A Proposal of Water Display

Yuki Sugihara*, Keigo YAMAMOTO* and Hideki HASHIMOTO**

*Department of Imaging arts and sciences
Musashino Art University
Ogawa 1-736, Kodaira, Tokyo 187, Japan
yuki@vss.iis.u-tokyo.ac.jp, keigo@nn.iij4u.or.jp
**Institute of Industrial Science
University of Tokyo
Roppongi 7-22-1, Minato-ku, Tokyo 106, Japan
hashimoto@iis.u-tokyo.ac.jp

Abstract

The purpose of this research is to show that how the Water display influence on a person. Water display is a sensing system using water. In this paper we would like to examine the implications of water as a display to a virtual environment.

Recent investigations have demonstrated that three-dimensional screen plays an important role in a virtual environment. It has been proposed that the wide-angle display such as Omnimax, CAVE to virtual immersion. It is clear that these cubic display is suitable for three-dimensional space. However, no speculation has been taken place concerning a shape varying screen and a well designed display. Therefor we would like to propose Water display. In the first part of this paper, we examine the construction of water display. In the second part of the paper, we explore the application of water display. and the third of it, we report future direction of this study.

Key words: water display, interactive art, interface, augmented reality, virtual reality

1. Introduction

1.1 Background

Fountain technology has been developed as water screen in past ten years. Let us begin our analysis from considering water screen. Figure 1 shows three methods to make a water screen using fountain technology.

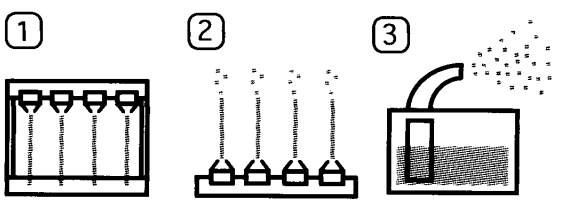


Figure1. three ways of water screen

In the first method, water is spouted down from many nozzles and it constitutes streaming water screen. Secondly, water spouted up from many nozzles in the same way as first one. In the third method, water is spread out and it makes misty water screen. First one can circulate water, however, others only emit water so that they must be set at sea or garden. We have to make clear next three problems. The first problem is that the size of opaque water screen is too big to set at indoor environment. The second point that requires clarification is that large scale water screen such as mist and waterfalls does not have a definite form. Water in the form of splash tends to be deformed the wind. The third point is the fact that large scale fountain need to be constantly maintained. It also have safety and high water consumption problems. Considering the above problems, we suggest water display as a new interface system. Water display is smaller and economic. It already has more defined form than the others. We use the term water screen for the former fountain using projection system, and water display for the proposed system.

1.2 The shape of the water display

First, Let us examine the shape of the water display. The first question we have to ask is how to compose a display using water. Falling water makes a water film when it strikes an object. Here, let us define falling water film as water membrane. We conducted the following three experiments to examine how to form a water membrane. Figure2 shows three characteristics examined in these experiments.

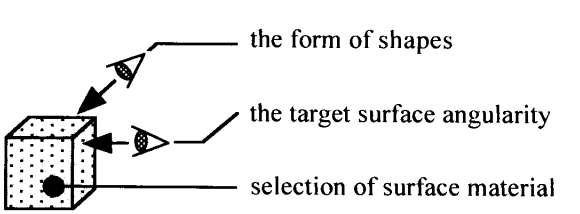
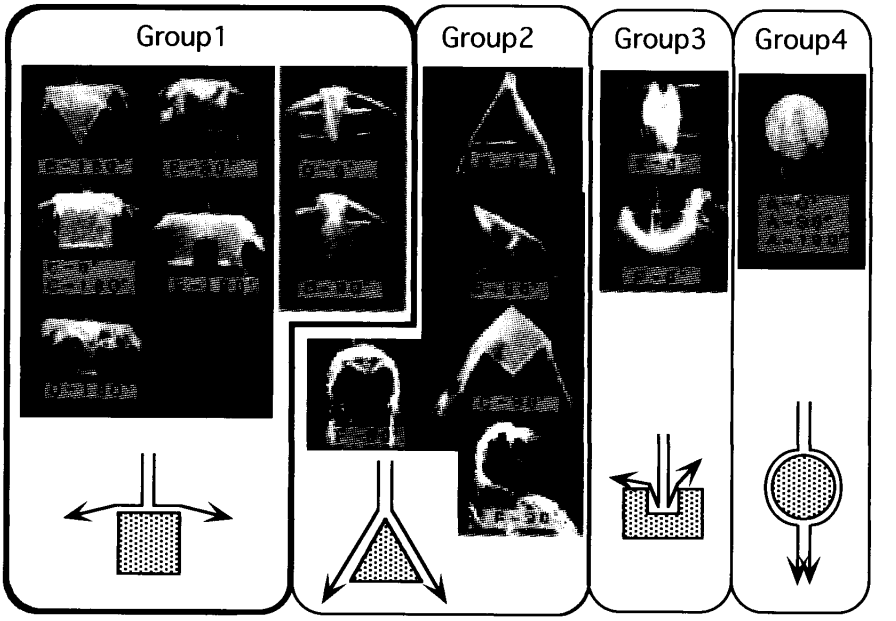


