Zephyr: A Musical Installation

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ABSTRACT

Zephyr is an interactive musical installation that facilitates multi-person engagement through the application of light, sound, and motion in response to hand gestures. The installation, comprised of an array of floating balls and tubes, explores the relationship between interdependent physical controls and corresponding auditory and visual feedback.

Dynamic musical content relies on the engagement of multiple players, utilizing the strategic placement of sensors to encourage collaboration. The visual display reflects the fluid expression and nature of music and creates an experience that embodies the full continuum of sound amplification through a gradual increase and decrease in airflow. Through mapping simple hand gestures to a flux in sound output, the installation offers an intuitive and emotional experience accessible to both novice users and expert musicians.

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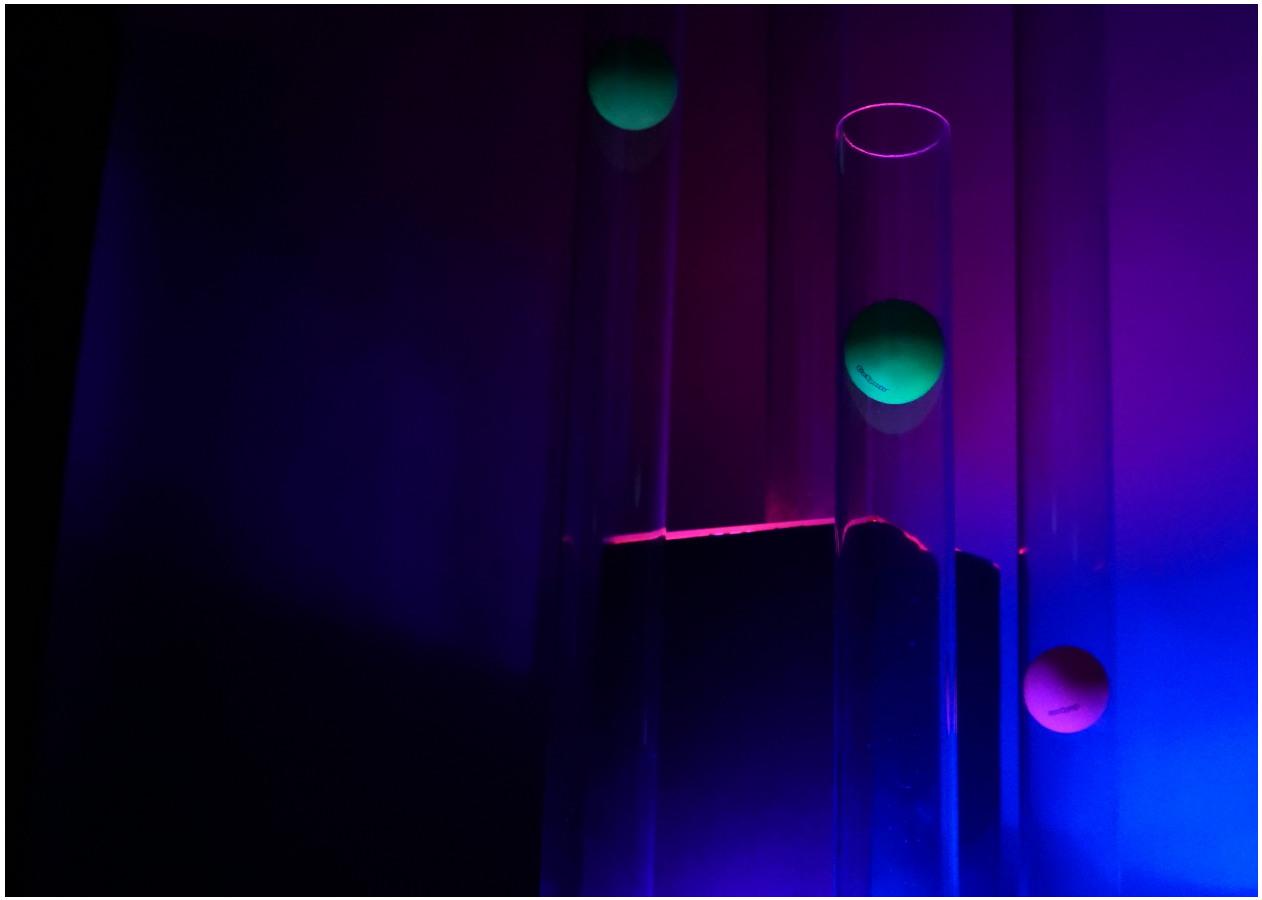

