DiVerdi, S., Rakkolainen, I., Höllerer, T., and Olwal, A. A Novel Walk-through 3D Display. *Proceedings of SPIE 2006 Electronic Imaging, Vol. 6055 (Stereoscopic Displays and Virtual Reality Systems XIII)*, San Jose, CA, January 15-18, 2006, pp. 428-437.

# A Novel Walk-through 3D Display

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## ABSTRACT

We present a novel walk-through 3D display based on the patented FogScreen, an "immaterial" indoor 2D projection screen, which enables high-quality projected images in free space. We extend the basic 2D FogScreen setup in three major ways. First, we use head tracking to provide correct perspective rendering for a single user. Second, we add support for multiple types of stereoscopic imagery. Third, we present the front and back views of the graphics content on the two sides of the FogScreen, so that the viewer can cross the screen to see the content from the back. The result is a wall-sized, immaterial display that creates an engaging 3D visual.

**Keywords:** Fog screen, display technology, walk-through, two-sided, 3D, stereoscopic, volumetric, tracking

## 1. INTRODUCTION

Stereoscopic images have captivated a wide scientific, media and public interest for well over 100 years. The principle of stereoscopic images was invented by Wheatstone in 1838 [1]. The general public has been excited about 3D imagery since the 19th century – 3D movies and View-Master images in the 1950's, holograms in the 1960's, and 3D computer graphics and virtual reality today. Science fiction movies and books have also featured many 3D displays, including the popular Star Wars and Star Trek series. In addition to entertainment opportunities, 3D displays also have numerous applications in scientific visualization, medical imaging, and telepresence.

Many techniques have been developed to create the impression of a 3D image floating in mid-air for different applications. These display technologies all attempt to artificially recreate the depth cues we naturally perceive when viewing a real 3D object. For example, stereoscopic imaging simulates binocular disparity cues by presenting slightly different images of the same scene to the left and right eyes, which is interpreted by the brain as a single 3D image. Virtual reality applications simulate motion parallax by tracking the user's head and rendering different views of the same 3D object depending on where the user is in relation to the object. 3D applications in general simulate realistic 2D images of objects with perspective and complex shading algorithms to create the impression that the virtual object is seamlessly integrated with the 3D scene.

Our contribution in this paper is the application of these simulated depth cues to a new display technology, for an exciting new way to view 3D imagery. We present a novel walk-through 3D display based on the patented FogScreen, an "immaterial" indoor 2D projection screen [2,3,4], which enables high-quality projected images in free space. We extend the basic 2D FogScreen setup in three major ways: first, we use head-tracking to provide motion parallax and correct perspective rendering for a single user. Second, we support multiple types of stereo vision technology for binocular disparity cues. Third, we take advantage of the FogScreen's two-sided nature to render the front and back views of the 3D content on the two sides of the FogScreen, so that the user can cross the screen to see the content from the back.

In this paper we first discuss related work in Section 2. The basic FogScreen is described in Section 3, and its pseudo-volumetric extension is explained in Section 4. In Section 5, we discuss the results and evaluation of our 3D display, and finally we present future work and conclusions in Sections 6 and 7, respectively.

## 2. RELATED WORK

One goal for all 3D displays is to create an illusion of depth in the image, so the user perceives a full 3D scene instead of a flat, 2D image. Since the eye only captures 2D images on the retina, 3D perception comes from a variety of cues that imply depth in the scene. Human depth cues of binocular disparity, motion parallax, convergence, and to a lesser extent, ocular accommodation, linear perspective and shading are essential for 3D image perception. Images, objects and user interfaces that seem to float in mid-air and have real 3D extent can be generated in a variety of ways, by artificially recreating the effects of depth cues from natural viewing. We briefly discuss various such displays here.

### 2.1. Stereoscopic and autostereoscopic displays

Stereoscopic displays [5] provide slightly different images for the left and right eye. This can be achieved many ways, such as with colored, polarized, or shutter glasses. The image pairs can be rendered on a monitor or projection screen, or even printed on paper for some techniques. The 3D object appears to float in air in front of, or behind the screen. Tracking of the user is not necessary but the correct viewing perspective is restricted, and user-worn glasses are required.