Figure.2 Three experiments

Table1. the six sample objects

rotation	0°	90°	180°
A			
B			
C			
D			
E			
F			

Table2. the form of water firm



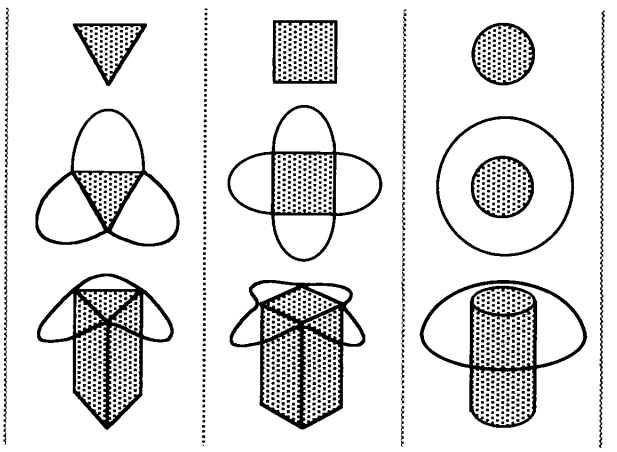
1.3 the target surface angularity

We prepared objects with various surfaces. Table1 shows the six sample objects. Each object have a cross area section of 38.4 cm and is 10cm long. We observed the resultant membrane when a water flow with 5.6l/s collide with each object in three positions. Table2 illustrates the groups of resulting water.

We see that in group2 water falls along tangent lines. Water did not form any water membrane in group3,4. Plane objects of groupe1 formed horizontal water membrane. Thus the conclusion from the above experiments is the fact that plane surface objects are the best for constructing water displays.

Table3 shows the experimented shapes. When water strikes an object with corners such as triangle and square, the membrane is divided at the corners. On the other hand, circle resulted in hemisphere water membrane, we selected it for constructing the water display. The target surface shapes ware examined in the experiments.

Table3. Experimented shapes



1.4 selection of surface material

Wet angle of water depends on material. We prepared six materials and measured with gonio-matar. Figure3 illustrates the concept of wet angle. measurements were realized using 10×10×6mm samples. Before the measuring, all samples were washed with alcohol and dried. The result of wet angles shown in Table4. Acrylic is the material that most repels the water so, it was chosen for being used as the target material. Accordingly we choised acrylic for collided materials with water.

Table4. The result of wet angles

Acrylic	74°
Copper	72°
Iron SS41	70°
Marble	60°
Stainless steel	65°
Aluminum	54°

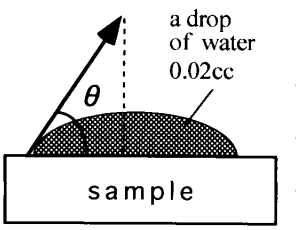


Figure3.
Measurement of wet angle

1.5 experiment of water membrane

The form of water display should be considered. The form of water membrane may change from flat to hemisphere. We made observations for the relation between the fluid and the water membrane. Figure4 illustrates the five points studied. Flux was held constant at18l/ min.

(1) callable of hose

Using 15mm caliber hose did not made water membrane. water became splashes.

Using 22mm caliber hose made water membrane hemisphere.