Figure 1. The installation in low lighting

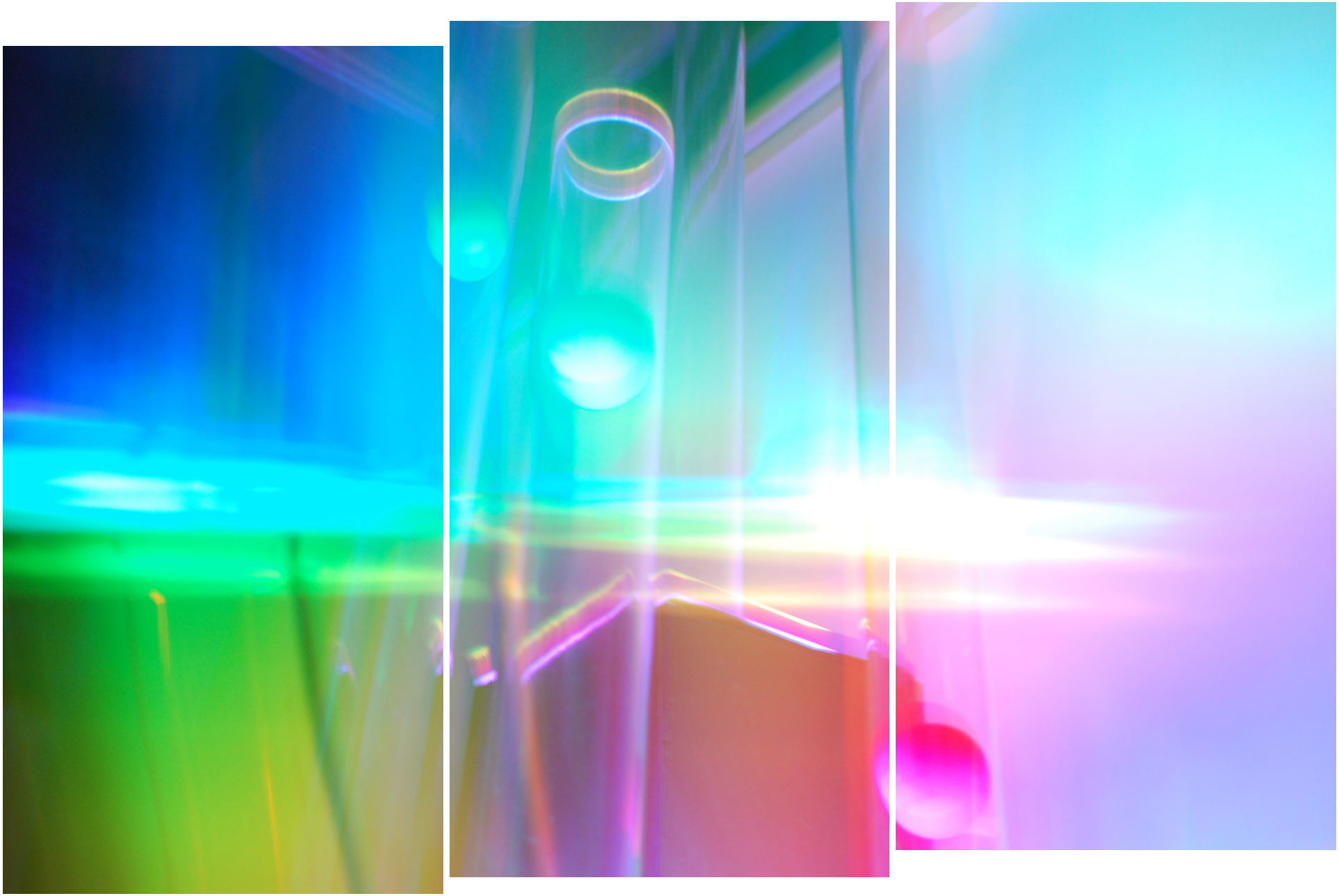

Figure 2: A photographic collage of colors and shapes that embody the flux in sensory outputs achieved through interaction.

Authors Keywords
Human-Computer Interaction; Soundscape; Interactive Installation; Multisensory Processes

SIGCHI Keywords
Collaboration ; Sensors ; Touch/Haptic/Pointing/Gesture ; Art ; Industrial Design ; Interaction Design ; Visual Design

INTRODUCTION

Computer-based musical instruments operating using traditional controls (such as knobs and buttons) function sequentially and can lack the full effect of embodying the musical output they control [17]. In effect, the controls themselves can fall short of representing the fluid and organic nature of sound and music. While practical in nature, such controls have the risk of diluting the ability to express oneself musically though the lack of immersion in their approach [17]. Attempts to enhance the connection between player and instrument often incorporate multi-modal feedback in additional to more traditional control methods [17] [9] [13] [11]. Kinetic counterparts to these multi-modal controls have similarly been explored in generating new emotional responses to music [14] [10]. Our installation introduces gestural controls reactive to players movements that offer an immersive, connected experience between movement and sound. The goal of our work is to stimulate conversations around the embodiment of space through audio and visual feedback, and explore gestural controls in facilitating this feedback in tandem with collaborative interactions between players.

Through the application of principles of industrial design, human-computer interaction, and music technology, we developed an installation that supplements the existing literature surrounding interactive environments and novel user interfaces. Many contemporary artists and academics have explored interactive environments that support multi-modal feedback [19] [10]. Further, existing literature on these installations often includes themes of collaboration or elicitation of social interaction between players [11] [7] [17]. Our installation showcases an example of an interactive environment involving gestural, collaborative communication to provide an emotional experience between players and their surroundings.

DESIGN PHILOSOPHY

Explorations between players, environments, and sound were generated during informal brainstorming discussions early on in the project timeline [figure 4]. The artifacts gathered during these sessions were later used to provoke discussions surrounding relationships between physical space and sound, and what avenues would be most fruitful to pursue to achieve our goals for this project.

