Levitate: Interaction with Floating Particle Displays

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ABSTRACT

This demonstration will showcase the current state of the art levitating particle display from the Levitate Project. In this demonstration, we show a new type of display consisting of *floating voxels*, small levitating particles that can be positioned and moved independently in 3D space. Phased ultrasound arrays are used to acoustically levitate the particles and users can interaction with each particle individually using pointing gestures. Users can interact with the system in a walk-up-and-use manner without any user instrumentation, creating an exciting opportunity to deploy these tangible displays in public spaces in the future. This demonstration explores the design potential of *floating voxels* and how these may be used to create new types of user interfaces.

Author Keywords

Tangible Displays, Ultrasonic Levitation, Multimodal Displays.

ACM Classification Keywords

H.5.2. User Interfaces (Input devices and strategies).

INTRODUCTION

Novel display form factors are becoming more increasingly prevalent in public displays as technology because more robust and new input techniques are developed to enhance interaction at public displays. Levitating particle displays are a promising approach to create tangible displays to support direct manipulation. Sound can be used to levitate objects in mid-air by trapping them in the low-pressure nodes of standing waves. Recent research has enhanced this simple concept with the ability to levitate multiple objects in a plane [4], move multiple objects in 3D [5], and rotate them as well [2,6].

This demonstration explores different techniques for interacting with individual pixels on a levitation particle display. We consider levitated objects as *floating voxels,* and see their potential as a new type of display. Displays created from floating voxels do not require any user instrumentation (e.g., head-mounted displays), can be viewed from many angles, and users can see through them, since the objects are held in mid-air by sound. This means they naturally support collaboration and could be used to create new multi-user interactions and experiences. In this demonstration, we describe a design space for *floating voxels* and how these can be enhanced by multiple modalities.
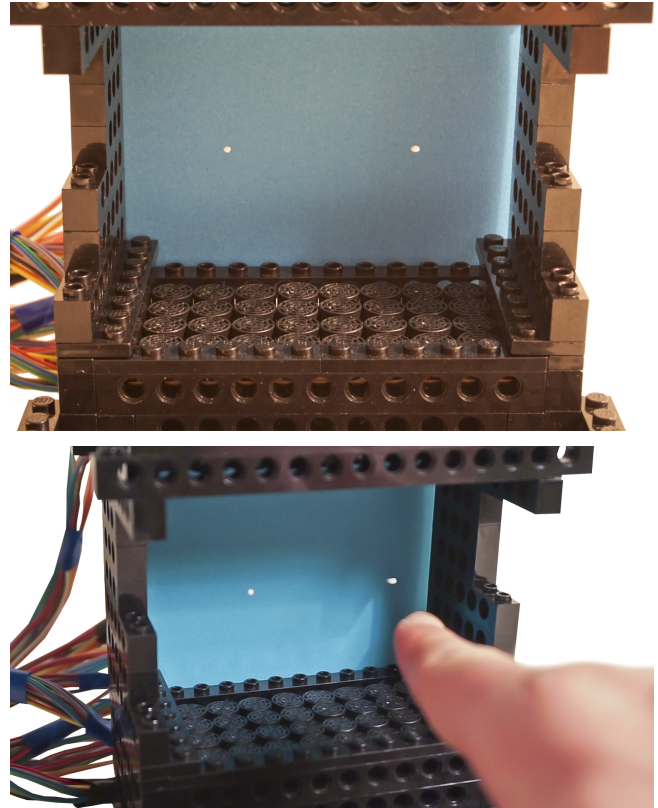

Figure 1. Arrays of ultrasonic transducers can levitate particles to create tangible displays. We are exploring different techniques for interacting with these displays. Note that the blue background is only included to increase visibility of the levitating particles and is removed during demonstration so that users can look *through* the display. Top: Two floating particles create a two pixel display suspended in mid-air. Bottom: Users can select pixels by pointing without wearing any additional sensors.

RELATED WORK

Tangible displays made from dynamically controlled particles have been attempted using a variety of techniques. Ishii's radical atoms vision, which describes human-material interaction through material that can change form and appearance dynamically, has inspired many different interfaces. Levitation has been achieved using magnetic forces [1] and acoustic fields [3–5].

One area in need of additional research is how input and interaction should be design for levitating displays using acoustic fields. Although acoustic field levitation provides a highly flexible and promising approach, direct input can

disrupt fields and make levitation difficult. New techniques must be designed to provide a rich experience without disrupting levitation.

LEVITATE: CREATING DYNAMIC DISPLAYS

Our acoustic levitation system (Figure 1) uses two 8x4 arrays of 40kHz ultrasound transducers (Murata MA40S4S, 10mm). The arrays face each other and are vertically separated by 65mm, a similar arrangement to LeviPath [5] and Floating Charts [3]. The arrays are controlled by a custom board with two XMOS processors; the board uses information from a PC to generate the voltage necessary to drive the transducers to produce the required output. Note that 40kHz ultrasound is inaudible to humans. We used expanded polystyrene beads (1–2mm) for the levitating objects because of their suitable size and low density.

We use a Leap Motion sensor to track user input. We use the position and direction of an extended index finger to determine which levitating object the user is pointing at. Since our system uses small objects (1–2mm), we place a virtual sphere at each object position; a user is pointing at an object when a vector in the direction of their finger intersects a sphere.

The demonstration will present *floating voxels,* individual pixels that can be interacted with using touch. For each pixel, users can select a pixel and drag it through 3D space to position it anywhere within the display area. These manipulations are supported by visual, tactile, and audio feedback to create a dynamic multimodal experience.

Key Issues for Levitating Displays

Demonstrating the hardware at this time will be useful to the pervasive displays community to help explore the current design considerations for levitating particle displays and discovering potential use cases for this technology. We are currently exploring the following key issues:

Feedback techniques for physical interactions. Because physical manipulation of the particles in the display could disrupt levitation, feedback must be designed to create the sensation of direct manipulation without actual physical contact. Additionally, in order to maximize the realism of the display, we must explore different combinations of modalities. We must design techniques that work within the constraints of the hard to create realistic experiences with the floating particles.

User experience and acceptability. The user experience and user expectations of these devices is still an open issue. We are still determining key factors in walk up experience, control and usability, social interactions, and user expectations. For example, while some users may be intrigued, others may be uncomfortable with the technology if it is not immediately apparent how it works.

Applications areas for levitating displays. Given this new form factor, new applications areas need to be developed that fully exploit the dynamic nature of the display to achieve new interactions not possible on traditional displays. Related work such as *Floating Charts* [3] demonstrate how such displays can be used, but more research is needed to develop a range of application areas.

VISION AND FUTURE DIRECTIONS

There are numerous applications for this display technology that could be used in public spaces. In our long-term vision, the computer can control the existence, form, and visual appearance of levitating objects of any given size composed of tangible "levitating particles". Users can reach into the levitating matter, feel it and manipulate it, with all feedback originating from the levitating object's position in mid-air. For example, instead of having to reach for an iDrive dial in a car, users may just reach out and the dial is created directly under their hand. The flexible medium of floating particles could be used by artists to create new forms of digital interactive installations for public spaces.

CONCLUSION

This demonstration explores input techniques for a levitating particle display using acoustic fields. With pointing gestures, users can select and manipulate particles in the display.

ACKNOWLEDGMENTS

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