Autostereoscopic displays [6] require no special glasses or other user-worn devices for stereoscopic viewing. This can be achieved using e.g., parallax barriers or lenticular lenses. Typically, the correct viewing area and the resolution are somewhat limited.

In both stereoscopic and autostereoscopic systems, the viewer's position can also be tracked using any of a variety of standard tracking techniques, allowing the rendered images to be modified for the user's correct perspective, creating a more realistic effect. It expands the viewing area and enables the user to experience parallax by moving the head. However, this usually limits the display to effectively work for only a single user.

### 2.2. Head-mounted displays

Traditional augmented [7] and virtual reality often use head-worn, tracked displays [8] which draw virtual images directly in front of the user's eyes. World-stabilized 3D objects are possible using position and orientation head tracking to always draw objects from the correct point of view for the user. More sophisticated displays present different left and right images for stereo separation effects, but in general focal length remains constant across the entire image. These setups typically only provide a private image which cannot be seen without cumbersome user-worn equipment – collaboration requires each user wear separate display hardware. Artifacts such as misregistration and lag are commonly experienced problems that detract from the sense of presence in the virtual or augmented reality scene and may cause eyestrain, headache, and other discomforts.

### 2.3. Volumetric displays

While head-worn displays attempt to create the appearance of virtual objects within some work space, volumetric displays actually create the 3D image of a surface within a volume. The surface can be viewed from arbitrary viewpoints with proper eye accommodation since each point of light has a real origin in 3D. Tracking of the viewer is not necessary.

Volumetric displays are based on a broad and diverse collection of various methods, technologies and ideas. Numerous techniques incorporating e.g., fibre optics, mirrors or oscillating screens, have been developed to achieve this effect. Traub's display [9] creates a virtual image by varying the focal length of a mirror to produce a series of 2D images at different apparent depths. A real 3D image is generated by Actuality Systems' Perspecta display [10], which draws 2D images on a quickly rotating screen to fill the entire volume swept out by its path. The DepthCube Z1024 display [11] takes yet another approach, using 20 stacked LCD panels to light 3D points in space without any moving parts.

Unfortunately, these displays all create their 3D imagery in a fairly small enclosed volume that the viewer cannot enter. They are more suited for computer graphics than video applications due to the difficulty in capturing suitable natural imagery in 3D. One drawback is typically image transparency where parts of an image that are normally occluded are seen through the foreground object. Yet another difficulty that could give an unrealistic appearance to natural images is that of the inability to display surfaces with a non-Lambertian intensity distribution.

### 2.4. Large translucent displays

The dnp Holo Screen [12] and the HoloClear [13] displays make the screen practically transparent from the viewer's point of view, showing only projected objects. They are examples of screens that consist of an acrylic plate that is coated with a holographic film, such that it catches only light that is projected from a 30-35 degree angle. A bright and clear image can thus be obtained in daylight conditions, while the display is transparent from the opposite side. These types of transparent displays are single-sided and not penetrable.

When a projection system is combined with user tracking and a large semitransparent display, the result is a projection-based optical see-through AR system [14]. A serious limitation of such a setup, however, is its inherent single-sidedness. Requiring the user to stand on one side of the semitransparent display limits the number of simultaneous collocated users and complicates eye contact. Large planar collaborative workspaces, such as digital whiteboards with computer-supported interaction, suffer from the same problem. Even if these display technologies could be amended to support dual-sided rendering, collaboration across the display would be hindered by the material screen separating users.

### 2.5. Immaterial displays

There have been several displays using water, smoke or fog, with an early example presented by the Ornamental Fountain from the end of the 19th century [15]. More recently, water screen shows such as Water Dome [16], Aquatique Show [17] and Disney's Fantasmic [18], spray sheets of freely flowing or high-velocity water to create impressive displays for large audiences. The magnitude and wetness of these screens, as well as their large water consumption, make them impractical for indoor or small-scale applications, as well as preclude the viewers from comfortably passing through the display space and seeing crisp images from short distances. However, these water screens may be large and look good if viewed from afar and on-axis.