In particular, we were interested in Interconnected Musical Networks (IMNs), and their ability to augment social interactions through the expression of music [18]. The dynamic between group and individual players in music differs drastically in terms of the interdependencies that shape the eventual output of musical content. Collaborative music platforms offer potential in building on subtle interactions performed by players to manifest unique harmonious experiences that may otherwise be untapped. As Weinberg describes, "Such an environment that responds to input from individuals in a reciprocal loop can be likened to a musical ecosystem" (Weinberg 24). In turn, IMN's offer possibilities of musical expression that reach beyond those without such a network involved.

Figure 3. Simple hand gestures control the outputs.

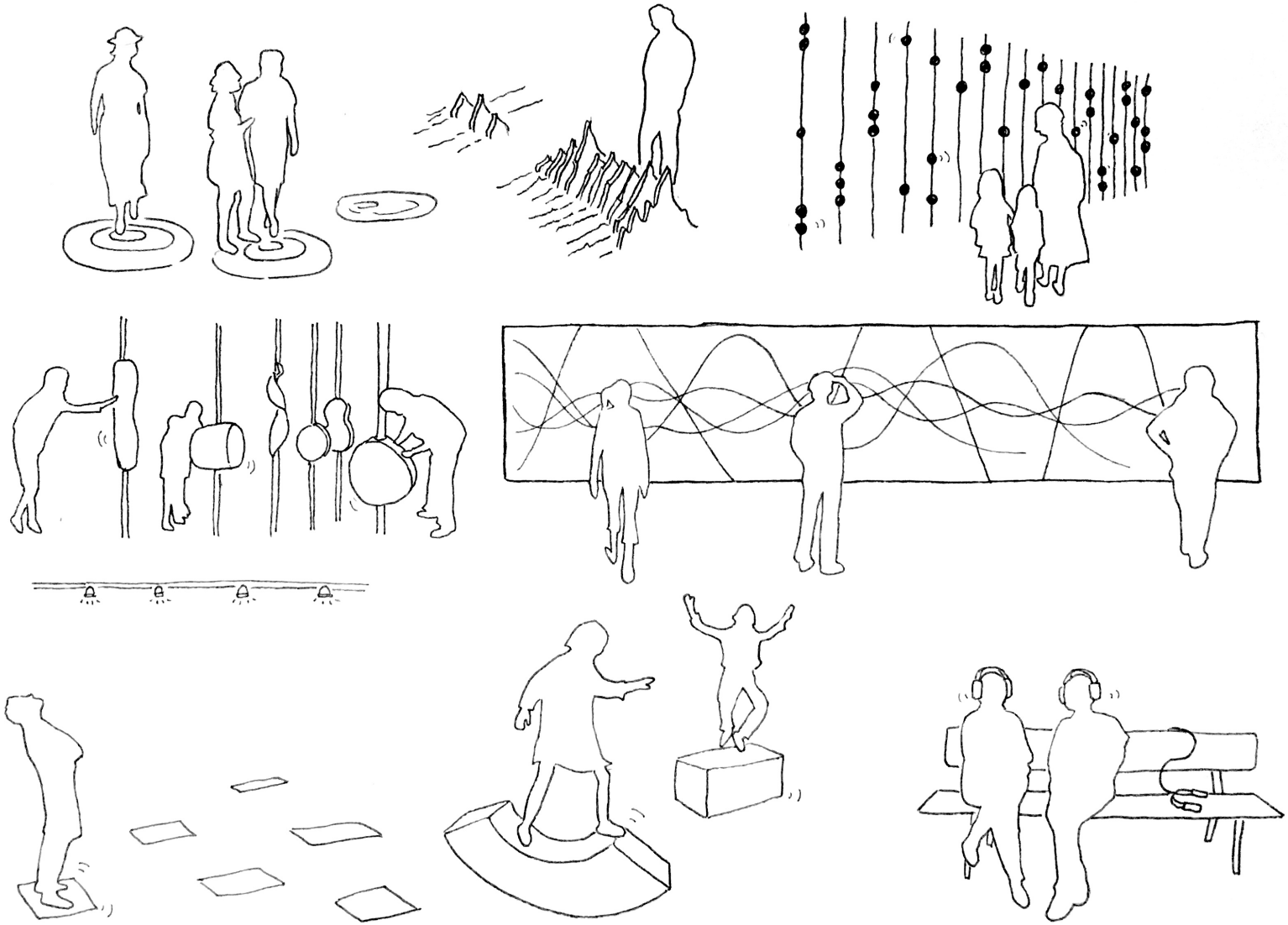

Figure 4. Sketches exploring collaborative musical interactions in relation to an embodied physical space.

IMPLEMENTATION

The physical build factored in constraints with budget, time and access to sufficient hardware. Our initial concept for this installation detailed an environment composed of an assortment of tubes with floating balls, each at different placements with a set of hardware built inside the infrastructure. We decided to modify this initial concept towards one stand-alone sculpture that would embody aspects of the initial concept in its design. The final concept still involves the interaction of multiple players, but on a smaller scale. By compacting the size of the installation to one base we were able to reduce the amount of hardware needed to carry out the experiment, and make the installation easily portable to different locations.

HARDWARE

Peeking beyond the exterior black shell of our installation you'll find a number of hardware components that power the interactions between the player and the sound and visual outputs. Primarily, An Arduino Uno and Arduino Mega were utilized to power 4 12.2 volt fans connected to four sets of tubes and Ping Pong balls. Multiple color changing LED strips were soldered together and woven throughout the installation underneath the acrylic panels. Ultrasonic distance sensors were placed underneath the acrylic panels (with laser cut holes to make them flesh with the surface area).