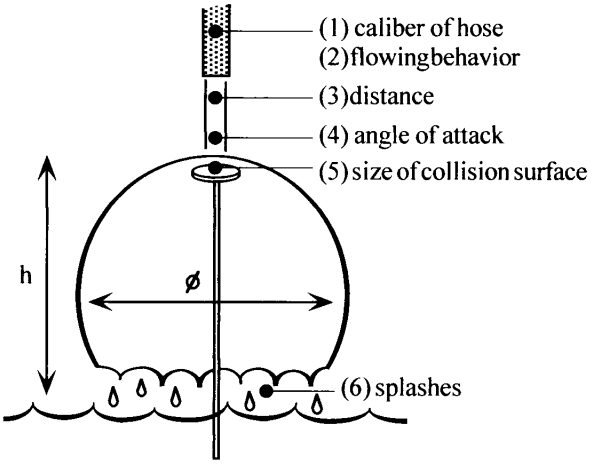


Figure4. experience of water membrane

(2) flowing behavior
15mm caliber hose emit water mixed air.
22mm caliber hose emit clear water.
Based on fluid dynamics, we can apply the following formula to these phenomena.

$$Re = \frac{U\,d}{v}$$

$Re < 2320$, laminar flow
$Re > 2320$, turbulent flow

The result means that water mixed air is turbulent flow and clear water is laminar flow. Only Laminar flow may form water membrane.

(3) distance
As set hose near collided materials, the diameter and the height of water membrane became bigger.

(4) angle of attack
When falling water makes a right angle with collided materials, water membrane is symmetry.

(5) size of collision surfaces
The diameter of water membrane may not depends on the diameter of collided materials.

(6) splashes
The end of Water membrane, water change into splashes.
On the assumption that the water membrane is boundary layer, we conclude that splashes are vortex flament of turbulent flow. Figure5 indicates boundary layer.

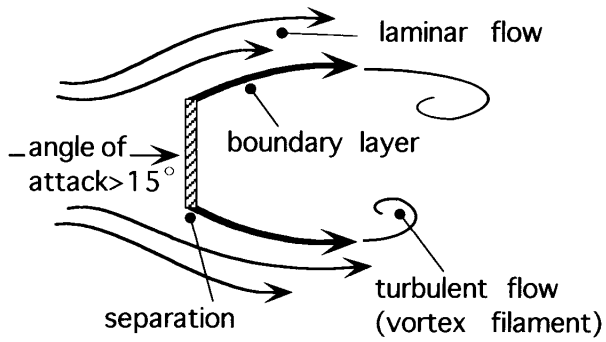


Figure5. boundary layer

2. Water dispaly

2.1 water and images
The former water screen system composed of water, projector and pump in shown Figure6.

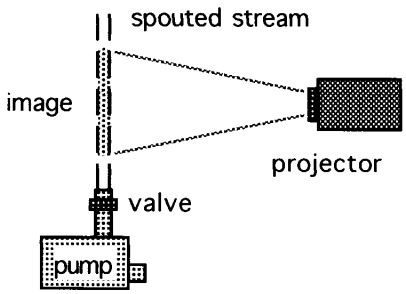
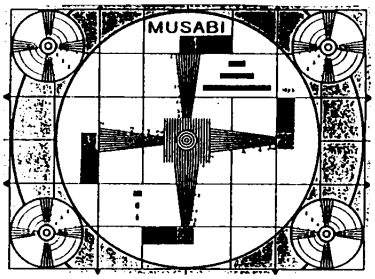


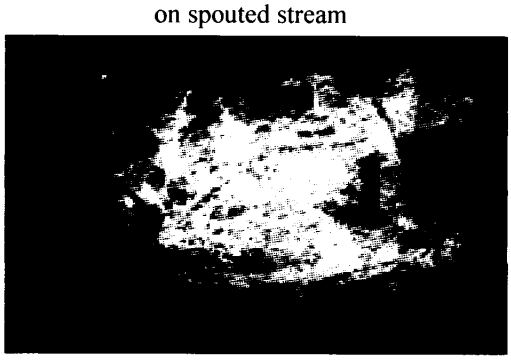
Figure6. water screen system

The main problem in this approach is how to project images into a opaque water screen. Water transformed into spouted stream contains air, consequently, it is muddy white. Water display, in contrast, is made of transparent, continuous water fluid. We used test pattern to compare images on both. Images obtained on spouted stream and continuos flow are shown in Table5 for comparison.

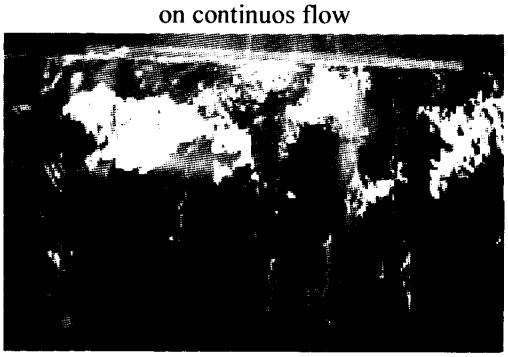
Table5. test pattern



on spouted stream



on continuos flow



It was demonstrated that spouted stream produces better screens probably because there is diffused reflection on its surface. Continuos flow go through, so it is hard to see images on it. Figure7 shows light reflection.