Many types of fog projection systems [19,20] have been used for art and entertainment purposes, but the rapid dispersion of the fog seriously limits the fidelity of projected images. The dispersion is caused by turbulence and friction in the fog's flow, which disrupts the desired smooth planar surface, causing projected points of light to streak into lines. This streaking causes severe distortion of the image from off-axis viewing angles.

Closely related to the FogScreen is the Heliodisplay [21], a medium-sized (22-42 inches) immaterial display based on the same principle as the patented FogScreen. It harvests humidity in the air by condensing it into water, which is then broken into fog. Heliodisplay's configuration blows these particles upwards to create a stable fog screen for rear-projection. An infrared (IR) laser can be used to illuminate a finger while a camera provides unobtrusive finger tracking. However, considering its single-sidedness, smaller format (compared to the FogScreen's ~100 inches) and tabletop setup, it is not a suitable basis for the kind of walk-through human-scale interactive display we are pursuing.

## 3. THE "IMMATERIAL" FOGSCREEN

To achieve an immaterial display, the FogScreen [2,3,4], on which our system is based, uses fog as a projection surface, creating an image floating in thin air (see Figure 1). If people walk through the FogScreen, the image will instantly reform behind them. It allows projection of interactive content, such as images, videos or animations, to appear floating in free space. It also enables to create special effects like walking through a brick wall or writing fiery characters in thin air.

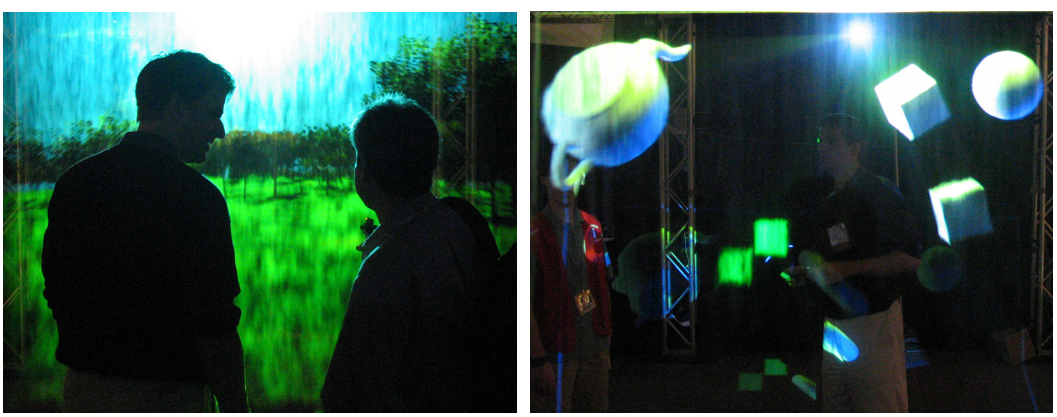

Figure 1: FogScreen can create fully opaque or very translucent high-quality images in mid-air. It can provide high visual detail.

The FogScreen employs an optimized, patented method for forming a physically penetrable 2D particle display. The basic principle is the use of a large non-turbulent airflow to protect a flow of, for example, dry fog particles inside it from turbulence. The outer airflow may get slightly turbulent, but the inner fog layer remains thin and crisp, enabling high-quality projections and the walk-through possibility. Ordinary tap water is broken into fine fog droplets and trapped inside this non-turbulent airflow. Even though the fog is made of water, it appears dry to the touch, just like air. The resulting thin, stable sheet of fog enables projections on a screen that is dry and feels like slightly cool air. The light from a standard projector is scattered through this sheet of fog, creating a rear-projection image.

The standard 2-meter-wide FogScreen works much like an ordinary screen in terms of projection properties. The FogScreen, however, passes some of the projected light, so it makes sense to use a bright projector. A 5000 ANSI lumens projector is usually sufficient for lit environments such as trade shows, if the background is dark. In dark rooms dimmer projectors will suffice.

Very tiny details like small text or extremely low-contrast images can not be seen clearly on the screen due to the changing texture of the flowing fog. The effective image resolution is best towards the top of the screen and somewhat deteriorates with increasing distance from the fog dispenser. Imagery without very fine details looks good, and color and contrast are vividly preserved. The image looks the best when viewed on-axis towards the projector, and is usable in most off-axis viewing directions. Only when viewed from side, over about 60 degrees, the adjacent pixels start to get disturbingly mixed with each other, due to the thickness of the screen (see Figure 2). Naturally this depends on the quality of flow, which depends also on environmental issues like wind.