While a number of sensors were explored during the ideation process of the project, ultrasonic distance sensors were selected as the favored control of the sound and visual outputs. A power source was also required for the LED strips and ultrasonic distance sensors. Lastly, a Bluetooth speaker played the auditory feedback generated from the sensors.

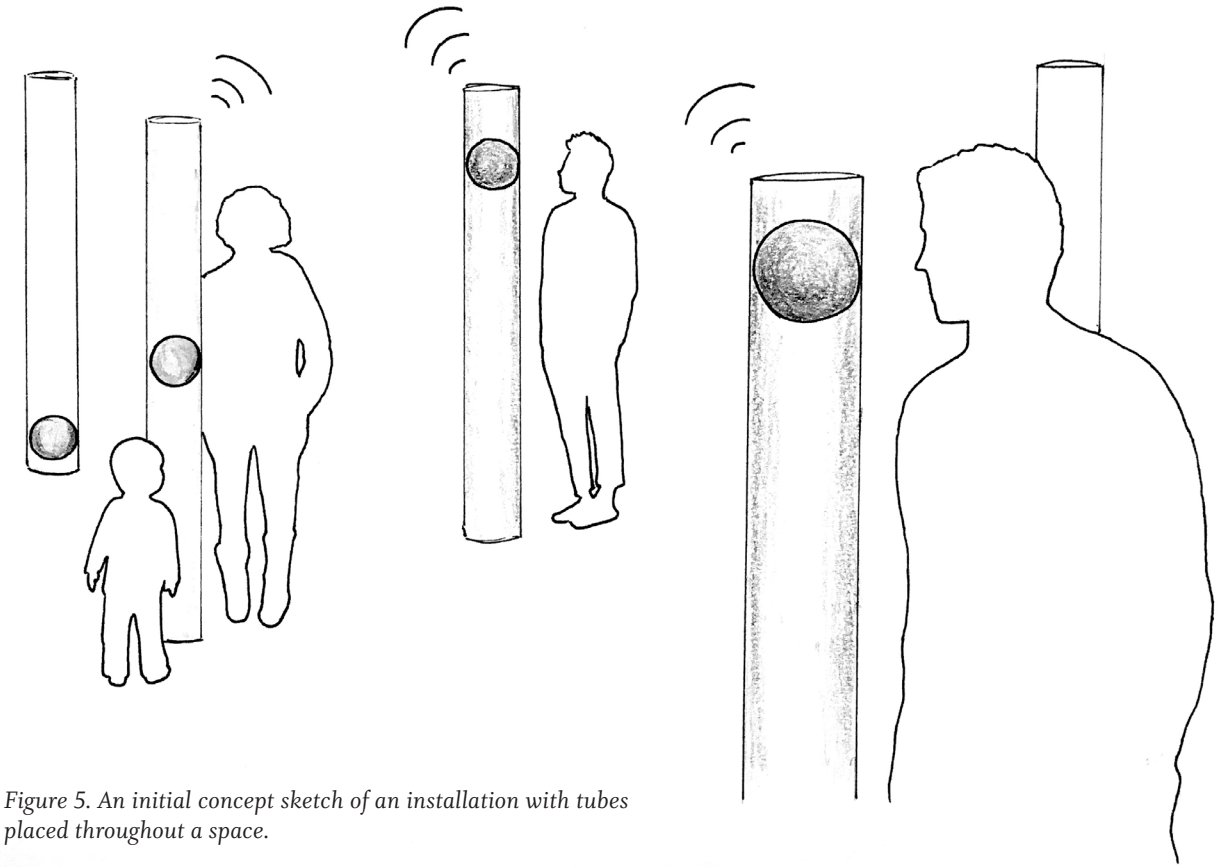

Figure 5. An initial concept sketch of an installation with tubes placed throughout a space.

SOFTWARE

Software included in our installation utilized Arduino IDE to write code which reads the inputs from the ultrasonic distance sensors. The distance sensors control the airspeed released by the fans and accordingly the elevation of the floating balls. The LED lights are engaged through related code that coincides with the other visual and auditory outputs. The software sends corresponding sensor readings to Processing, an open sourced graphical library. Processing records the software readings sent by the Arduino Uno and Arduino Mega and in turn controls the amplitude of the music based on the hand gestures used by players interacting with the installation.

PHYSICAL DESIGN

During initial idea conception we arrived at a simple mechanic composed of a paper ball and a cardboard tube powered by 7 volt dc fan. Though subtle changes in the airspeed we found that a playful experience can emerge between the player and the height of the floating ball. We continued to refine this micro-interaction through a series of low fidelity tests involving various lightweight objects, tubes, and fans. The final installation is composed of a set of 36" polycarbonate tubes and Jumbo Ping Pong balls. The diameter of the balls is just short of the diameter of the inner polycarbonate tubes, allowing for a relatively low airspeed to be required to propel the ball upwards. While a seemingly simple interaction, the immediate visual feedback it offered was surprisingly captivating.

Various materials were considered for the base of the installation. The base material had to be lightweight and transportable, but also sturdy enough to hold the 4 tubes upright. The base possesses the task of housing all of the internal hardware components, and as a result a network of inner shelving units were constructed. A small back door was later added to the base to increase accessibility to hardware elements in case maintenance was needed.