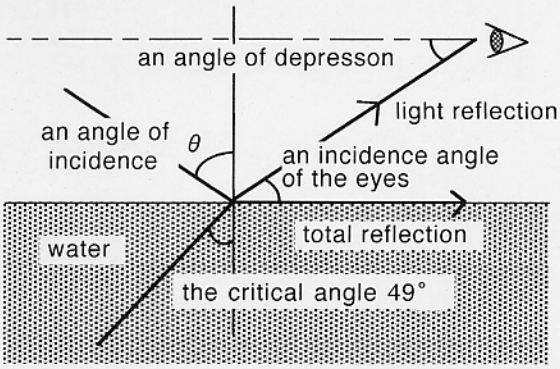
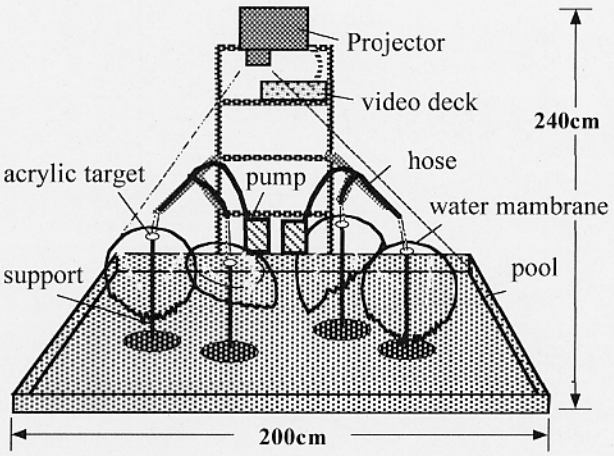


Figure 7. Light reflection

Light reflection depends on an angle of incidence to the surface of water. As an angle of incidence θ is become big, the percentage of light reflection on the surface of water become big. Increase of light reflection begin more than 60°. If θ is more than 49°, it is total reflection. For this reason, the light reflects on the surface and go through[1].

2.2 Installation of water membrane.

Based on these experiments, we constructed "Jerry fish" in 1994 and 1996 . Figure8 shows the water membranes in a pool that "displays" images using a projector. This installation was enjoying great popularity among spectators. In spite of water appear images on it, water colored with the images.



