

# Proposal for the Object Oriented Display :

## The Design and Implementation of the MEDIA<sup>3</sup>

Naoki KAWAKAMI, Masahiko INAMI, Taro MAEDA,  
and Susumu TACHI

Faculty of Engineering, University of Tokyo  
7-3-1 Hongo, Bunkyo-ku Tokyo 113, JAPAN

*kawakami@star.t.u-tokyo.ac.jp, minami@star.t.u-tokyo.ac.jp, maeda@star.t.u-tokyo.ac.jp*  
*tachi@star.t.u-tokyo.ac.jp*

### Abstract

This paper describes design and implementation of the MEDIA<sup>3</sup> (MEDIA cube). In this paper we also propose the concept of “object oriented display”. The MEDIA<sup>3</sup> is trial product of an example of “object oriented display”. The MEDIA<sup>3</sup> consists of liquid crystal displays (LCDs) which arranged in the shape of a cubic body (exactly a rectangular parallelepiped). According to the position of an operator's eye and the position of MEDIA<sup>3</sup>, synthesized images of virtual objects located inside the MEDIA<sup>3</sup> appears on each LCD. Because the motion of the MEDIA<sup>3</sup> and the synthesized images on each LCD are interactive, it is very useful to observe or recognize 3-dimensional shape of the virtual object inside the MEDIA<sup>3</sup>.

**Keywords** : object oriented display, virtual reality, visualization, CAVE, display system.

### 1. Introduction

#### 1.1 MEDIA<sup>3</sup> Overview

Display systems for virtual reality / computer visualization can be grouped into following three types.

1. traditional flat display systems, such as CRT or Screen.
2. display systems which locate on operator's head, such as HMD (which was developed by Fakespace Inc. in 1988).
3. display systems which surround operator, such as OMNIMAX (which was developed by IMAX Inc. ) , CAVE[1] (which was developed in Univ. of Illinois in 1993) or CABIN [2] (which was developed in Univ. of Tokyo in 1997).

The MEDIA<sup>3</sup> is fourth type of display systems, that is , MEDIA<sup>3</sup> is display systems which surrounds an object. In comparison with those previous three types , the MEDIA<sup>3</sup> is more conscious of the object.

Figure 1 shows positional relationship between the operator, the object and display system. HMD is the display system which surrounds the operator's head and CAVE or CABIN surrounds the operator's body. And CRT is located between the operator and the object. In the case of object oriented display, display encloses the object.

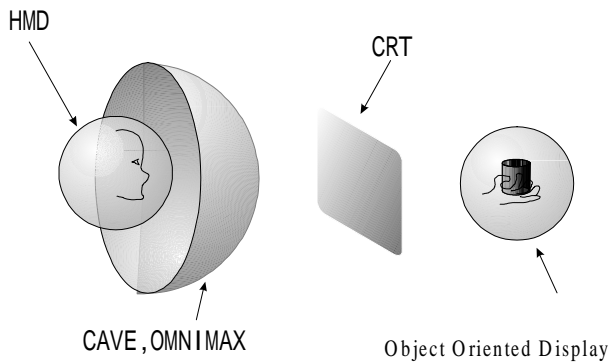


Figure 1: Positional Relationship between the Operator, the Object and Display System

In other words, the purpose of the MEDIA<sup>3</sup> is the presentation of the virtual object, though the purpose of previous three types display systems is the presentation of the virtual environment. The MEDIA<sup>3</sup> is duality of display systems such as OMNIMAX, CAVE or CABIN. In the case of OMNIMAX, CAVE or CABIN, an operator is located inside the display system and see outer virtual world through the display. And in the case of MEDIA<sup>3</sup>, an operator is located outside the display system and see inner virtual object through the display.

## 1.2 Details of MEDIA<sup>3</sup> design

The MEDIA<sup>3</sup> consists of liquid crystal displays (LCDs) which arranged in the shape of a cubic body (exactly a rectangular parallelepiped 159mm(W) x 127mm(H) x 189mm(D) 1.8kg(Weight) see figure2,3). Each LCD is 84.2mm in length and 115.2mm in width and the number of pixel is 224,649(960 x 234). And the view angle is 120 degree in horizontal 50 degree in vertical. It is ideal that LCD is square, but considering the cost we use common rectangle LCD.