The focal point of the installation, however, is drawn away from the base and towards the tubes. To emulate a glowing, ethereal effect, we selected to use frosted acrylic panels on top of a matte black base. The full impact of these materials is especially evident in low light environments, where only the acrylic panels and glowing balls are illuminated. The color of the balls also turned out to play a major role in shaping the experience of the interactions. Initially, the balls were white. In later iterations the balls were painted with glow in the dark paint, and then with flourescent pink and green colors. When painted white, the balls faded to the background. With color, however, they became a crucial component to the installation. In certain environments, the colored balls even appeared as if propelled in midair. By making one simple design choice such as the addition of color, the experience of interaction with the installation was greatly changed.

The form factor of our installation took inspiration from contemporary art pieces and exhibitions. The form selected creates a variable, dynamic space utilizing a small square footprint. Heights and distances of the various tubes were strategically places to elicit engagement of a variety of postures and gestures. Collaboration between players was also considered when placing the ultrasonic distance sensors. The sensors are placed on four corners of the installation, and are impossible to engage fully without the collaboration of multiple players. As an additional benefit from utilizing different heights, our installation caters to various members of the population and is inclusive in design. This inclusion is seen during observations of interaction with children and adults alike.

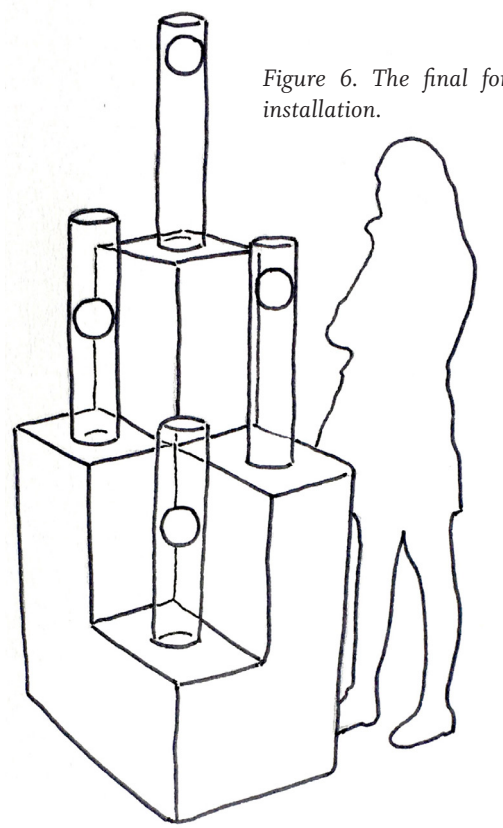

Figure 6. The final form figure for the installation.

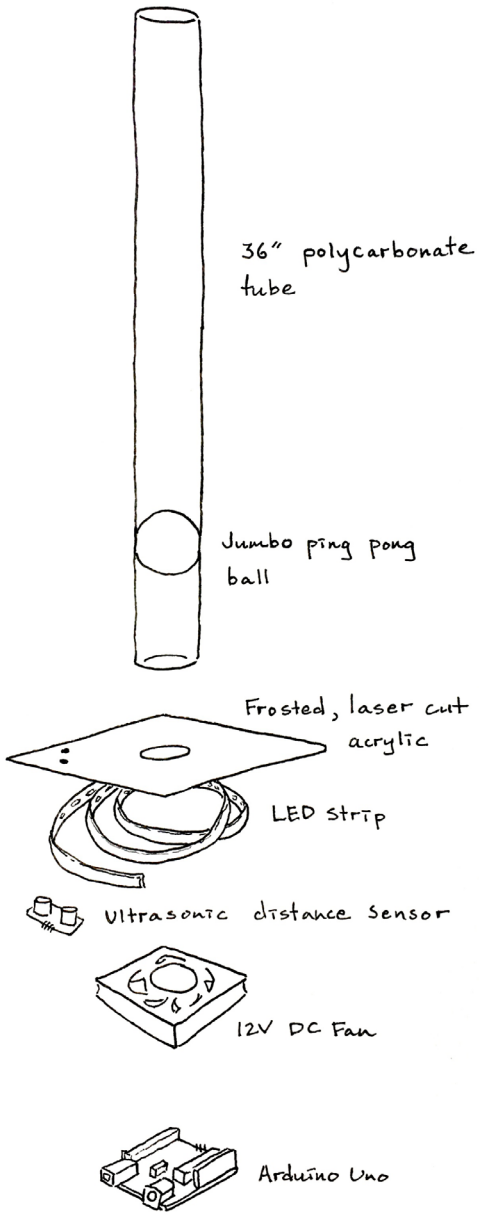

Figure 7. An expanded view of the inner components of the installation.

INTERACTION DESIGN

In reference to Schneiderman [16], feedback is encouraged for every operator action. This principle can be expanded towards the interactions that take place within our installation, supporting the argument that input actions from the players (hand gestures) should correspond with timely output actions (increase in sound, fluxuation in ball height). Furthermore, these interactions operate on a continuum of gradual increase and decrease in outputs, generating a feedback loop acting in real-time to the players actions.

