Penetra3D: A Penetrable, Interactive, 360-degree Viewable Display

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ABSTRACT

Until today, though interaction modalities with a computer have seen changes, the very way of accessing the digital information has not changed. To access, all the digital information is left behind a screen. The work of ours, in this paper, looks into the possibility of whether this digital information can be brought out of the screen and be interacted with, as if with a real object. In this paper we present a novel, 360-degree viewable 3D display which not only enables the user to visualize 3D content, but also facilitates 3D interactions and other interesting possibilities for more advanced applications. Two such applications, navigation through maps and application in the field of medicine are also presented in the paper. The display system is an 'immaterial' fog display which exploits the property of directional scattering of light by fog. Using multiple projectors, different perspectives of a 3D scene/object can be projected and viewed on the screen, making it an auto stereoscopic 3D display. The depth sensor in combination with the display enables 2D and 3D interactions by the users, with the objects on the screen that appear floating in air.

Keywords: fog display, directional scattering, Mie scattering, 3D visualization, 360 degree viewable, motion parallax, stereoscopic, 3D interactions.

Index Terms:

1 INTRODUCTION

Since the evolution of computers we have been constantly trying to make the interface between the user and the computer better. We have moved from Command Line User Interface to Graphical User Interface and currently exploring the possibilities of Tangible User Interface [1]. But what has not changed over the years is from where this digital information is being accessed. The digital world is left behind a (computer) screen for close to a decade now. Our research was focused on 'whether it is possible to bring this digital information out from the screen, into the real world, render it in 3D and interact with it – the very same way we interact with a real 3D object?'. This required two steps – rendering 3D images in mid-air and interacting with them. In the later parts of the paper, we discuss the hardware enabling rendering of 3D images and interaction with them – our approach to solve the above said problem.

Over last few decades, stereoscopic imagery has been exciting general public – from 3D movies, holograms to present day computer graphics and virtual reality. Also, the ideas of 3D displays were presented in many science fiction movies till date. 3D displays, in addition to entertainment opportunities, also have numerous applications in medical imaging, scientific visualization and in realizing telepresence.

Many techniques have been developed in the past to realize 3D images appear floating in mid-air. Technologies used in Hitachi's Transport [2] and Sony's RayModeler [3] provides 3D visualization, but do not enable the user to directly touch and interact with the images appearing in 3D. Also, many of the existing 3D display technologies attempt to create the third dimension, for depth, artificially. For example, an illusion of a third dimension can be created by presenting slightly different images of the same scene to the left and right eyes, which is interpreted as a single image by the brain. Virtual reality employs head tracking and rendering different views of the same object depending on the user's relative position, to create motion parallax. In most 3D applications, 2D images of objects with perspectives are simulated with complex algorithms to create an impression of seamless integration of the object with the 3D scene.

For enabling both 3D visualization and direct interaction by the user, we have employed 'immaterial' fog display system. There have been systems which provide only 2D images on a flat fog screen, and enable both 2D and 3D interactions [5]. The fog display system [4] is a better solution to visualize 3D content. But it offers less room for natural interaction using an Infrared Camera and sensor. Unlike the fog display system [4], our display's down-up design may give a better feeling of images 'floating' in air. Also the depth sensing and finger tracking Leap Motion sensor enables direct gestural interaction with the virtual objects.

2 INTERACTIVE ATOMIZER-LEAP FOG DISPLAY

The fog display system being presented in this paper is based primarily upon the principle of Mie scattering. One of the motivations for exploiting Mie scattering is the formation of rainbow, which is a mid-air projection. As microscopic water droplets of size comparable to the wavelength of light causes Mie scattering, a cylindrical fog screen with atomized water droplets of size comparable to the wavelength of light is used. For the purpose of interaction, a depth sensing device (commercially available Leap Motion sensor) is used in combination with the cylindrical fog screen.

2.1 Hardware

The proposed hardware (Fig. 1) is a novel method for forming physically penetrable display. The basic idea underlies in creating a cylindrical fog screen where the particles suffer minimal turbulence. This is achieved by using an ultrasonic humidifier to atomize water to the size comparable to the wavelength of light. However, the fog thus formed is highly turbulent. A cylindrical tube with a nose cone structure built into it is used, with nozzles along the boundary of the tube, to reduce the amount of turbulence. The voltage controlled fan used at the bottom of the tube helps in increasing the vertical length of laminar flow of fog thereby increasing the vertical length of the cylindrical fog screen.