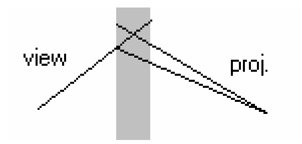


Figure 2: As the FogScreen image plane is not infinitesimally thin, the pixels may mix with the neighboring ones, if the image is viewed or projected very off-axis.

The FogScreen's opacity depends on many parameters such as fog density, projector and image brightness, and background of the viewing area. Depending on what imagery is projected onto the FogScreen, a variety of different effects can be achieved. By simply showing a computer's desktop display it acts much like a traditional projector screen. However, if the image is mostly black except for a few objects, the black areas appear transparent and create the effect of virtual objects floating in space in front of the user. If a full screen image of a virtual environment is displayed without text or abstract imagery, it creates more of a portal effect, giving the impression of looking through a window into another world.

The screen can also be made interactive, reacting to the touch of the viewers [22]. This turns the passive projection screen into an immaterial touch screen, and greatly extends the application possibilities. Interaction can be implemented with, for example, laser scanning [23]. The finger or a hand of a person standing in front of the FogScreen can be tracked to emulate mouse functionality.

The ability for a viewer to walk completely through the FogScreen makes it appropriate for enabling new viewing and interaction possibilities. While two traditional displays mounted back-to-back could present a similar pseudo-3D display to multiple viewers, the opaque displays would prohibit viewers from effectively collaborating across the two displays by obscuring users' views of each other, distorting speech, and making it difficult to pass physical objects across the display. This permeability of the FogScreen is important not only for imaging and visualization, but also for a variety of new interface techniques.

## 4. THE PSEUDO-VOLUMETRIC 3D SCREEN

Even though the basic walk-through FogScreen is a plain 2D projection screen, it is a volumetric display in the sense that the floating image is formed within a volume of empty, freely accessible space. The basic FogScreen can be extended to become a pseudo-3D display, while still fundamentally being a 2D display technology.

Our contribution is a novel interactive, dual-sided, wall-sized system that allows a single user to view objects floating in mid-air from any angle, and to reach and walk through them. Two individual, but coordinated, images are projected onto opposite sides of a thin film of dry fog, and an integrated 3D tracking system allows users on both sides to interact with the content, while the non-intrusive and immaterial display makes it possible to freely pass physical objects between users or move through the shared workspace. Our system opens up possibilities for a wide range of collaborative applications where face-to-face interaction and maximum use of screen estate is desirable, as well as the maintenance of individual views for different users.

The screen affords an image of 2 meters width (or 2.5 meter screen diagonal at 4:3 screen ratio) in the center of a large open viewing area that is limited only by available space and coverage by a 3D position tracker (see Figure 3). By tracking a single viewer's head, using correlated projectors on each side and adjusting the projected 3D graphics rendering accordingly, we create a pseudo-volumetric 3D display. This makes the 3D effect more convincing by showing the 3D object from the appropriate angle. The viewer can see objects floating in mid-air from both sides and freely walk around and through them to examine the scene from almost any angle. The eye cannot correctly focus at a real point within the image, but an impression of depth is still achieved due to other monocular cues, most notably motion parallax.

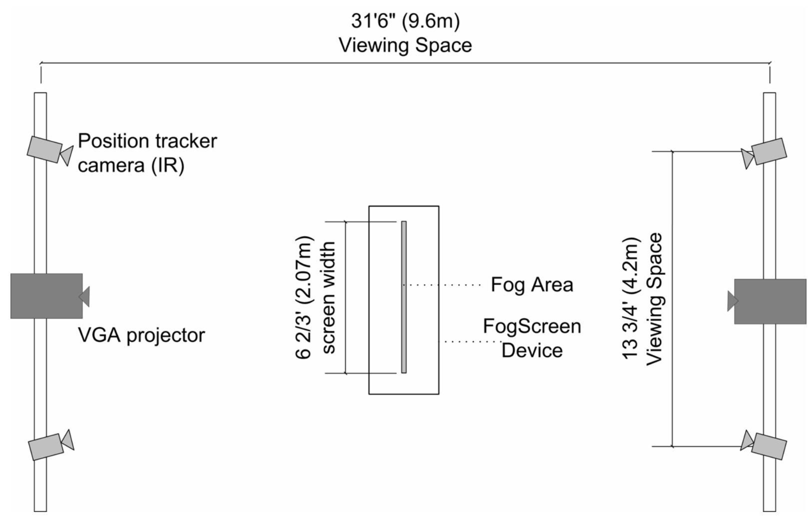


Figure 3: The dual-sided prototype system setup.

