

## A HIGH-RESOLUTION WIDE-SCREEN DISPLAY FOR SIMULATORS AND VIRTUAL REALITY

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We have developed virtual worlds that run on a single personal computer and can be displayed using two outputs. A single display of the two outputs has a resolution of 3200 x 1200 pixels. The field-of-view may be as large as 120 degrees with little distortion. Frame rates are in excess of 60 per second. The common use of such high-resolution wide-screen displays in simulators and virtual reality could significantly improve the experience of participants. Such a near-photorealistic large display may enhance the believability of scenarios and raise a person's sense of presence in the virtual experience. This may increase the sensitivity and validity of performance measures. Virtual reality application areas that could benefit from using a high-resolution wide-screen display include those used for training, education, and medical applications such as the treatment of psychological disorders. Since many driving tasks involve a large field of view, low-cost effective driving simulators can now be easily constructed. We use a driving simulator to demonstrate the use of a high-resolution wide-screen display.

### INTRODUCTION

For virtual reality systems, a popular request has been for low-cost, high-resolution displays that have a large field-of-view (FOV) (Blackham, G., 1999). This request is now becoming possible. Relatively inexpensive graphic cards are now available that have sufficient bandwidth to support high-resolution displays at fast frame rates when rendering complex three-dimensional virtual environments. Below, we consider possible outcomes when simulators and virtual reality use 1) high-resolution displays, and 2) displays with a wide FOV.

#### Higher-Resolution Displays

One reason to strive for higher resolution displays in simulators and virtual reality is to enable the participants to use search and scan patterns that are similar to those that would be used in a real-world environment. That would help validate the virtual environment in terms of performance measures.

Drivers generate complex eye movement patterns when driving in the real world (Mourant and

Rockwell, 1970). These eye movement patterns are dependent on the detail that a human can perceive in the real world. Humans can resolve approximately 1 minute of visual arc depending on color, contrast, and lighting (Moon, 1961). For a 60 degree FOV, it would take a display of 3600 x 3600 pixels to enable humans to see similar detail. Today, such displays are not commonly available. Most likely, drivers using today's simulators would have search and scan patterns different from those in the real world. This difference should decrease as simulators use higher resolution displays.

The perception and comprehension of road signs has always been a problem for driving simulators. Often, road signs are larger in the virtual world than in the real world due to the lower resolution of the simulator's display. The larger signs distort the virtual scene and may block other relevant features in the virtual environment. Higher-resolution displays will help alleviate this problem.

When comparing driver performance in terms of mean speed and mean lateral position on curves, Jamson (2001), found no differences when a display of 1280 x 1024 pixels was used as compared to a display of 960 x 620 pixels. However, drivers

drove significantly faster in the simulator conditions than in the real world.

### Wide FOV Displays

In many virtual environments, a wide field of view is important (Stanney, et. al., 1998). When driving, an operator needs to monitor both to the left and right of the vehicle for other vehicles, pedestrians, etc. Designers of driving simulators have recognized this and provide simulators that have very wide FOVs. In the past these have required multiple synchronized computers and are very expensive. Using the technology we outline below, simulators and virtual reality displays can be low-cost and have a wide FOV.

An increased sense of presence in virtual environments has been found to be associated with a large FOV (Prothero and Hoffman, 1995; IJsselsteijn, et. al., 2001; Meehan, et. al., 2001). Prothero and Hoffman found significantly higher presence at 105 degrees as compared to 60 degrees. IJsselsteijn, et. al. found that a large increase in subjective presence was due to screen size (28 degrees versus 50 degrees).

Jamson (2001) compared three FOV levels in a driving simulator (50, 120, and 230 degrees) with driving in the real world. As the FOV increased the validity of speed choice and lane position between driving in the simulator and the real world increased.

### OBJECTIVES

Our main objective was to build a realistic three-dimensional virtual environment that 1) can be rendered at high resolution with a fast frame rate, and 2) can be displayed on a wide screen with little distortion. We programmed using OpenGL. The software contains two “cameras” each of which has a 60 degree horizontal FOV. The “cameras” supply the input to render the left and right sides of the forward scene with their respective frustums. The rendered output from each “camera” is sent to its associated output device (monitor or projector). Each of the two outputs was displayed at a resolution of 1600 x 1200 (UGA).

Our secondary objectives included modeling road signs and other objects in the environment in approximately the same scale as in the real-world. We could then determine if the high-resolution display results in more time being available for drivers to read road signs. Furthermore, by maintaining optimal frame rates, we hope to provide a more stable display and thus reduce possible simulator sickness. The rendering of the environment at UGA resolution could also increase a subject’s believability, and hence the sense of presence in the virtual environment. A screenshot of our driving environment at a screen resolution of 1600 x 1200 (Figure 1) is shown below. The total number of pixels in the horizontal direction is 3200 because of the two outputs. Until now, it has not been possible to achieve such a wide FOV (120°) by using a single desk top computer.



**Figure 1. Driving environment at UGA resolution with a 120° field-of-view.**

## EXPERIMENTAL PROCEDURE

In order to estimate possible benefits of using the high-resolution 1600 x 1200 and wide FOV (120 degrees) display, we compared it with the same environment rendered at 800 x 600 (SVGA) with a 120 degree FOV. The equipment used consisted of a computer with a 2.8 GHz P4 processor, 1024 MB RAM, a monitor capable of displaying images at UGA resolution, and an NVidia GeForce 5900 Ultra graphics card.

The modeled environment contained road signs one would normally find when driving. Subjects were instructed to signal the moment that they could read a sign while driving at a constant speed of 60 miles per hour. They also gave a signal just as the sign was no longer visible.

This data was collected and recorded for four different types of signs (differing in color, shape, size, etc.) at both resolutions (800 X 600 and 1600 x 1200). We could then determine if a higher resolution contributed to longer readability times.

## RESULTS

Our tests concluded that the sign readability times were about double when the virtual environment was displayed at 1600 x 1200 (UGA) resolution in comparison to when the virtual environment was displayed at the 800 x 600 (SVGA) resolution. These results support the hypothesis that by rendering and displaying the virtual environment at a high resolution, the time available to read the road signs increases. Drivers also reported that the virtual environment appeared to be clearer and more realistic at the higher resolution.

Although this demonstration focused on driving simulators, the general idea can be extended to other types of virtual reality. Furthermore, three dimensional virtual training scenarios for firemen, military personnel, and others could benefit from using a high-resolution display with a wide FOV.

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