As discussed earlier, fog/mist shows strong forward scattering of light. As a result, even if multiple images are projected from multiple projectors onto the fog screen, the observers can see only those images emanating from the frontal projectors (the projectors across the viewing user). Therefore when multiple perspectives of a single 3D scene are projected using multiple projectors, the

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observers can realize the 3D shape of the object when looked around the cylindrical fog screen. This system acts as a good auto-

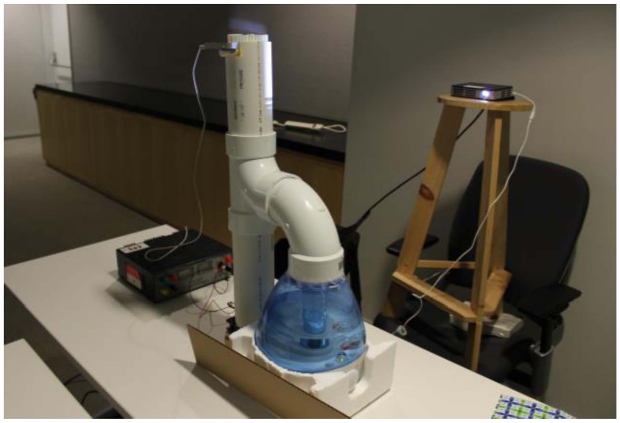

Figure 1: Cylindrical fog screen prototype with depth sensor

stereoscopic system. Also, different users can see different images/content on (around) the screen, without interfering with each other. This opens interesting possibilities of space multiplexed computing.

While the above-mentioned arrangement helps in pseudo-3D visualization, the depth sensor (commercially available Leap Motion sensor) arrangement on top of the cylindrical tube – just below the cylindrical fog screen – helps in interacting with the virtual objects projected on the fog screen, directly with hands.

In the current prototype, projector with resolution 800x600 pixels is used. The image can be viewed in most off-axis viewing directions, up to 40 degrees w.r.t. axis, though viewing on the axis towards the projector yields the best image. When viewed from off-axis angles, quality of the image from the sides is reduced as pixels blur into each other. Though tiny text and images may not be very clear, most imagery looks good with color and contrast vividly preserved. The thickness of the fog causes images to become quite blurry compared to conventional projector setups.

2.2 Interactions and Applications

The proposed system is applicable in a variety of fields ranging from geological surveillance, to medical imaging, to art and advertising installations and many more. This system, equipped with a 3D depth sensing device, enables the user to interact with the virtual digital image with as much ease as with a real object. Also it offers an excellent advantage of visualizing the digital content as 3D/pseudo-3D projections in mid-air.

An application of Google maps was launched to evaluate the ease of navigation on the system (Fig. 2). The interface was completely natural and the user was able to navigate through places intuitively. A second application involved display of 3D structure of brain where the user would be able to navigate through different layers of brain, as if a real brain is dissected (Fig. 3). But as the picture was somewhat blurry on the fog screen, only the outer layer was relatively effective to see.

3 Conclusion And Future Work

We have presented novel hardware and interaction technique for bringing the digital information out from conventional computer screen, render the digital information in 3D and interact with it.

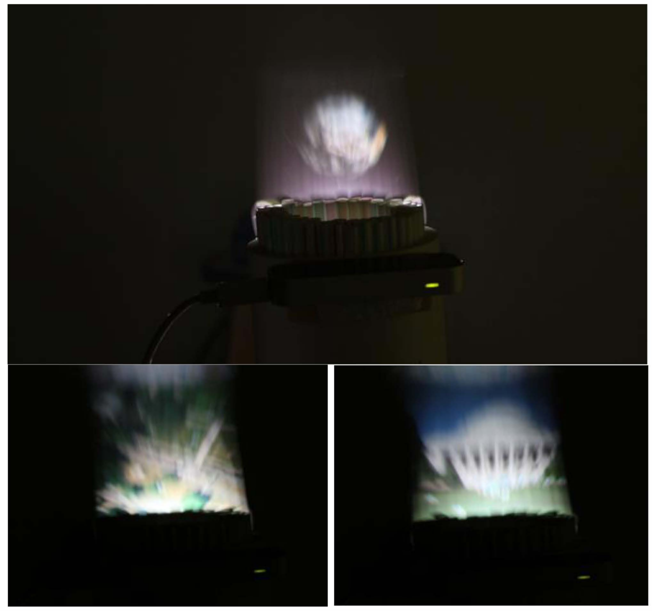

Figure 2: Photographs showing navigation through maps.

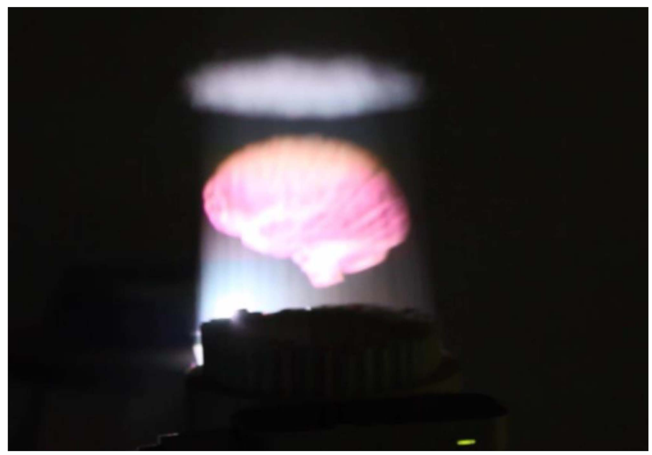

Figure 3: A 3D visualization of human brain.

Future work includes scaling up the current hardware, improving the quality of the images and adding more interaction techniques.

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