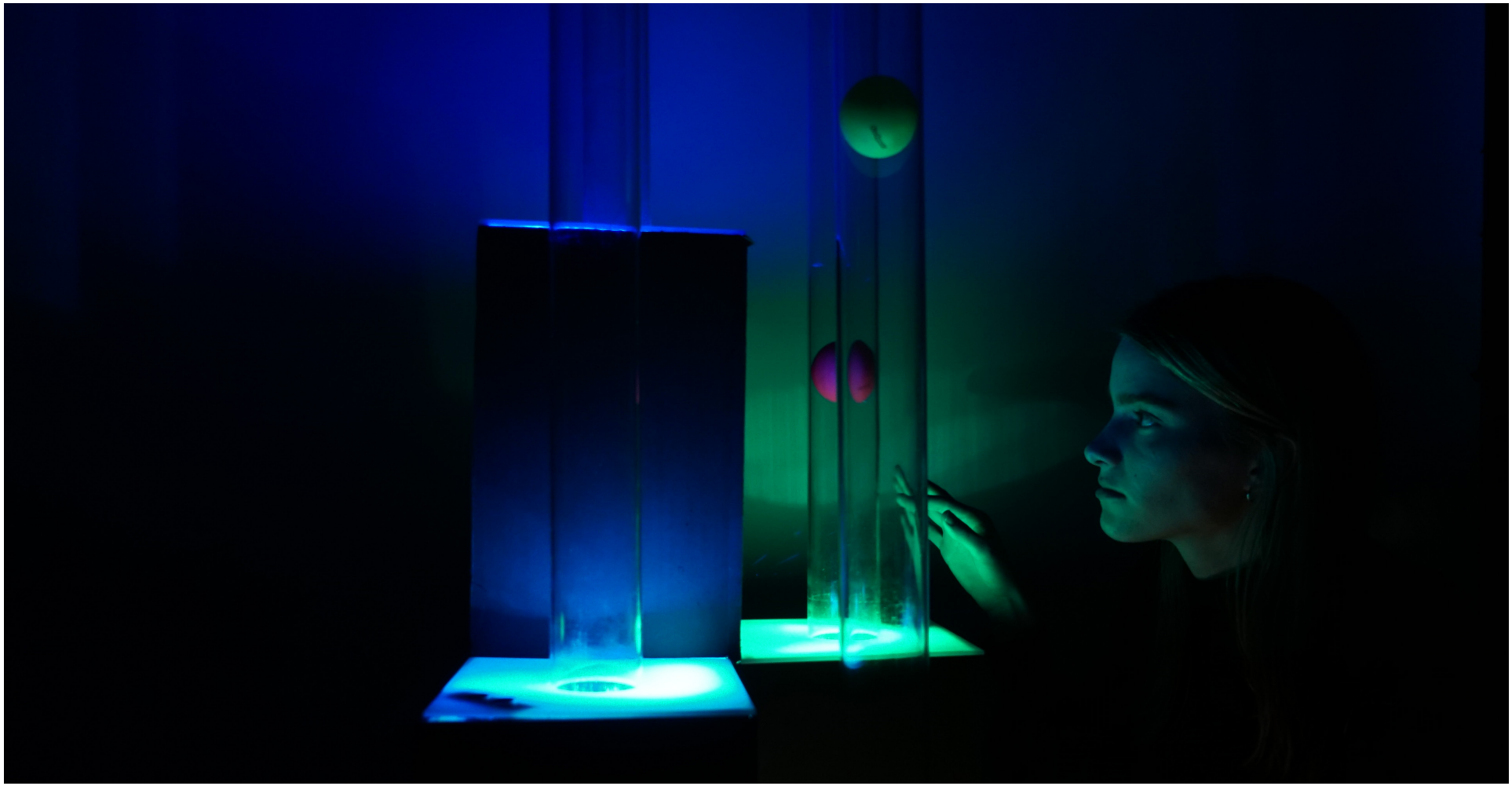

Figure 8. Gestural controls manipulate the output of sound and airspeed, creating a multi-modal experience for the player.

MOVEMENTS AND GESTURES

Our installation is built around hand gestures and fluctuations of the body that influence the audio and visual feedback outputs. Hand gestures have many societal and cultural implications around communication strategies and innate behavioral patterns [2] [6]. Research on gestural patterns of hands and arms show influences from cultural emblems, deictic gesture and iconic gesture, yet across all cultures many similar gestural patterns are evident throughout [3]. These similarities in hand gestures across cultures speak to the ways in which we as humans communicate with one another through movements of our body. These actions are deeply embedded within our behavioral makeup, and subtly influence the ways in which we navigate throughout life.

From an abstracted view, the gestures of an orchestra conductor are emulated in the patterns observed by players interacting with our installation. The gestures give a sense of power and control over the exhibit, and reflect the real-time responses generated from subtle movements.

Looking broadly at digital interfaces as a whole, the current models of musical expression are being challenged by modern designers who question their binary nature and ability to fully convey music. A shared view among many in the field argue that sound alone is not the only element involved in communicating music [5]. As an alternative to previous models, authors like Gurevich describe ways in which "an ecology of musical creation accounts for both a diversity of aesthetic goals and the complex interrelation of human and non-human agents" (Gurevich 10). These newly defined means of communicating expand the boundaries of musical expression and reveal new insights on how to engage music through technology. Our design, embedded in technology, connects with non-human and human agents and embodies an invisible sonic agent through physical motion.

