

## Double-Channel Stereoscopic Display Technology Based on OpenGL

Liu Shu, Fan Yangyu and Zhang Chenrui

Department of Electronic Information, Northwestern Polytechnical University Xi'an 710072, China

**Abstract:** The multi-channel stereoscopic display technology has become an attractive frontier research area in recent years, supporting users with correct spatial perception and large vision experience. This paper studies on the easiest case of double-channel. Focusing on the problem of complex network programming in traditional synchronous display method, a design plan of double-channel stereoscopic display system on one PC based on OpenGL is proposed, which reflects some innovation of the paper. A series of performance tests have been taken and the results agree well with the need for three-dimensional effect and synchronism.

**Keywords:** Double-channel on one PC, double-channel stereoscopic display system, OpenGL, stereoscopic display

### INTRODUCTION

For a long time that what we saw in real world is three-dimensional while almost all of artificial images are flat, failing to create immersive sense. Not until the late 19th century did human begin to study stereoscopic display technology. Undoubtedly, the advent of multi-channel display technology has made perfection more perfect. The flawless combination of the both technology provides high resolution and more lifelike effect, thus developing rapidly with the increasing attention people paid. The appearance of 3D blockbusters like Avatar indicated that multi-channel stereoscopic display technology has been close to maturity.

Generally, when viewing a scene in real life, people see two different images with binocular parallax and this causes visual perception of depth. Therefore, by simulating two pictures for each eye based on that vision theory, people can see 3D display images. 3D display is classified into two types: stereoscopic display and auto- stereoscopic display. The former requires observers to wear polarized glasses or Head Mounted Display (HMD) and the latter is called true 3D display without any special aided device (Zhang *et al.*, 2010). Because the traditional stereoscopic display can provide us better lays of graphics, and its equipment is simple which makes it easy to implement, the paper adopts this method. In terms of multi-channel display, synchronization is a crucial problem. The common solution is to use different computers, each of which fulfills partial rendering and computing work independently and then to establish master-slave communication environment. Although various improved techniques of channel synchronization

emerge in endlessly, complex network programming is unavoidable.

Our endeavor in this study is to make some improvement for the easiest case of double-channel. We have proposed a design plan of double-channel stereoscopic display system on one PC, using OpenGL to realize it. A series of performance tests have been taken and the results agree well with the need for three-dimensional effect and synchronism.

### THE IMPLEMENTATION OF STEREOSCOPIC DISPLAY

**Stereoscopic display principle:** Physically, a certain separation exists between two eyes, therefore when viewing the same object; the two retinal images have slight position difference which is called binocular parallax. After analysis and synthesis, the brain integrates the images into one single three-dimensional image to create stereoscopic perception (Zhang *et al.*, 2006). Based on the binocular parallax principle, the implementation of stereoscopic display has two preconditions (Li and Guan, 2005): one is to use software (such as OpenGL) to generate a stereo image pair with unique parallax of the same scene for each eye, another is to use hardware to separate the two images, i.e., the left eye can only see the left image and so does the right eye.

**Stereoscopic display model:** To simulate the human's stereo vision and generate the stereo pair, first we have to establish an accurate mathematical model. According to the different projection modes, it can be divided into convergent binocular model and parallel binocular model. Because the two optical axes in convergent

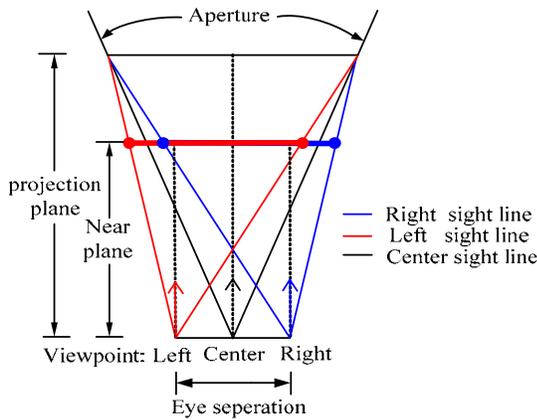


Fig. 1: Principle of parallel binocular model

model are not parallel, as well as the two projection planes, it brings about vertical parallax, thus creating more malaise for observers. However, the parallel model can avoid those disadvantages to make the image pair fusion easier and give people lifelike also comfortable stereoscopic sense. It is the reason why the study choose this model. As the principle diagram shown in Fig. 1, the frustums of two eyes are asymmetric and OpenGL supports the projection method (Paul, 2006).