Figure 2 : MEDIA<sup>3</sup>

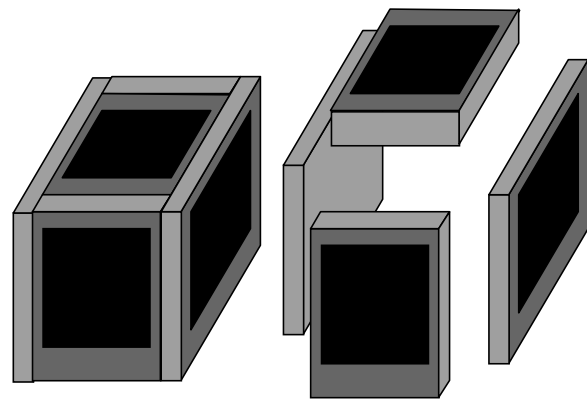


Figure 3 : The Structure of MEDIA<sup>3</sup>

Figure 4 shows the system of the MEDIA<sup>3</sup>. On the top face there is a transmitter coil of "POLHEMUS" sensor, which measures 3-dimensional relative position of receiver coil to transmitter coil by using magnetic field. And the operator put on a sensor cap, which have a receiver coil. In this way, we can obtain the relative position of MEDIA<sup>3</sup> to operator's view point. In this system, we use a SGI IMPACT2 for the graphic engine, and Impact Channel Option to output 4 images (NTSC) for each LCDs. But we are also able to build the system using 4 computers for each LCDs.

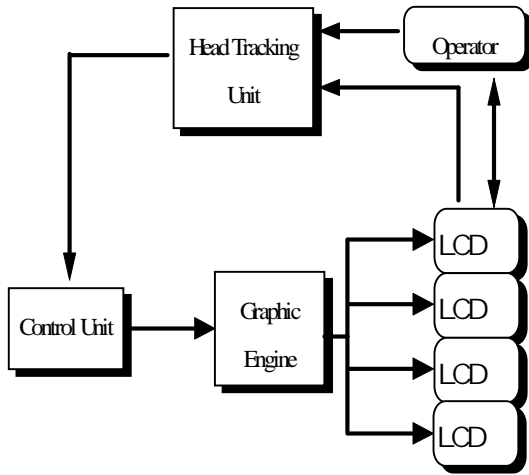


Figure 4 : Block Diagram of MEDIA<sup>3</sup>

And in this paper we describe how to synthesize those images. First, track operator's head position by POLHEMUS sensor (60 per second / maximum, 20 per second / average) and calculate the operator's viewpoint. According to the obtained viewpoint data, 3-dimensional data of virtual object inside the MEDIA<sup>3</sup> and the position of four corners of top plane LCD of MEDIA<sup>3</sup>, perspective view for top LCD can calculate by following way (using OpenGL).

We define the reference coordinate system as Figure 5.

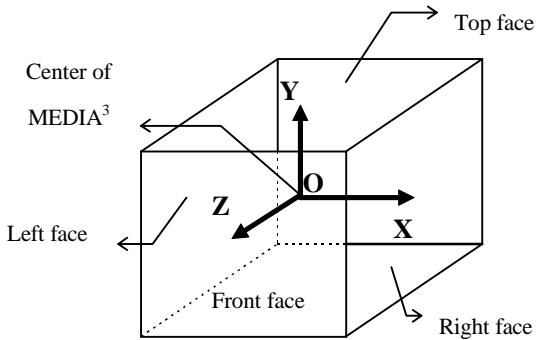


Figure 5: MEDIA<sup>3</sup> Reference System

As well known, The projection matrix of figure 6 is :

$$P_f = \begin{pmatrix} \frac{2near}{right-left} & 0 & \frac{right+left}{right-left} & 0 \\ 0 & \frac{2near}{top-bottom} & \frac{top+bottom}{top-bottom} & 0 \\ 0 & 0 & -\frac{far+near}{far-near} & -\frac{2far \cdot near}{far-near} \\ 0 & 0 & -1 & 1 \end{pmatrix}$$