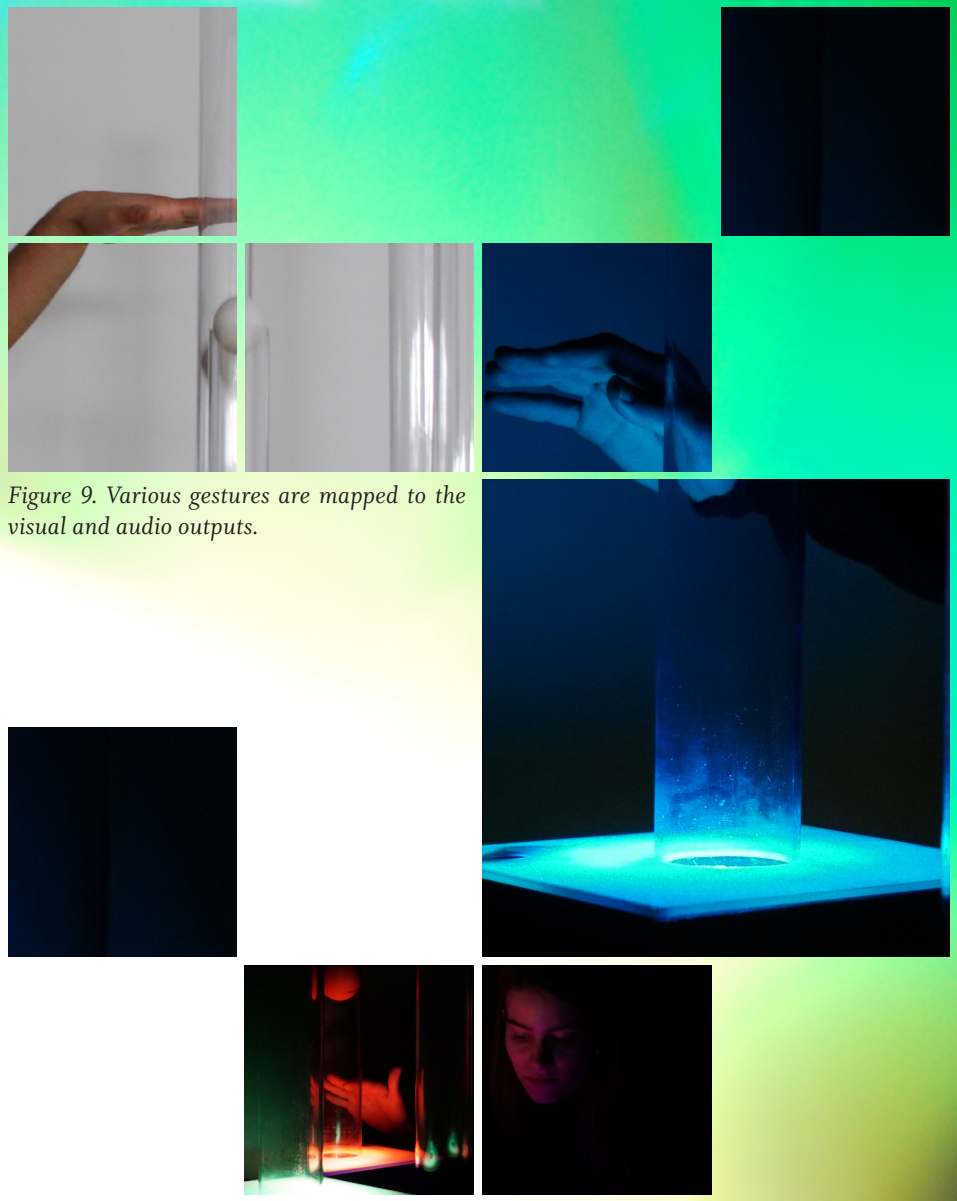

Figure 9. Various gestures are mapped to the visual and audio outputs.

AUDIO SELECTION

Audio files acted as an integral component to the overall experience of interacting with our installation, and were selected carefully based on a number of criteria. Primarily, we wanted to select audio that could stand-alone, but also create a complex and enriched experience when played in harmony with one another. When creating the audio files to play in our installation, the consonance, tone color (timbre), and texture (melodies) of the sounds were considered. Music editing software programs, including Garageband, were used to compose short tracks of music that would perform in a loop upon interaction with the ultrasonic distance sensor.

We went through a series of iterations of sound files to arrive at a set of four complementary compositions. A number of sound files generated using Garageband were played with one another at overlapping time intervals. Through these iterations we carefully selected the audio samples that, when played with one another, generated beautiful compositions. The four different compositions fall into three categories. One audio file contains more a more melodic structure, two audio files create a harmony, and one audio file adds texture and tonality to the music. The melodic composition grows in intensity of volume the closer the hand is to the ultrasonic distance sensor. This increase in volume corresponds with a rise in ball height. Similar interactions occur between the other three audio files. The music files themselves are composed of electronic and synthetic sounds.