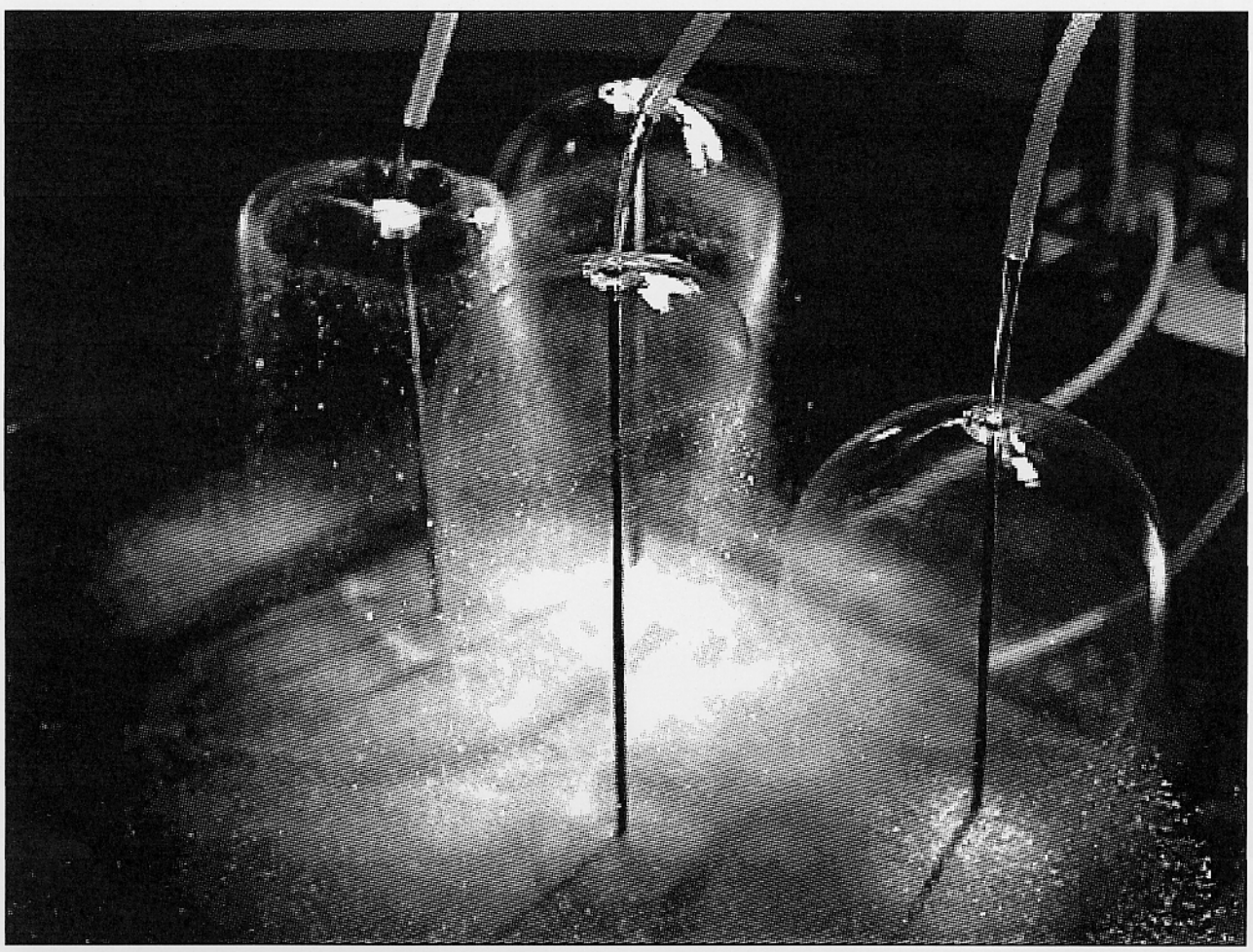


Figure 8. "Jerry fish"

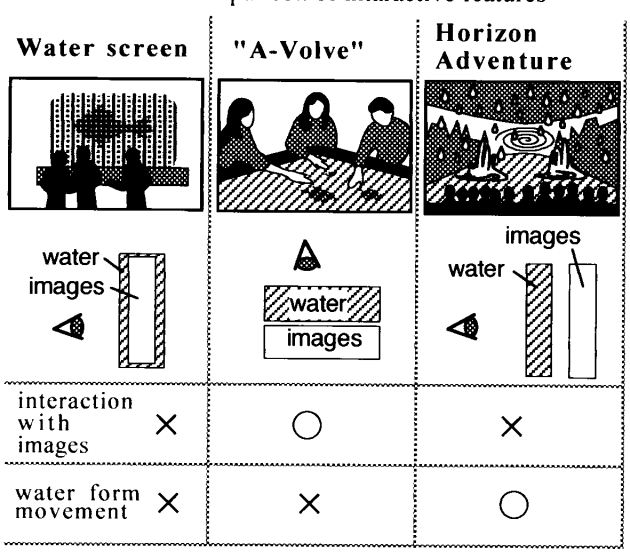
3. Water and interaction

Since the baroque era, in Europe, fountains have been constructed at center of the city. Cities in Italy are an example of the fountain people gathered around. In Japan, the oldest fountain was built at Kenrokuen, Ishikawa-ken in 1861. Fountain is a moving sculpture that appeals to eyes and ears simultaneously. These years, a system added advanced technology to fountains has been developed. Before we examine applications of water display, we tried to look over related works.

3. 1 Water application

We can experience the system of water and images, that is water screen at amusement park such as Disney Land. "Horizon adventure" at Huis Tenbosh in Nagasaki, Japan is likewise famous for riding simulator and 800 ton of water. Next, let's see an example of artificial life. Christa Sommerer & Laurent Mignonneau applied a water filled glass pool to their artistic computer installation "A-volve"[2]. All of them deal with water, there are own features in interaction. The comparison of interactive features are represented schematically in Table6.

Table6. comparison of intaractive features



It is clearly shown in the water screen that water can cast appear images and attract people, but there is no interaction at all. In "A-volve", visitors steep their hand in water and can interact with virtual creatures. In this case, water did not change the shape of water, however, it can be highly evaluated in using water as an interface. "Horizon adventure", the system of virtual reality, shakes people with motor-drived seat and surprises people with a large amount of water, nevertheless it is not interactive. It is the current state that of affairs that few interactive system you can change the shape of water and images. To satisfy these requirements of interaction, we develop an application of water display, "Mizunova".

3.2 Water display and interaction

We would like to focus attention on the feature of water display. When water flow is 5.6 liter per minute, water membrane is 0.7mm. It is very thin and when you touch the water membrane, it divides and the location of finger is clear. The phenomenon of water flow is shown in Figure9.