The immaterial nature of a thin sheet of fog allows a user to penetrate and even walk through the screen, while tracking a single user's head enables the pseudo-3D visualization. Using the dual-sided option of the screen, projecting coordinated opposing views, 3D objects can be observed from all sides. Also, stereoscopic imaging techniques can be used with the FogScreen. These techniques were all demonstrated to a small number of viewers for an informal user study to get an idea of 3D perception performance.

### 4.1. Stereoscopic projection

We experimented with a variety of passive and active stereoscopic rendering techniques on our display.

Passive stereoscopy with linear polarized glasses and filters [5] works without difficulty, as a thin fog layer accurately preserves light polarization. We used standard polarization filters and glasses for our experiments. Cross-talk between the left and right images is comparable with that resulting from the use of a standard silvered screen. Polarization requires two projectors, which raises the system cost. The computer must also be able to drive two separate projectors for a single-sided display, requiring four different views being rendered for dual-sided polarized stereo.

We also tested passive stereoscopy with red-cyan colored glasses [5], which worked fine with the FogScreen as it maintains proper image colors. Red-cyan stereoscopy only requires a single projector, making the system less expensive and complex than polarized stereoscopy, but the effect is limited to monochromatic imagery.

Since the FogScreen preserves image colors, the Infitec [24] passive stereo system could also be used, but we did not have one available for testing.

The last passive stereoscopy technique we tried was ChromaDepth [25], which color codes an image by depth value, with red pixels being nearest to the camera, followed by orange, yellow, green and finally blue in the background (see Figure 7). A pair of diffraction grating glasses shift colors so red areas appear near the user, while blue appears far away. The main advantage of this technique is that if the users are not wearing the special glasses, they still see a single coherent image, instead of two superimposed views as with red-cyan or polarized stereo. However, the tradeoff is that ChromaDepth is more of a heuristic and does not actually simulate eye separation and focal length of the user's visual system.

For active stereoscopy, we used a DepthQ 3D projector [26] with shutter glasses. While this projector model is quite affordable and may serve as an example for the ongoing reduction in costs for active stereo systems, this was still overall the most expensive option we tried, and the projector's brightness was lower than that of cheaper passive stereo solutions. Initial results indicate that the quickly changing turbulence pattern of the fog's surface over time causes a subtle difference between the left and right images of an active stereo projection, disrupting accurate separation and making it somewhat difficult to see a clear stereoscopic image. This problem will be partially solved as the screen quality will improve in the future.

In Section 5, we discuss the results from the various stereo options in a little more detail.

### 4.2. Additional depth cues

**Tracking the viewer's position in 3D**

Motion parallax, achieved by tracking the user's head position, is a strong monoscopic depth cue. Most any tracking technology suitable for virtual or augmented reality work could be used with our system. For this work, we employed a WorldViz Precision Position Tracker (PPT) wide-area 3D optical tracker [27] for head tracking. The PPT is a wireless 3DOF vision-based system that uses 2 or 4 cameras to track small near-infrared LEDs, which in our system are head-mounted. Each LED marker needs to be visible by at least two cameras at all times. The PPT can track up to 8 LEDs, but we need only one to track the viewer's head position.

Our setup uses four cameras, two on each side of the display (see Figure 3). The FogScreen is invisible in IR spectrum so it does not hinder the visibility of our IR LEDs. We developed a proxy VRPN tracker server [28] that filters the PPT output into more reliable data. The VRPN proxy analyzes the position and velocity of tracked objects to predict future positions and remove spurious detections.

