Chapter 82
Improved Interaction for Mid-Air Projection Screen Technology

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ABSTRACT

Mid-air, walk-through fogscreens are frequently used in trade shows, theme parks, museums, concerts, etc. They enhance many kinds of entertainment experiences and are captivating for the audience. Currently, they are usually employed only as non-responsive, passive screens for "immaterial" walk-through special effects. Suitable sensors can turn fogscreens into interactive touch screens or walk-through virtual reality screens. Several interactive systems have been implemented. However, the cost and other features of 2D and 3D tracking sensors have been prohibitive for wider commercial adoption. This chapter presents a Microsoft Kinect-based 2D and 3D tracking for mid-air projection screens. Kinect cannot track through the fogscreen due to disturbances caused by fog. In addition to robust tracking and lower cost, the custom Kinect tracking also brings along other advantages such as possibilities for projector's hotspot removal, ballistic tracking, multi-user, multi-touch, and virtual reality setups, and novel user interfaces.

INTRODUCTION

A "holographic" display in thin air has been the Holy Grail of display technology (Shedroff & Noessel, 2012). Many techniques can create an impression of a 3D image floating in mid-air (Benzie et al., 2007). Most such 3D displays are not truly mid-air or penetrable, but only provide a limited visual illusion. For example Musion Eyeliner projection system (http://www.eyeliner3d.com/) can create stunning illusions of objects in mid-air, but the image is actually on a transparent, solid sheet. Walk-through is not possible. Volumetric displays emit light from the actual 3D positions, but the images are usually in a confined display volume and interaction with them is limited.

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There are many water, smoke and fog screens and related patents since the end of the 19th century, as the Ornamental Fountain (Just, 1899). Even before that the Phantasmagoria stunned people in the 18th and 19th centuries (Blundell, 2011). More recent examples are impressive water screen shows outdoors (e.g., Aquatique, 2014) and a 360-degree multi-projector fog display (Yagi et al., 2011). The image quality of these particle screens is usually low, or the overflowing wetness makes many of them impassable.

Fog is a good candidate for the material of a particle screen. It can be created from pure water, being thus very low-cost and available everywhere, and if the fog particles are small enough, they feel dry to the touch, enabling a dry walk-through experience. The "dry" fog evaporates quickly and does not cause significant accumulation of humidity in normal environments.

An unprotected fog flow disperses rapidly due to the turbulence induced by the dynamic pressure differences between the flow and the surrounding air, disrupting the desired smooth and planar surface and thus severely distorting the image. Even if the goal were to make a 3D or volumetric image on a particle screen, this is best accomplished with a very thin, non-turbulent flowing particle screen aided with proper viewer tracking.

Creating a thin, uniform, lasting particle screen is essential for good image quality. Even if the fog flow is non-turbulent when ejected, it will disperse rapidly, and will not create a thin and long screen. Some patents have tried to solve the planarity/image quality problem by using various kinds of air curtains etc. to protect the planarity of the particle flow, but even so the fog flow and the two protecting flows have some dynamic pressure differences.

The optimal method for forming a particle display (in terms of image quality) is the FogScreen (Palovuori & Rakkolainen, 2004). It forms only one wide, non-turbulent flow, within which there is a thin fog flow, being a part of the other flow. The injected particle flow is protected by the surrounding airflow, thus keeping the screen flat and enabling high-quality projected images hovering in thin air. Separate air curtains are not required at all, and the one flow containing the projection screen in itself is adequate.

These fogscreens (Fogio, 2014) create stunning effects among the general public or performers on stage. To some degree, the fogscreen is always a living surface, as the fog flow tends to get slightly turbulent further away from the device and eventually starts to break up. Nevertheless, it creates a concise and thin particle projection screen and produces superior image quality compared to previous methods.

The FogScreen enables high-quality images to float in free space. The images can be walked or reached through, as the screen is unobtrusive and "immaterial", and consists of a thin sheet of dry fog. The light from a rear-projection is scattered through this sheet of fog, creating an image in mid-air. The general public and media often describe these walk-through mid-air images as "holograms".

Any standard projector can be used, even though ultra-short throw projectors are not recommended, as it reduces the visual quality significantly. A dark backdrop is very useful for the mid-air effect. A window or bright lights behind the screen are not good for the experience. The fogscreen also passes some of the projected light, so a slightly brighter projector than usually is needed. Laser projections can be extremely bright and truly impressive.

The challenge for *interactive* fogscreens is to robustly track a pointer or a finger of a person standing in front of the FogScreen to implement reliable and accurate touch screen functionality. Many types of sensors can be used to create interactive displays (Benko, 2007; Buxton, 2014). However, there are no off-the-shelf user tracking solutions for the fogscreen. Some tracking products are fairly suitable, but typically modifications for them are needed due to the immaterial nature of the mid-air screen or disturbances caused by the fog. Also the accuracy, price or other features of various trackers often leave much to be desired.

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