

# Chapter 36

## The Mid–Air FogScreen and User Experiences

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### ABSTRACT

*The “immaterial” FogScreen™ is an emerging display technology that enables high-quality projected 2D images in mid-air. It also appears dry and non-existent to touch, so reaching or walking through the image is possible. It is becoming widely used in many settings and can also be extended to become a stereoscopic or virtual reality mid-air screen. This chapter consists of two major sections. The first section describes the basic mid-air screen technology and its 3D and VR extensions. The second section describes our user experiences and lessons learned with them when using mid-air screen.*

### INTRODUCTION

Futuristic visions of mid-air images are frequently seen in TV commercials and sci-fi movies. Illusions of images floating in free space or 3D images that have real depth can be generated in a variety of ways, but most of them are not truly in thin air. Volumetric displays do create real 3D images instead of a 3D illusion, as the light is emitted from the actual 3D positions, but the images are in a confined display volume and interaction

with them is limited. Virtual environments try to create illusions of virtual objects in an immersive environment, whereas augmented reality adds synthetic objects to the real world.

The patented FogScreen™ (Palovuori & Rakkolainen 2002, Palovuori & Rakkolainen 2004, FogScreen 2010) mid-air projection screen is an emerging display technology that enables high-quality projected images hovering in thin air, which the viewer can reach or walk through (Figure 1 left). It is a break-through technology, literally! It is basically a 2D screen, but it can be extended to a stereoscopic display. If 3D tracking

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of a viewer is used, it becomes a walk-through virtual reality display, which augments virtual mid-air objects into real environments (Figure 1 right). We will describe the technology in the next section of this paper.

The mid-air display is somewhat unusual, and also user experiences are different from other displays. The mid-air effect intrigues audiences and the user reaction is usually very positive. Due to the “immaterial” nature of the display, the user interface design requires also some extra attention and provides some new user interface opportunities. We will discuss our lessons learned in the later section of this paper.

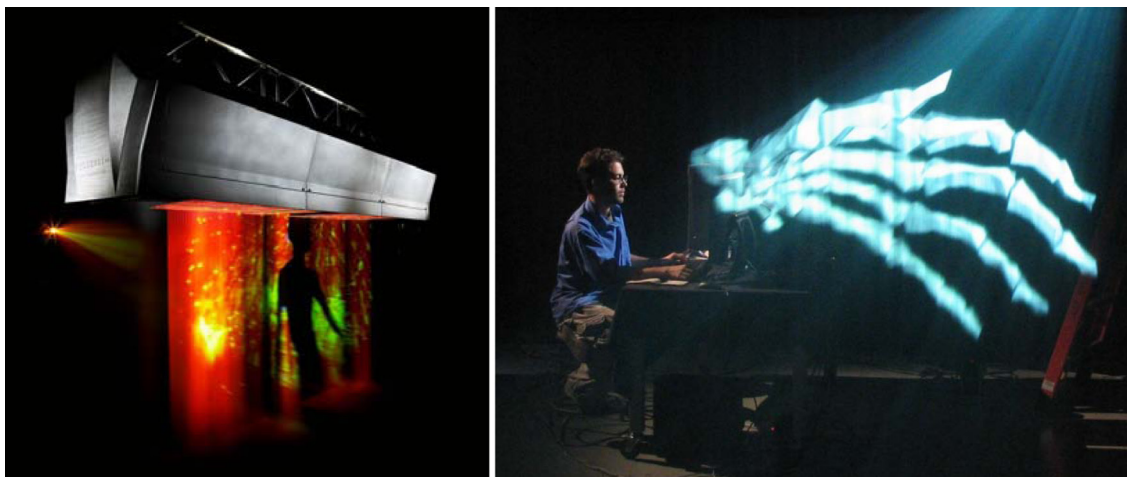
## **THE FOGSCREEN™ MID-AIR DISPLAY TECHNOLOGY**

There are numerous projection screens using water, smoke, fog or cryofog (liquid nitrogen), which have been used as a special effect in art and entertainment. The earliest example is the Ornamental Fountain (Just, 1899) dating back to the end of the 19th century. More recently, fog

and water screens such as Jeep Waterfall (Jeep Waterfall, 2010) and Disney’s Fantasmic show (Disney, 2010) create impressive screens for large audience. These screens are often wet, or the fidelity of the projected images is low. If fog is used, it disperses rapidly due to friction and dynamic pressure difference in the flow, which disrupts the desired smooth planar surface and severely distorts the image.

The image quality on the FogScreen is optimal for a particle screen and significantly better than with any previous particle screen methods, even though not quite as good as with traditional screens. Any kinds of particles such as water vapour (fog), dust, smoke or even wheat flour could be used, but fog is by far the simplest and lowest cost particle. Small amount of tap water is broken into tiny fog particles so that they feel very dry and soon evaporate to air. No chemicals are used. The injected thin, non-turbulent particle flow is protected by a surrounding non-turbulent airflow, thus keeping all flows laminar, as depicted in Figure 2 left. This enables high-quality projections and a dry walk-through experience. Any projector and media content (e.g., images, videos or 3D

*Figure 1. The FogScreen mid-air display is an intriguing walk-through experience. The device is suspended e.g., from a truss and a projector is placed behind the screen (left). A 3D model of hand bones on a virtual reality FogScreen (right).*



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