**Stereoscopic display process on OpenGL:** As an open graphic software interface, OpenGL has about 250 functions and provides a powerful function of 2D and 3D (Mason *et al.*, 1997; Li, 2002). The concrete steps to realize stereoscopic display using OpenGL are as follows:

- Confirm that the graphics card supports stereoscopic display, then load the stereoscopic buffers (two front buffers and two back buffers) when initialize the display window.
- Set respective frustum parameters for two eyes and render scene in two back buffers (the back-left and back-right buffer).
- Exchange the front and back buffers, then images in back buffers are shown and the original front buffers become the back ones for new drawing.

The whole drawing process is a circulating process from (1) to (3).

**The implementation of single-channel stereoscopic display:** The implementation steps of single-channel stereoscopic display are as follows:

- Let a computer generate stereoscopic signal
- Divide the signal in two via VGA distributor, send one to computer display, the other to stereo projection AP converter

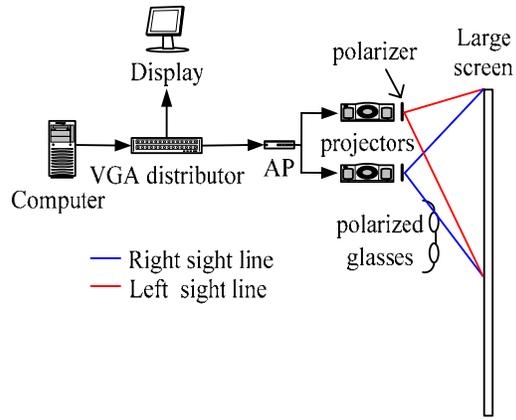


Fig. 2: System architecture of single-channel stereoscopic display

- AP converter transforms the signal into two phase separated signals for each eye, transfer them to two projectors
- Project the signals onto the large screen after polarizers and optical fusion (note that the actual projection region is 4/7 of the screen not 1/2)
- Wear polarized glasses to see the separated left and right images, then generate one single 3D image in the brain [a1]

Figure 2 shows the architecture of single-channel stereoscopic display system.

### THE IMPLEMENTATION OF DOUBLE-CHANNEL DISPLAY

Multi-channel display is an important technology that provides high resolution and immersive effect. With a large screen projection, it is more suitable for VR educational research and tactics stimulation than common desktop computers.

Double-channel display divides a large visual scene into two continuous parts, each of which is rendered and displayed independently by the corresponding computer and projector. When projectors display simultaneously, observers can enjoy an immersive environment. So as to ensure a consistent and complete image on a large screen, one key is related to scene division technology. Moreover, how to make the two channels displaying simultaneously is also important, which synchronous display technology is responsible for. Introduction of both techniques is given below.

**Double-channel scene division technology:** Scene division is a process of dividing a large frustum into two small parts, and splicing the two parts together must be the original frustum. Only this can ensure the

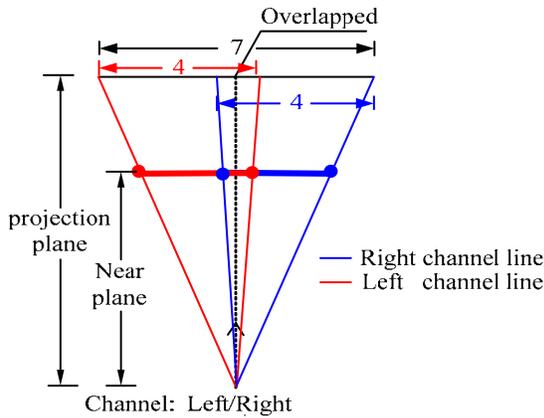


Fig. 3: Principle of scene division

Double-channel scene is the seamless combination of the two single-channel scenes.

As the principle of scene division shown in Fig. 3, the whole scene consists of two equal parts, therefore the frustums of them are asymmetric. The 1/4 overlapped display area of the two channel set by projection system should also be noteworthy.

**Double-channel synchronous display technology:** A double-channel display system is traditionally supported by two computers to establish a distributed communication environment. Choose one host to be the master, which takes charge of system activation and synchronization data sending, and also as one of display channels. The other computer is the slave, receiving synchronization information and sending feedback to the master, thus guaranteeing the master and slave render and display simultaneously. Because double-channel display on one PC can simplify complex network programming in synchronization technique, the paper adopts this method.

To realize double-channel on one PC by OpenGL, creating a left and a right window in program is needed. After scene division, put the left segmentation in left window and so does the right one. Once the program is run, two windows must render and display simultaneously, which means they satisfy the synchronism automatically. Therefore it reaches the goal of double-channel display and avoids master-slave communication programming so that work efficiency is greatly improved.

