the application, operating system, video card, and display system. This sketch was taken directly from the student’s lab notes.

Figure 1 – 3-D Gaming Concept Sketch



REPORT:

This lab outlined the following important points about three-dimensional projection systems, and other types of 3-D display systems:

- 3-D systems imitate a three dimensional image by sending two different images out of the display.
- Each image is seen by one eye, and each is perceived by a different eye.
- Most 3-D projection systems utilize some form of polarized display system in order to send separate images to each eye, which also requires special glasses or goggles to be worn.
- In a passive stereo system (such as the one toured for this lab), the Operating System recognized two output devices, and sends different data to each output based on the information supplied to it by the running application. A 2-D image, such as the desktop background, would still send out an image to each display, but they would be identical images, not offset.
- 3-D gaming systems utilize alternating cycles of the display device's refresh rate, combined with special LCD goggles, in order to produce results similar to a 3-D polarized projection system.

CONCLUSIONS:

The results of this lab can be considered a success in light of the fact that each objective of the lab was met. Consider the following questions:

- Why are two projectors required for 3-D projection?
 - This simulates the manner in which the human eye sees three dimensionally. Each projector is intended to display an image for only one eye. The other projector displays an image slightly offset from the first, intended to be seen by the other eye. This simulates the way the human eyes perceive a 3-D object from two slightly different angles.
- Can any displayed object be projected three dimensionally, or does the system require some sort of 3-D preprocessing?
 - The application displaying the object or image must send two distinct images to the display devices. Thus the object or image must be preprocessed, or prepared before being able to achieve this. Without this preprocessing, the display would send two identical images to the displays, thus producing a two dimensional image.
- What is the relationship between the Operating System, Video Card(s), and Projection System?

- In a passive stereo system (such as that used in this lab), the application divides the object or image into two separate images and tells the operating system that each image should go to a different display. The operating system then sends one image to one display device, and the other to the second display device. The display devices act as a 2-dimensional system, displaying only the single 2-D image provided to it. However, with special polarized material, each projector can send its image to only one eye of the viewer, thus together, they simulate a 3-D image.
- Why do three dimensional gaming systems require special goggles, but do not require a special monitor or display device?
 - These systems utilize the refresh rate of the monitor to display alternating images on each cycle of the refresh. This enables any ordinary computer monitor to display two different images on the same screen, quickly enough that it appears continuous to the viewer. The goggles will then alternate in sync with the refresh rate in order to allow each eye to only see one of the displayed images. Thus each eye is provided with a seemingly continuous image, but each eye sees a slightly different image.

This lab was valuable in teaching the student about how 3-D images can be simulated. The lab provided an interesting and informational tour of a working 3-D projection system. The instructor of the lab provided the technical information necessary for the students to gain a deeper understanding of how these systems function, and also demonstrated some of the limitations of these systems. Overall, the lab was an enjoyable method for learning about 3-D and virtual reality systems.