The use of IR LEDs imposes the requirement of controlled lighting, since many regular light sources have IR radiation that will generate noise in the near-IR camera image. This problem is evident especially in environments with daylight or bright incandescent spotlights. Standard fluorescent lighting works fine, and the use of specific spotlights (i.e. with minimal IR radiation) or IR filters additionally allow incandescent light sources.

We use an IR LED on a headset for 3D position tracking (see Figure 4). The marker could also be custom-made into a miniature version for stereoscopic glasses. The right image in Figure 4) shows the current results of our miniaturization efforts. Our system works correctly for a single viewer, similar to virtual rooms and immersive workbenches [29].

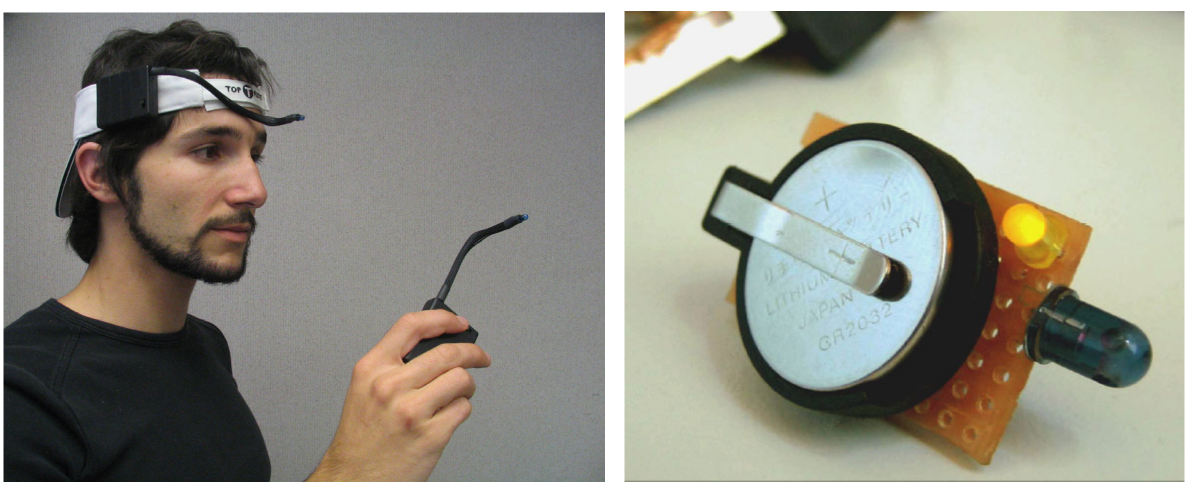


Figure 4: Left: Prototype headset with an IR LED for viewer's 3D tracking, and a hand-held IR pointer for 3D interaction.
Right: prototype miniaturized IR LED.

**Dual-sided projection**

To accentuate the sensation that these virtual objects actually exist in the physical world, the dual-sided capabilities of the FogScreen are used to show both the front and back of the objects, so that viewing the scene from opposite sides will present a consistent perception.

Back-projection is much brighter than front-projection. Very little of the projected light actually reflects from the fog layer back towards the projecting source. Therefore, the image is predominantly visible for a viewer on the opposite side of a projector (viewing a rear-projected image). The image on the same side as the projector is extremely faint. This feature enables us to simultaneously project different images on the two sides of the FogScreen without the images significantly blending with each other. The faint front-projection image means that there will be a slight ghosting in high-contrast regions, but, in our experience, the cross-talk is generally tolerable, and, in fact, negligible apart from the case where very bright imagery on one side coincides with very dark regions on the other.

More interestingly, two coordinated views of a 3D object can be shown on each side of the screen. For example, an application that displays a 3D object, such as a modeling and animation package, could show both sides of the object on the two sides of the FogScreen, creating a more convincing sense of presence of the virtual object in the physical environment. Figure 5 illustrates the dual-sided screen with the example of a human head seen from the front and back.

Dual-sided displays present many new opportunities in application interfaces. Perhaps the most straightforward idea is to display two independent applications on opposite sides of the screen, allowing multiple users to collaborate across multiple applications with ease.

Figure 5: The FogScreen's support for dual-sided projection allows two independent images to be projected on each side of the screen, such that the opposite sides of a 3D object can be rendered on the screen for a pseudo-3D effect. Left: front view. Right: rear view (as the head model's geometry is open at the neck, the front side of it is visible there).