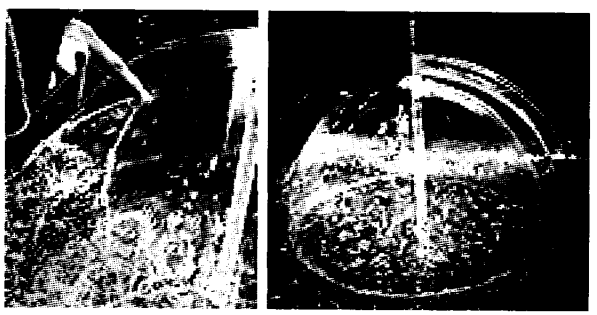


Figure9. disturbance in the water flow

3.3 Conception of MIZUNOVA

As development of media technology, the form of information has been changed. Besides, as advance of virtual reality, an interface of virtual world has became important. We created thus new system which presents virtual world and its contents with water display from motive of globe. In MIZUNOVA, we examined the study of senses of seeing, hearing, and touching of water interface. MIZUNOVA means a place of water in Japanese and we wished it would become new star as tool of virtual reality.

3.31 Globe

Globe is a ball-shaped model because of the earth is regarded as perfect sphere of invented in the Greece era. Surely the globe represents distance, direction, and area precisely than a plain figure. Searching a place which you want to know means only touching and rotating globe. Operation of globe is very simple and interesting. Turning now to the daily use of globe, we find the descent of chances to touch the globe. We often see the globe model in the programs of news and entertainment of a television as a set. We speculate that the globe has a special attraction to people.

3.32 internet

It is needles to say that internet has made great progress today. It is world wide network everybody receive and transmit information in real time. It is the merit of this internet to be free from a time and a place of access. We would like to stress that the construstion of hypermedia, that is you can deal with graphics, text, furthermore, the easy operation of to click. Animations of the rotating globe are freaquentry appere in homepages. It seemed reasonable to think that the social background to the present connection on the internet beyond the border. We similary find images of the globe in many chances presented 3D

Table7. Comparison of the contents of the world

	Globe	internet·WWW	MIZUNOVA
feature	Atom (analog)	Bit (digital)	+ Virtual Reality
surface materials	metal, plaster, stone, paper, plastic, etc..	monitor	water
type	ball-shaped	2D display	3Dworld + water membrane
feeling of touch	hard	click of mouse	cool
amount of imformation	on the surface	free	depends on hard disk
contents	text, illustration	images, text, sound	images, text, sound

computer graphics. It is likely that the images of globe is easy to describe thanks to the spherical form as a primitive model.

3.33 MIZUNOVA

A comparison of the worlds is shown in Table7. On the one hand the traditional globe is only a map (information) printed in a sphere, but on the other hand Internet allows interaction with various kind of information. Globe-display and Internet constitutes virtual worlds. The act of touching the globe corresponds to the act of clicking on a Internet link. Both of them direct us to the chosen information world. The present art tide includes the use of globe[3].

"MIZUNOVA" was proposed after the above considerations. Water display were used to enhance the sensation of touch and interaction. Water membrane remember us that earth is the water planet.

3.4 See-through head mounted display

We integrated images constructed with computer graphics, see-through head mounted display (SHMD) and the water display. It is difficult to project images on screens in illuminated rooms so water screens would be used only in dark rooms. Water screens could only be used in limited spaces and programmed times. The integration of SHMD removed restrictions on the system utilization and allowed us see superimposed virtual images on the water screen.

Virtual world and real environment integration through SHMD had to be performed carefully. The brightness of the SHMD was adjusted to allow the integrated visualization. In the first stage, a rear projector was used. The rear projector allows a better visualization of the finger touching and the real world during the interaction with the virtual world.

3.5 Interaction of MIZUNOVA

Polhemous sensor was used to combine water display and the pictures generated by computer graphics. Figure10 shows a user wearing a sensor on the finger and a HMD on the head.

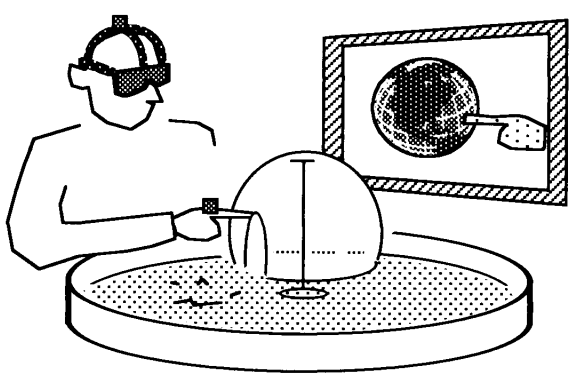


Figure10. water display as MIZUNOVA

Computer calculates the finger position and draws the picture corresponded to the touched region. One will see the water division and a CG-object projected from the division after touching the water display. Figure10 illustrates a users sight using SHMD. Water display will represent the globe in our setup. Water display is hemispheric and fits exactly to the globe shape.One needs to touch the globe with the forefinger for accessing the virtual world through the water display.

