Chandelier: Interaction Design With Surrounding Mid-Air Tangible Interface

Vivian Hsinyueh Chan*
National Taiwan University
Taipei, Taiwan
vivian.chan@hci.csie.ntu.edu.tw

Chiao Fang*
National Taiwan University
Taipei, Taiwan
chiao.fang@hci.csie.ntu.edu.tw

Yukai Hung
b09902040@csie.ntu.edu.tw
National Taiwan University
Taipei, Taiwan

Jing-Yuan Huang
National Taiwan University
Taipei, Taiwan
b08901081@ntu.edu.tw

Lung-Pan Cheng
lung-pan.cheng@csie.ntu.edu.tw
National Taiwan University
Taipei, Taiwan

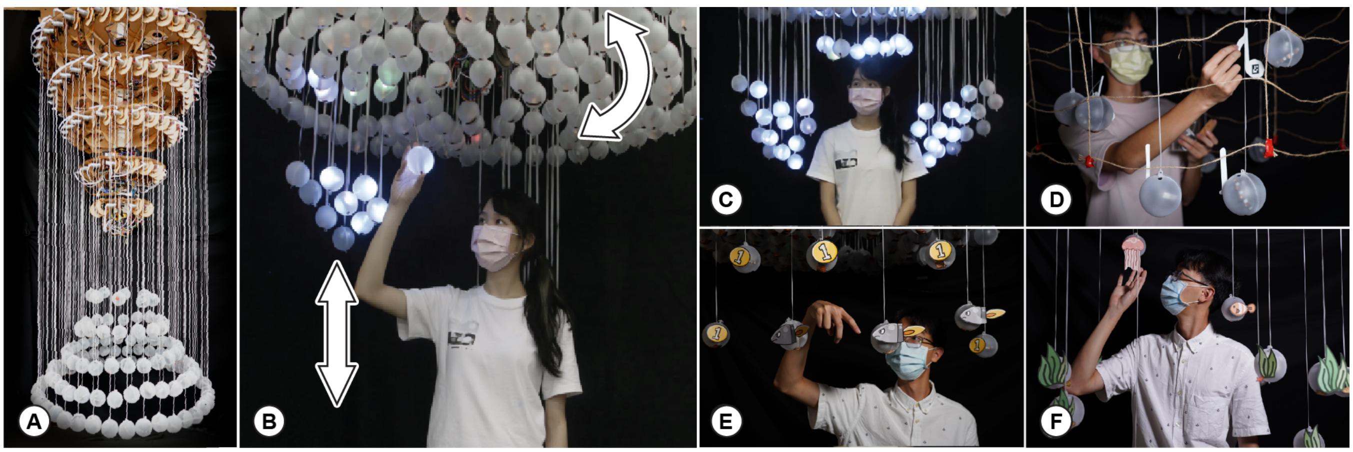

Figure 1: (A) *Chandelier* is a surrounding platform that consists of 120 pendants moving up and down independently on the rims of 5 motorized wheels. (B) The user interacts with pendants around it by hovering, touching, and manipulating them under the center of the platform, allowing (C) full-body shape changing such as animated wings on the user's back, (D) looping music composition by putting embodied notes spatially, (E) tangible endless-scrolling games, and (F) personal walk-in-place theme park.

ABSTRACT

Chandelier is a mid-air tangible interface where a user is surrounded in the center by 120 *pendants* that levitate independently and orbit in 5 concentric circumferences, where each pendant is touch-enabled and color-changeable by default. We explore interactions with Chandelier such as change blindness and repurposing formations from immersive experiences to mitigate the limitation of the hardware systems. We discuss the extent of Surrounding Mid-Air interactions in tangible interfaces and the design factors that could be brought into experiences of future levitation interfaces.

*Both authors contributed equally to this research.

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CCS CONCEPTS

• **Human-centered computing** → **Interaction devices**.

KEYWORDS

Surrounding platform, mid-air tangibles, levitating interfaces

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1 INTRODUCTION

Tangible user interfaces (TUIs) have emerged from 2D tabletop systems [9] and evolved towards 3D space. Actuated interfaces [30] such as shape displays [10, 33] and swarm robots [27, 34] have extended to 2.5D. Field-induced levitating interfaces [8, 23, 28] have pushed the boundary even further against gravity for extra degrees of freedom.

As more researchers have looked into tangible augmented reality [4, 16], researchers have proposed human scale shape displays [35] and drone swarms [12] that are able to cover a large space while having high degrees of freedom.

