Real-time rendering for autostereoscopic 3D display systems

Yasunobu Yamauchi Shingo Yanagawa Hitoshi Kobayashi Kazuki Taira Yuzo Hirayama
Corporate Research & Development Center, Toshiba Corp.
{yasunobu.yamauchi | shingo.yanagawa | yan.kobayashi | kazuki.taira | yuzo.hirayama}@toshiba.co.jp

Introduction

The long-standing goal of the computer graphics community is to be able to view 3D objects as we see them in real world without the need for special glasses. This sketch shows our integral imaging based 3D display and real-time rendering system using commodity graphics hardware. Traditional stereoscopic 3D display uses binocular or a multiview method with two or more converging points of light rays that correspond to the positions of the viewer's eyes. However these methods suffer from problems such as restricted viewing angle, and image flipping when the viewer moves. We developed a light-ray based 3D display and real-time rendering system to solve these problems. As a result we created an autostereoscopic 3D interactive system with a wide viewing angle and less visual fatigue.

1D integral-imaging based 3D display

Our 3D display creates real-world light rays by controlling the light direction of sub-pixel colors (red/green/blue) on a flat panel display (FPD). This display is composed of FPD panel and a lenticular optical plate on the FPD, which controls the sub-pixel image's light ray direction. Figure 1 is a concept image of our 3D display. Contrary to the traditional integral photography method, we rearranged the ray space to optimize and widen the user's viewing area [Fukushima 2004]. By arranging the image contents on the FPD that correspond to each ray direction, realistic 3D images can be viewed. Furthermore our display enhances the number of parallaxes by changing the color filter from the conventional stripe alignment to a mosaic alignment. The FPD is a 15 inch WUXGA (1920x1200 pixels) LCD panel and one lenticular component corresponds to 18 or 19 ray elemental images according to the viewing area setting. The 3D imaging resolution is 300 x 400 pixels and the viewing angle is 28 degrees.

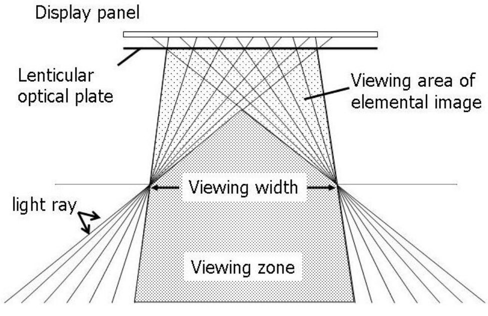

Figure 1 Viewing zone of 3D display system

3D display system configuration

Our 3D display system is composed of 3 parts; the 3D display, the pixel alignment engine, and the rendering PC. The pixel alignment engine is a custom FPGA board that realigns each pixel's color component to vertical 3 sub pixel locations automatically. Mosaic alignment of display panel's color filter reconstructs appropriate pixel color information. Horizontal 3D image resolution therefore becomes 3 times wider of the FPD panel resolution itself.

3D image rendering using pixel shader

3D image rendering is composed of 2 main steps; the rendering of each parallax image and the sub pixel alignment of the rendered parallax images. Firstly we render each parallax image and store them in tile format on the back buffer. We call this buffer the "render texture". To optimize the viewing zone as mentioned in the previous section, we totally render 30 parallax images. Next, we prepare sub-pixel alignment tables that store the pixel locations to be aligned on the final 3D image. The alignment tables must be prepared uniquely for each 3D display specification. Generally 3 tables for each sub-pixel location are needed. We assign each alignment table as a 2D texture of 16-bit 2-integer format. The texture components show pixel coordinates on the "render texture" for retrieval. We call this table an "alignment texture". We then render a screen-sized quadrangle primitive with the "alignment texture" using a pixel shader. Inside the pixel shader, each pixel's color is retrieved from the "render texture" based on the specified alignments described in the above 3 "alignment textures". Orthogonal cameras are used to render each parallax image, however a horizontally-orthogonal and vertically-perspective camera should be used for correct 3D image generation for 1D integral-imaging based systems [Saishu 2004]. The total rendering speed is about 40 fps (6,840 skinned mesh model, CPU: Pentium 4 2.8 GHz, GPU: RADEON 9800 Pro or GeForce FX 5900 Ultra with pixel shader version 2.0). Furthermore, we can display 3D contents on any 3D display with a different lenticular panel configuration by changing the "alignment texture" without changing the 3D application programs. We also developed 3D image-content authoring software for high quality 3D scenes using commodity CG software. Figure 2 shows some parallax images and 3D image compositions of Japanese "kabuki" dance scenes.

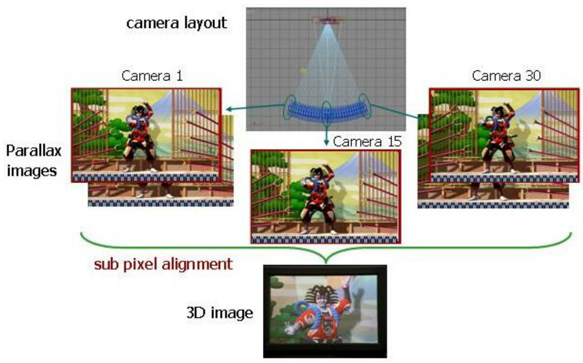

Figure 2 Parallax images and composition of 3D image

References

Fukushima, R., et al. 2004. Novel viewing zone control method for computer generated integral 3-D imaging. Proc. SPIE Vol. 5291.

Saishu, T., et al. 2004. Distortion control in the one-dimensional integral imaging autostereoscopic display system with parallel optical beam groups. Society of Information Display 2004 Symposium, Paper Number 53.3.