3.6 Contents

The earth was divided in 30 regions considering factors such as localization, country borders and cultural differences for constructing the virtual reality program. A correspondent object was chose for each region. For instance, pyramid and smiling sphinx were selected for

Egypt and a horse running around a pao-house for Mongolia. Big countries such as America were divided and were assigned more than one object. There is a cowboy for west America and the building of Manhattan for the east America. You will see these objects when you touch the water display. Figure11 shows the system.

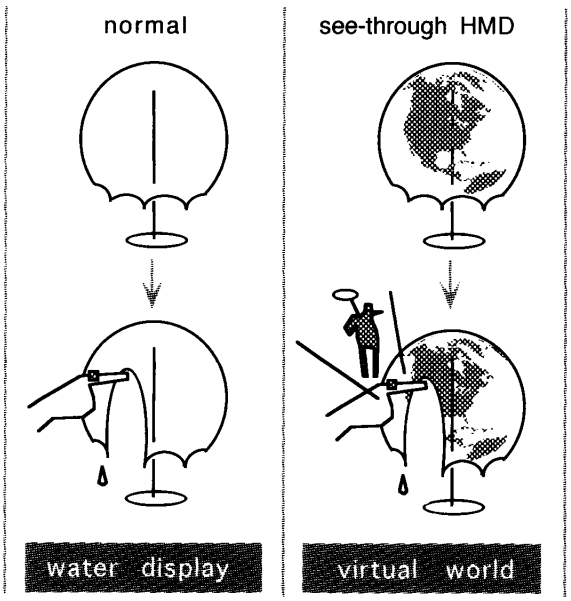


Figure11. water display and virtual world

Globe rotation is controlled by two virtual boxes projected besides the operator. Each box makes the globe rotate in the direction correspondent to these box. MIZUNOVA uses interaction to tell us small stories and to teach us about the various countries of the world.

3.7 The result of MIZUNOVA

Experimental results show that people with different ages can easily learn how to interact with the water display. Water display called the attention from persons with different nationality.

Water display is hemispherical and may be used as interface to any spherical virtual object. Water display is not an haptic device and does not have force feedback. A person may see movements and invisible objects in the present virtual reality systems. However, MIZUNOVA adds the sensation of soak to the virtual world.

The real-time interaction using water and images may result in a new interactive art. It was surprising how a lot of persons enjoyed the water touch and shape. MIZUNOVA was displayed in the Inter-College Virtual Reality Contest '96. It receive the art award[4].

4. Water head mounted display

Wide-angle displays such as Omnimax, CAVE, and Full solid angle display[5] were proposed for virtual immersion. In these displays, the projection system is big. These Big dimensions is a disadvantage due to the

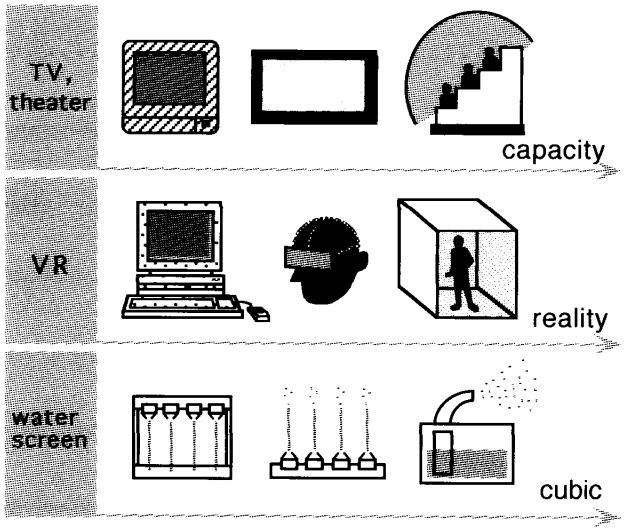


Table8. Displays size

reduction of places it can be constructed. The big dimensions represent high cost for maintainance, difficult structureproject, and high implementation cost. The above problems are similary for the water screens. Table8 shows the various dimension implementation of the diverse screens.