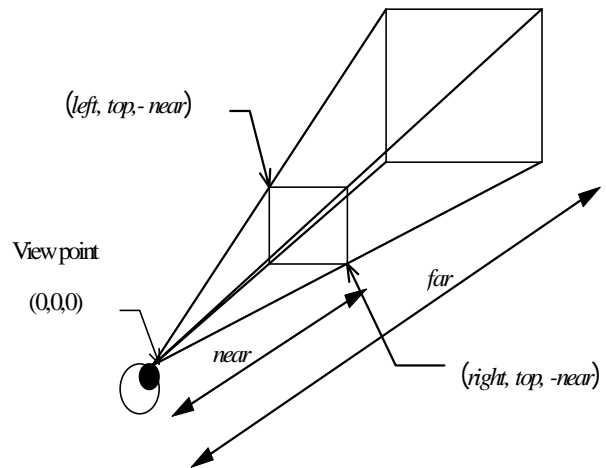


Figure 6 : Perspective Projection

Then the projection matrix for front face  $P_{front}$  is shown using a view point  $v(v_x, v_y, v_z)$ ,

$$P_{front} = Tv \cdot P_f$$

where  $Tv$  is  $-v$  parallel translation matrix,

$$Tv = \begin{pmatrix} 1 & 0 & 0 & -v_x \\ 0 & 1 & 0 & -v_y \\ 0 & 0 & 1 & -v_z \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

and using the width  $w$ , the height  $h$  and depth  $d$ , replace the variable as following.

$$\left\{ \begin{array}{l} right = -\frac{1}{2}w - v_x \\ left = \frac{1}{2}w - v_x \\ bottom = -\frac{1}{2}h - v_y \\ top = \frac{1}{2}h - v_y \\ near = -\frac{1}{2}d + v_z \\ far = \frac{1}{2}d + v_z \end{array} \right.$$

It is very easy to derive the matrices for the other face. Notice that since some graphic library (including OpenGL) defines the display plane as x-y plane, we need to multiply the matrix by convert axes matrix and/or multiply by the rotation matrix. Then we obtain all projection matrices and able to synthesize all images. Keeping on these sequence(60 times per second / maximum : 20 times par second / average), we can use MEDIA<sup>3</sup> interactive.

We indicate that MEDIA<sup>3</sup> is duality of CAVE (or CABIN). In the case of CAVE (or CABIN), an operator is located inside the display system and see outer virtual world through the display. And in the case of MEDIA<sup>3</sup>, an operator is located outside the display system and see inner virtual object through the display. So to speak, MEDIA<sup>3</sup> is not "CAVE" but "CAGE". This means some techniques for CAVE (or CABIN) is suitable for MEDIA<sup>3</sup>. It will possible and easy to create common graphic library for CAVE (or CABIN) and MEDIA<sup>3</sup>.

We also point out that graphic engine will synthesize at most three images at same time. Because when we see a certain face, we cannot see the opposite face at same time. Even if we want to construct six face MEDIA<sup>3</sup>, we need graphic engine which can display at lease three images and switching unit for selecting output display.

### 1.3 Using Multi-viewpoint Pictures

We also suggest not only 3-dimensional data but also multi-viewpoint pictures is effective for showing 3-

dimensional virtual object by MEDIA<sup>3</sup>. Prepare many photos from various angle in computer's memory, and select suitable photo according to the operator's viewpoint. Then mapping the photo on the plane which is perpendicular to the line from viewpoint to the center of MEDIA<sup>3</sup>. This means that not only virtual / computed object but also real object is able to be displayed by MEDIA<sup>3</sup>.

### 1.4 Applications

For the application of MEDIA<sup>3</sup>, we suggest some examples. MEDIA<sup>3</sup> is very useful for museum exhibits, for visualizing engineering or medical data such as CAD and MRI, as well as for communication, education and entertainment. For example we can use MEDIA<sup>3</sup> for the simulation of a wind-tunnel test. MEDIA<sup>3</sup> will allow us to get more intuitive and multilateral knowledge than when merely seeing the results on a 2-D display.

MEDIA<sup>3</sup> can also be a useful device for showing 3-dimensional crafting and assembly processes. When using an ordinary display, it is usually difficult to demonstrate how to make a 3-dimensional structural object. But using MEDIA<sup>3</sup>, this can be done easily because operator can directly compare the real object and the CG model.

As we have already mentioned, MEDIA<sup>3</sup> can be used as an electric pop-up encyclopedia or a virtual museum. Operator can even touch and handle an object which is dangerous or rare in the real world. Of course, additional programming will allow for more interaction between operator and the virtual objects. MEDIA<sup>3</sup> has many possibilities for educational applications.