Our system nicely accommodates multiple users. Different users that wish to view the 3D scene do not need to be on the same side, as is the case with traditional display technologies. Tabletop systems and immersive workbenches allow more users to share a workspace, but they do not all view the data from the same side – while a user on one side of the table may see text correctly oriented, a user on the other side will be unable to read it as it will be upside-down. With our dual-sided display, the same interface and layout can be presented on both sides of the screen, but text and images can be properly oriented so the user can view them correctly.

## 5. RESULTS

While the image quality is not perfect from off-axis viewing angles, the system works reliably and produces an appealing and intriguing human-scale reach- and walk-through pseudo-volumetric display. The viewer can view floating objects from both sides and freely walk around and through them and see the scene from any angle (see Figures 6 and 7). As the projection plane is 2D, the eye cannot accommodate to the right distance, but even without using stereoscopic effects the 3D nature of objects is emphasized by giving the impression of floating in free space. The 3D objects look fairly natural when viewed on-axis. On the sides the image starts to degrade and finally becomes unusable when viewed more than about 60 degrees off-axis.

Figure 6: A gray, non-textured teapot on the pseudo-volumetric 3D FogScreen as seen from the viewer.

Users who tried the head-tracking system took an initial period to become accustomed to the interaction, but found that the effect was convincing in making it seem as though a 3D object floated in the space of the screen. We had similarly encouraging results when we demonstrated the dual-sided rendering – users would often walk around the screen naturally to see the full scene and could easily get a better idea of the entire 3D volume without the need for interaction devices.

To test the stereoscopy techniques, we showed users a number of 3D images, including stereo photographs, random dot stereograms and rendered 3D images of simple geometric objects [30]. Overall, we found that the FogScreen is suitable for stereoscopic rendering, with an impressive 3D effect.

In particular, polarized stereo performed the best – the use of two projectors meant that images were brighter, which is an important consideration with FogScreen imaging. However, the downside to two projectors is that the stereo effect is very sensitive to correct calibration of the two images. The different projection angles for corresponding pixels also created some minor loss of edge sharpness at depth discontinuities, due to pixel smearing.

Red-cyan stereo also performed well, but the use of only a single projector resulted in darker images that were more difficult to see clearly.

ChromaDepth had the weakest effect, but this is not surprising as its performance is much less when viewed on a regular display as well.

Active frame-sequential stereo did not perform quite as well as we had hoped, as the time-varying turbulence of the fog disrupted correspondence between features in successive image pairs. The stereo effect was still quite perceptible, but overall, the passive stereo solutions performed better and were more cost-effective with the FogScreen.

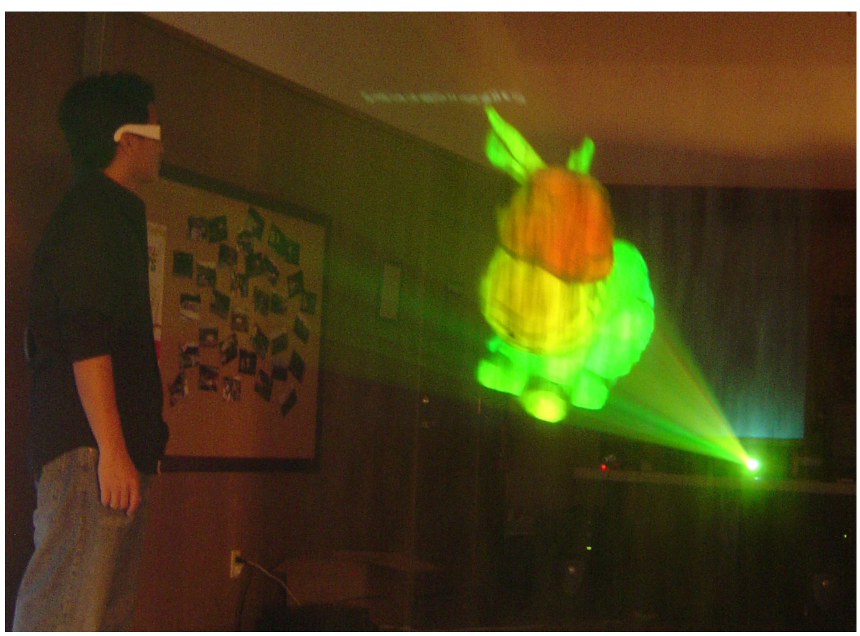

Figure 7: The pseudo-volumetric 3D FogScreen, displaying the Stanford Bunny [30] with ChromaDepth [25] stereoscopic imaging.