**The implementation of double-channel display:** The implementation steps of double-channel display on one PC are as follows:

- Let a computer generate double-channel signal.
- Divide the signal into the left-channel and right-channel signals via VGA distributor, send them to

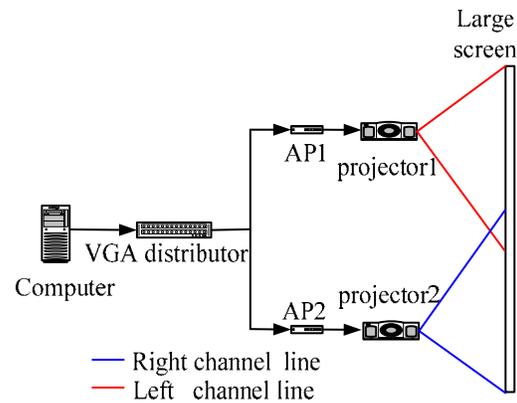


Fig. 4: System architecture of double-channel display on one PC

two edge fusion devices to complete tasks of edge intensity blending and color balance in the overlapped area (Note that the AP converters mentioned in previous section also have these functions).

- AP converters transfer the signals to two projectors, then project the signals onto the large screen to form double-channel images (note that the overlapped projection region is 1/7 of the screen).

Figure 4 shows the architecture of double-channel display system.

### A DESIGN PLAN OF DOUBLE-CHANNEL STEREOSCOPIC DISPLAY SYSTEM ON ONE PC BASED ON OPENGL

In the basis of the single-channel stereoscopic display, we use the technology in each channel of the double-channel system, thus developing a design plan of double-channel stereoscopic display system on one PC, based on available hardware equipments and software platform, then giving performance test results.

#### System configuration:

**Hardware components and settings:** The proposed system is composed mainly by a common PC, a large screen, two stereo projection AP converters, four projectors, and several polarized glasses.

The PC type is Lenovo 6900, equipped with professional stereo graphics card NVidia Quadro FX3450 to support double-buffer rendering.

The double-channel screen is the display device with the aspect ratio of 7:3, while the projection region on the screen of each channel is 4:3, which means 1/4 projection of one channel is overlapped with another.

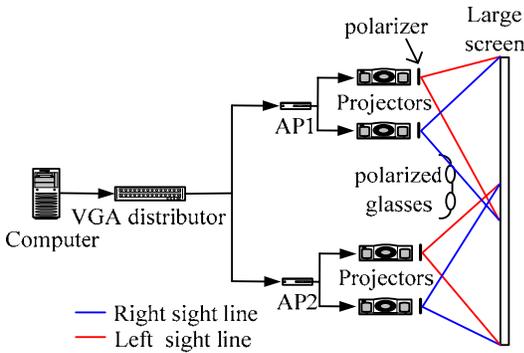


Fig. 5: System architecture of double-channel stereoscopic display on one PC

So it should be taken into consideration in double-channel display programming and edge fusion processing.

The stereo projection AP converters WSR801 have two functions, one is to transform stereoscopic signals into two phase separated signals for each eye; the other is to blend edge intensity and balance color in the overlapped area of two channels.

The original double-channel stereoscopic signal is finally divided into four signals, i.e., the left and right eye signal for each channel, so there need two groups four projectors for projection.

The polarized glasses belong to linearly orthogonal polarization. When lights shines on a polarized filter, only the polarized light with specific polarization direction can pass through. Based on this theory, observers wearing polarized glasses can see the left/right images for left/right eye, attaining stereoscopic perception.

When all the devices are connected together (Fig. 5), some settings are also needed. In control panel, set refresh rate as 60 Hz and resolution as 2048\*768, choose the View display mode as horizontal span and

enable the stereo option in 3D settings. In the program, set the left-upper vertex position of the left and right window as (0, 0) and (768, 0), the size of two windows is 1024\*768.

**Software environments:** The PC is on XP operation system, programming in the Visual Studio 2005 compiling environment and using OpenGL as graphics API. Because all these are developed by Microsoft, it can avoid compatibility troubles.

**Double-channel stereoscopic display process on OpenGL:** The concrete steps to realize double-channel stereoscopic display using OpenGL are almost the same with single-channel one. So it doesn't necessarily mention it again (Fig. 6).

**The implementation of double-channel stereoscopic display:** The implementation steps of double-channel stereoscopic display on one PC are obtained from steps in 2.4 and 3.3. Figure 5 shows the system architecture.