And using computer network such as Internet, we can share the 3-dimensional object like documents, pictures, sounds or movies. For example we can use MEDIA<sup>3</sup> with WWW browser. On a certain WWW-homepage, these is 3-dimensional data which described in VRML, DXF or other 3-D data format. An operator access this page and click the object then the 3-dimensional data is downloaded and show the 3-dimensional object by

MEDIA<sup>3</sup>.

## **2. Proposal of the Concept of “Object Oriented Display”**

### **2.1 Outline of the Concept of “Object Oriented Display”**

In this paper we propose the concept of “object oriented display”. The MEDIA<sup>3</sup> is typical example of “object oriented display”. Using object oriented display, the operator can recognize a virtual object as if it is a real object, and handle the virtual object through the object oriented display. We define the object oriented display as display which satisfy following three conditions.

1. The display has function to show the virtual object.
2. The display has function to operate the virtual object inside the display by operating the display itself.
3. The operate to the display is equivalent to the operate to the virtual object inside the display.

In other word object oriented display is the display which enables an operator to perceive and to operate the virtual object as if it is real object.

### **2.1 Adopt the Human Skill**

The first merit of using object oriented display is it is able to adopt human skill. That is to say, we handle or look about the object oriented display in same way to handle or look about the real object. In other word, object oriented uses human skill which studied during one’s life. Because we repeat same action from the time we born to now , when we act, we estimate correctly what will happen. Especially we interlock view space and tactile space, so we can estimate the future vision when we handle an object, and can conjecture what was happened from the vision.

So it is very easy and natural to use the object oriented

display. Owing to this feature, we can recognize 3-dimensional object precisely. And we are able to operate more quickly and correctly.

### **2.2 Conscious of the Object**

Imagine a wind-tunnel test of virtual car. There is virtual car model in the center of virtual wind-tunnel. And you want to observe the flow of air from various angle. Of cause, it is possible by traditional VR display such as HMD or CAVE. But if you want to move the virtual car, it will be very hard, because you cannot handle virtual object. There is three way to solve this problem.

- (1) Using indirect device such as mouse, keyboard, and so on.
- (2) Using force / tactile feedback device
- (3) Using object oriented display

The first way, you need some training to operate as you want. Because you must learn how to convert the motion which you want into the operation of those device. Generally speaking, indirect devices is less useful than direct devices.

The second way, you need some of expensive and/or binding device. Force / tactile feedback device is experimentally device under present circumstance.

After all, the best way is to use object oriented display. For example using MEDIA<sup>3</sup>, you can handle and observe the virtual object inside the MEDIA<sup>3</sup> very easily.

As described above, object oriented display enables to handle caged virtual object through the display itself. And we also indicate that display systems such as HMD or CAVE are conscious of the environment, and object oriented display is conscious of the object.

## **3. Conclusion**

Object oriented display is very easy and intuitively to operate because the operation apply the native human skill. So very easy to learn how to operate for any

people. Secondary merit is that visual space fits haptic space because input device and display device are same. One of the demerit is object oriented display is not suitable to show virtual scene or virtual environment. But this is not fatal problem because object oriented display is able to coexist with the displays which is effective to show virtual scene or virtual environment such as HMD, CAVE or CABIN.

## References

- [1] Carolina Cruz-Neira, Daniel J. Sandin, Thomas A. DeFanti: Surround-Screen Projection-Based Virtual Reality: The Design and Implementation of the CAVE, COMPUTER GRAPHICS Proceedings, Annual Conference Series, 135-142, 1993
- [2] Michitaka Hirose, Tetsuro Ogi, Shohei Ishiwata and Toshio Yamada: A development of Immersive Multiscreen Display(CABIN), Proceedings of the Virtual Reality Society of Japan Second Annual Conference, 137-140, 1997 (in Japanese)
- [3] Naoki Kawakami, Masahiko Inami, Taro Maeda and Susumu Tachi : MEDIA<sup>3</sup> the Virtual Hologram, Proceedings of the Virtual Reality Society of Japan Annual Conference, 99-100, 1996 (in Japanese)
- [4] Masahiko Inami, Naoki Kawakami, Taro Maeda and Susumu Tachi : Virtual Hologram Proposal for the Object Oriented Display, Proceedings of the Virtual Reality Society of Japan Annual Conference, 139-142, 1996 (in Japanese)
- [5] Naoki Kawakami, Masahiko Inami, Taro Maeda and Susumu Tachi : Study of Object Oriented Device, Proceedings of the Virtual Reality Society of Japan Second Annual Conference, 340-341, 1997 (in Japanese)