In general, users were able to see stereo imagery on the FogScreen reliably, but some types of imagery required more effort on the user's part than others. In particular, with random dot stereograms it generally took users some time for the 3D scene to become visible, while regular 3D geometry was easy and instantaneous to perceive. While the FogScreen can be viewed from up to 60 degrees off-axis for 2D imagery, effective stereo correspondence was limited to 15 to 20 degrees.

We also compared the FogScreen's stereo performance with a traditional silvered screen and found that the FogScreen creates a more pronounced sense of depth than a traditional screen. We measured this effect by having users estimate the extent along the viewing direction of the same geometry on the FogScreen and the regular screen, and found that users consistently estimated the same objects as roughly 50 percent longer when displayed on the FogScreen. Our theory is that this effect is rooted in the lack of a reference plane, as objects on the FogScreen appear to float in midair, whereas objects on the regular screen are perceived as being anchored in front of the screen plane. Also, the projecting "cones" emanating from the projectors, visualized by participating media beyond the transparent screen (clearly visible in Figures 6 and 7) may have contributed to this exaggerated sense of depth.

## 6. FUTURE WORK

In our future work we will improve the image quality of the display by further reducing turbulence in the smooth fog flow. This would improve image fidelity and increase the effective field of view, as well as allowing the realization of even larger screens. Stereoscopic imaging, especially active stereo, should also improve with less turbulence.

We are also interested in improving the sense of presence of virtual objects in the physical world by integrating haptic feedback into the interface. A haptic device such as the SPIDAR [31] would work well with minimal discomfort – a normal display would interfere with the necessary wires, but they can go through the FogScreen, and a SPIDAR is capable of the large range of motion necessary. It would also provide 3DOF tracking input for at least a single user, removing the need for an additional tracking solution.

Finally, in the interest in developing a fully volumetric 3D display, we are currently investigating the use of multiple FogScreens in various configurations to allow images to occupy a tangible physical volume surrounding the user. This would overcome a fundamental limitation of existing volumetric displays, allowing the user to become fully immersed in the 3D visualization.

## 7. CONCLUSIONS

In this paper, we have described a novel mechanism to create a pseudo-volumetric 3D walk-through screen. The implemented system enables one to view 3D objects in mid-air and observe them from almost any angle. Using it as an immaterial, head-tracked dual-sided display, has led to an enhanced visualization experience. It creates a strong visual effect of 3D objects floating in air, even when the image is not stereoscopic. This is a first step in the direction of a truly volumetric walk-through display.

Unlike many other volumetric displays, the pseudo-volumetric FogScreen is very large and does not restrict the user from "touching" the objects, leading to a more immersive experience. Interaction with the immaterial 3D objects can be supported, as we did in our demonstration at SIGGRAPH 2005 Emerging Technologies [22].

The FogScreen has shown itself to be a captivating display technology that immediately generates interest and excitement in the audience. The feedback from our SIGGRAPH 2005 demonstration was unanimously enthusiastic about the dual-sided, interactive experience. Since then, our demos of head-tracking and stereoscopy have been met with similar enthusiasm about the further improved perception of 3D imagery.

## ACKNOWLEDGMENTS

Special thanks to Andy Beall and Matthias Pusch at Worldviz LLC for loaning us a PPT unit in the early stages of this research.

This research was in part funded by grants from NSF IGERT in Interactive Digital Multimedia, the Sweden-America Foundation, Academy of Finland, the EC under contract FP6-511568 3DTV, TTY tukisäätiö, Emil Aaltonen Foundation, Tekes, Alfred Kordelin Foundation, Jenny and Antti Wihuri Foundation, and Finnish Cultural Foundation and its Pirkanmaa Branch.

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