4.1 Water head mounted display

As final topic we will explain the head mounted water display proposal. Display with these size look like the natural step before constructing a display that covers the whole body. We are planning to make a head mounted water display. Figure12 shows the sketch of head mounted water display.

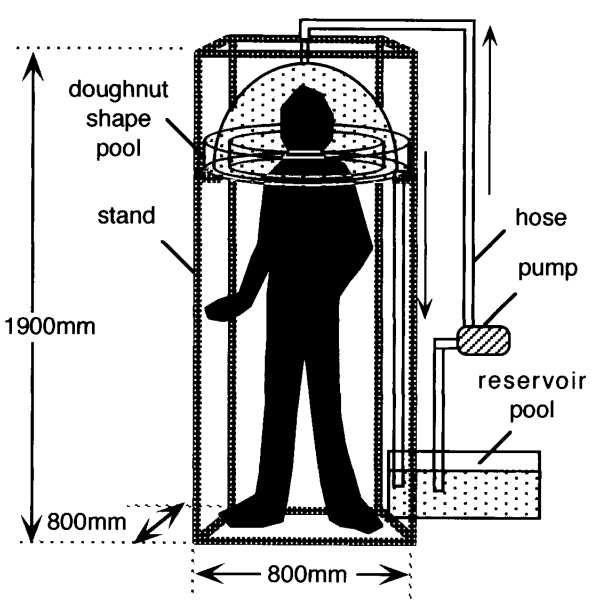


Figure12. Head Mounted Water Display

The head does not get drench because it is empty inside. You will put your head into a doughnut shape pool. Water will circulates through hoses. Adjusts the

water will cut the splashes.

Our first concern will be human feeling with head mounted water display. Following it, vision and audition data perception inside of display will be considered. The image projection will be studied after those consideration.

4.2 Other investigations

Iwata examined the projection of adjusted images to hemispherical display[6]. It seems appropriate to consider that add water dispaly to images in various way.

As Ishii Hiroshi has demonstrated in the case of ClearBoard that pairs of users shared workspace with glass board[7], and Jun rekimoto thorow out idea of human-real world interaction in augmented reality[8].It should be noted that water display provides tranceparent surface that you can see the other side of display instesd of usual opaque display. It could be compose with screen behind water display. Water display in addition, could face a certain object or a person. Water display may be used as a see-through display. From this point we might go on examine possibilities of various application of water display.

5. Conclusion

In this paper, the water display system design was investigated and implemented. The advantage of water display: possibility of image projection, interactions and enlargement ware also verified. Future developments will try to integrate these advantages in a system. The current research of water display and the future directions are shown in Figure13.

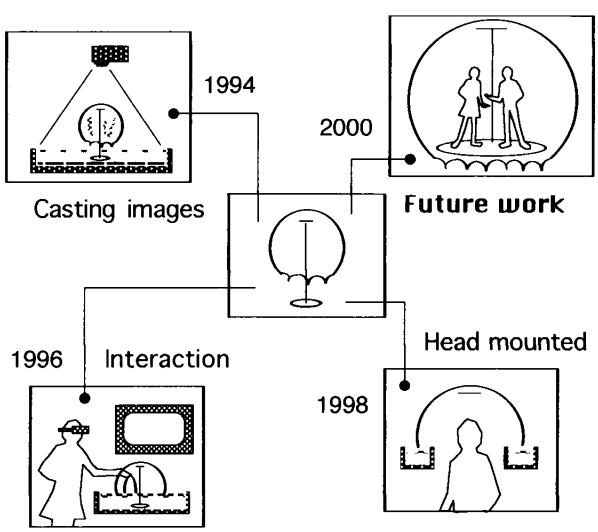


Figure13. future direction of water display

A lot of persons will criticize for not coloring the water to improve the projections. We would like to reiterate that we did not mixed anything to propse the transparent beauty and not poisonous character of the water. It is difficult to maintain these virtues when we add something to the water. One can experiment a non-pure water system at Kagakugijutsukan, in Tokyo. There a person can 'enter' a soap bubble. The experience leaves a uncomfortable sensation because of the mixture of soap and water. In view of fountain technology the use of mixture has the disadvantage of water cleanup necessity.

To achieve the aim of image display it will be necessary to consider adding another components: However, the biggest virtue of water display is its capacity of working as interaction tool. So despite the importance of image display we will continue to use pure water. Another similar problem is the viscosity change. In future works, the use of colored drinking water such as cocktail or hot spring water may be considered for 'water' displays. It would be interesting mainly for head mounted 'water' display.

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