Recently, AeroRigUI [37] moves swarm robots from tabletop to ceilings, utilizing suspending wires to enable a larger vertical interactive space. While AeroRigUI [37] emphasizes the deployability and controllability of the system, Chandelier explores a different form factor—concentric circumferences—inspired by a combination of the ball-hanging actuation [2, 15] and surrounding rotating platforms [18] to reduce potential entanglement from rerouting swarm robots with denser arrangement full-bodily around a user, which further consolidates the space of surrounding mid-air tangible interfaces as shown in Figure 2.

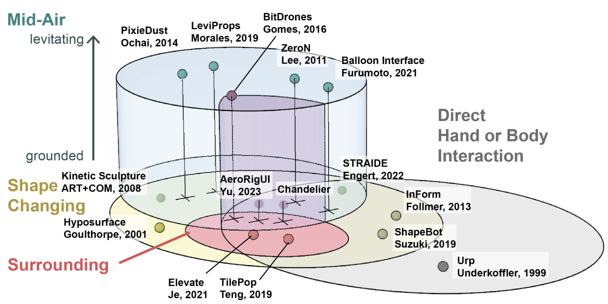

Figure 2: The space of surrounding mid-air tangible interfaces with regard to existing tangible, mid-air, and shape-changing interfaces.

Chandelier (shown in Figure 1A and B) enables interactions in a human scale (1.2 m in diameter), consisting of 5 individually actuated concentric wheels to hang 120 pendants and rotate. Each pendant moves vertically independently and has its own RGB LED and touch sensor; modules with speakers can be additionally attached.

We propose 4 interaction designs on surrounding mid-air interfaces and demonstrates each with an application. These interaction designs can be seamlessly brought into multi-drone systems or future levitating interfaces as it naturally prevents collision and complex path planning through the concentric circular formation. This enables Chandelier to play a role as a research platform for drone-human interaction and other future human-scaled levitating interfaces.

2 INTERACTING WITH CHANDELIER

We explore 4 interactions: continuous movement around the user, attaching passive objects to increase interactivity, changing blindness for endless scrolling, and reusing the formations of multiple pendants.

2.1 Continuous Movement Around The User

By rotating each wheel, the pendants continuously moves on a cylindrical surface in both longitudinal and latitudinal directions around a user in the center. This allows us to create dynamic shapes that have tightly spaced pendants relative to the user's body, such as embodying animated wings onto the user's body in Figure 1C.

2.2 Attaching Passive Objects

While the pendant in Chandelier is designed to be a generic sphere mainly for grasping, the uniform shape allows us to mount or attach passive objects for specific use. The attached objects provide the pendants with both thematic appearances for the applications and also affordance for manipulation or information such as AR tags.

For example, in Figure 1D, the user picks up music notes with an AR tag on the backside and moves them around the staff to compose. As the user performs conducting gestures, Chandelier starts rotating and plays the composed music. We used a camera in front of the device to recognize the tags behind each note and the user's gesture.

2.3 Change Blindness for Endless Scrolling

By rotating 360 degrees around the user, we can employ change blindness, a technique commonly used in immersive experiences, to reposition pendants in the back of the user. This technique allows us to create endless scrolling by combining it with continuous rotation to swap in and out contents in the back of the user, creating a seemingly endless experience with limited physical resources. We designed a side-scrolling game shown in Figure 3.

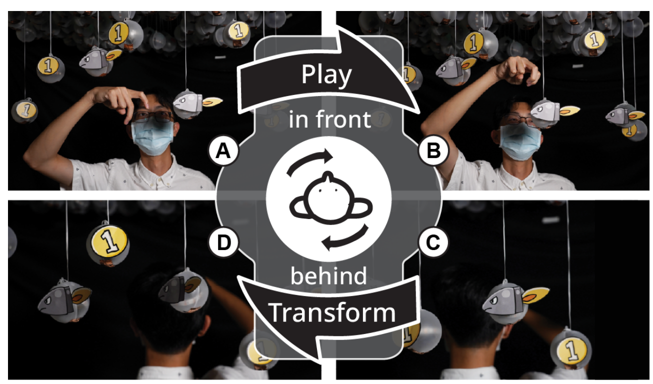

Figure 3: An endless side-scrolling game where the gaming area is reset literally in the background.

2.4 Reusing Formations

While a single movement of one pendant conveys limited information, combining multiple pendants and movements creates a formation—a sequence of forms to convey complex meaning. We further associate the formation with physical attributes to create a complete scenario. These physical attributes could be alternated to create various interactions with one programmed setting. Substituting only the decors attached and the soundtrack played by the pendant on Chandelier into different sets creates completely different experiences as shown in Figure 1F.

3 CONCLUSION

We have presented Chandelier, a device that enables Surrounding Mid-Air shape display and tangible interaction. Based on our experience with designing on Chandelier, we delivered concepts that could be used on Chandelier and moreover future levitating interfaces. We shared insights on where we see Chandelier positioned among related works, and future research potentials.

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