### EXPERIMENTAL RESULTS AND DISCUSSION

In order to improve stereoscopic effect, we draw four geometric solids with free rotation, then add lighting and simple texture mapping. The final effect pictures are shown in Fig. 7.

The display results indicate that the system has a good three-dimensional effect performance and consistency.

Due to the restrictions of hardware and time, together with double-channel stereoscopic display being a interdisciplinary complex technology, the study still exists some limitations, including following aspects.

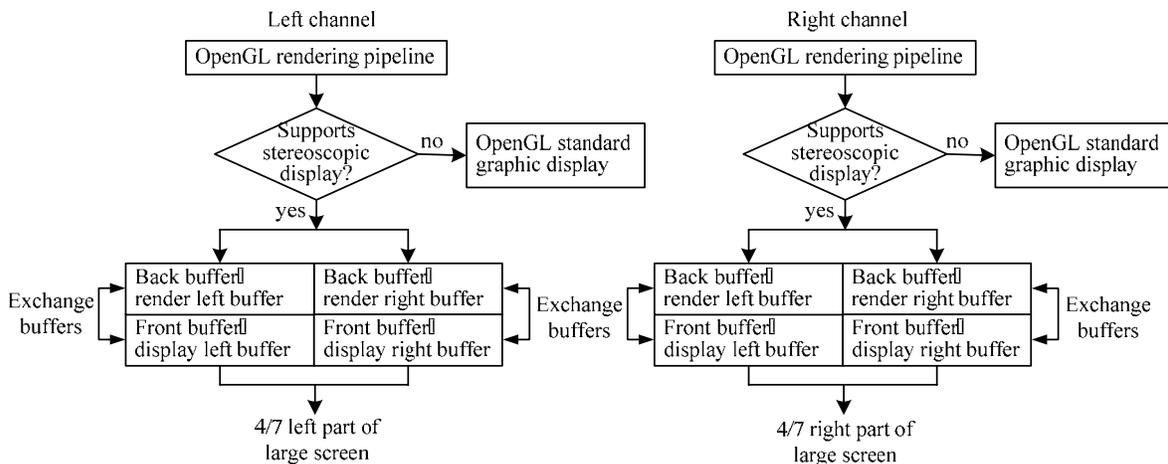


Fig. 6: Block diagram of double-channel stereoscopic display process on OpenGL



(a)



(b)

Fig. 7: Effect pictures of double-channel stereoscopic display

The study requires people to wear polarized glasses, but after long-time observation, it will cause uncomfortable feeling for eyes. With auto stereoscopic display becoming the research hotspot, changing stereoscopic display method to achieve better visual sense is reasonable.

In this study using one PC to realize double-channel display has several limits, though it also reflects some innovation. First, it can be only applied to two channels. Second, because the outputs of graphics card connect to two group projectors, there is no more output for computer display, thus bringing unexpected problems. So traditional master-slave communication network is still the main technique in multi-channels.

Moreover, for convenience, we only create simplest 3D scene based on OpenGL.

## CONCLUSION AND FUTURE WORK

The study describes the core content of stereoscopic display and double-channel display. A design plan of double-channel stereoscopic display system on one PC is proposed, giving OpenGL programming and hardware structure. The experimental results agree well with the need for three-dimensional effect and synchronism. In the future work, we will turn to the advanced 3D display technology, establish distributed communication environment, and create more complex and vivid scene to boost the system's performance.

## REFERENCES

- Li, Y., 2002. The Manual of Function and Paradigm on OpenGL [M]. National Defense Industry Press, Beijing.
- Li, J. and X.H. Guan., 2005. Review to 3D stereo display based on personal computer [J]. Railway Investigation Surv., 2: 24-27, (In Chinese).
- Mason, W., N. Jackie, D. Tom and S. Dave, 1997. The Official Guide to Learning OpenGL, Version 1.2 [M]. Addison-Wesley Publisher, New Jersey.
- Paul, M., 2006. OpenGL Distilled [M]. Addison-Wesley Professional, New Jersey.
- Zhang, Y.H., LV, G.Q. and HU, Y.H., 2006. Algorithm and implementation of binocular stereopsis models [J]. Comput. Eng. Appl., 35: 65-65, (In Chinese).
- Zhang, Y., Q.M. Jin and W.H. Zhang, 2010. Multi-view autostereoscopic 3D display. International Conference on Optics, Photonics and Energy Engineering, 2010 [C], WuHan.