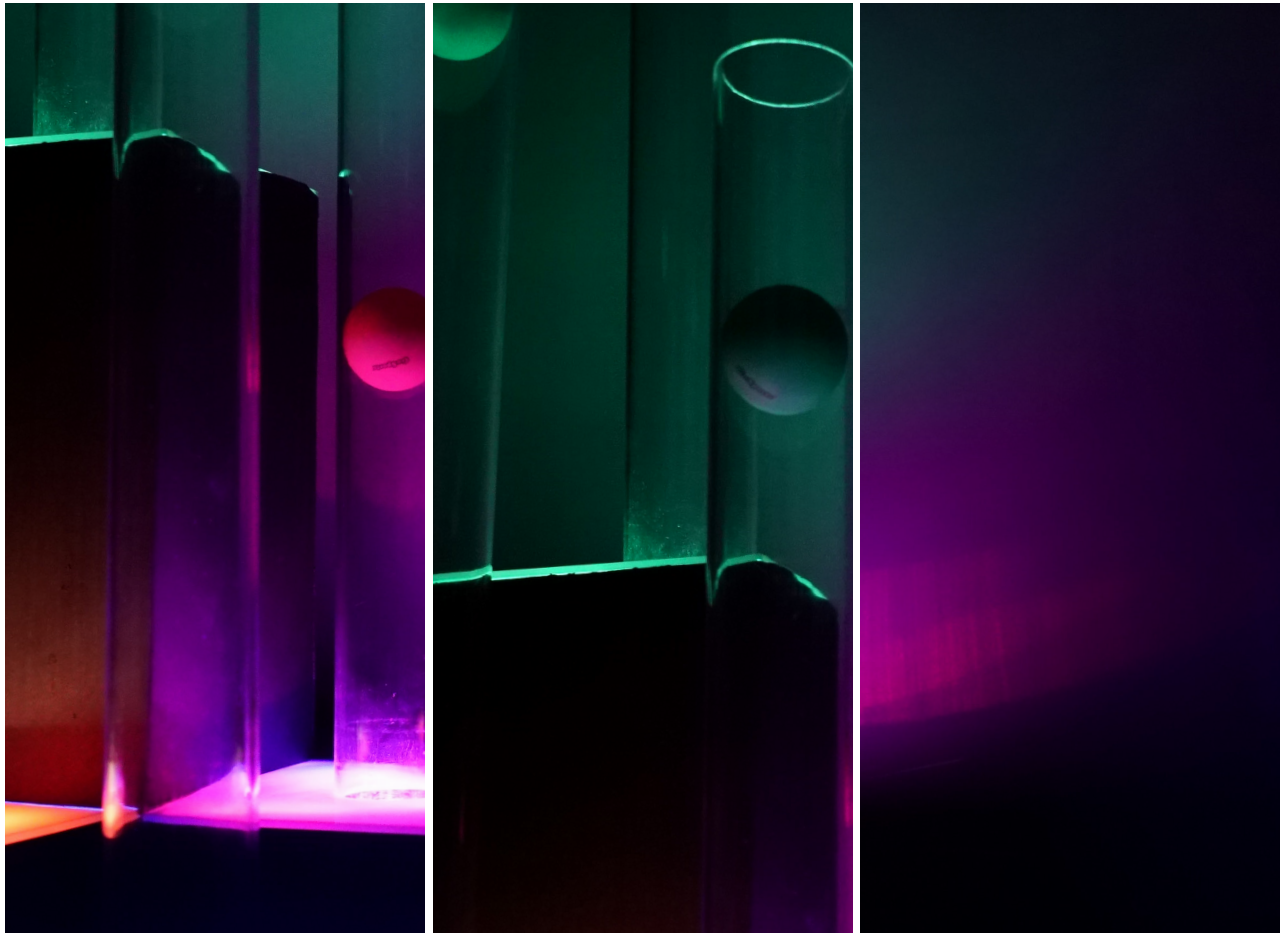

Figure 10. The projection of light can change the feelings of the entire surrounding environment.

Figure 11. The calibration of the ultra-sonic distance sensors requires the player to be in close proximity with the installation in order to operate the controls.

Figure 12. Multiple sensors can be engaged, however these interactions require shifts in body stature and positioning.

PERSISTENT METAPHORS

The use of "embodied metaphors" in the design process for tangible user interfaces has sparked interesting conversations around new interaction models [1] [8]. Through the engagement of physical feedback in response to sound and gesture outputs, our installation creates an analogy between the physical objects (floating balls) and the resulting response (sound, gestures). This connection between the action and the reaction supports intuitive learning and requires little familiarization with how the system operates.

DISCUSSION

Our installation was shown in multiple settings and was engaged with a large public audience, serving us in evaluating the outcomes of our design decisions. Young and old users alike interacted with our installation in ways in which were both predictable and unexpected.

Interestingly, one important component of the ecosystem that we neglected to highlight was the audience observing the interactions. Modern musical interfaces in particular have the potential of engaging performers and audience members through offering new possibilities for artistic engagement [4]. While we focused our discussion primarily on the engagement of the players interacting directly with our installation, through observations we found audience members to play a crucial role in defining the space and interactions that occur.

During one such instance, we observed someone slowly approach the installation, garnering little attention from others. As soon as this person engaged with the artifact to produce sound and a fluctuation in visuals, a huddling effect occurred causing a number of people to circulate and observe the interactions. This experience, in turn, changes the role of the player from a solo actor to an entertainer, engaging an audience through his or her actions. Turn-taking behaviors also arise when multiple members of an audience wish to partake in the act of interacting with the installation. They wait patiently until they see an opportunity arise, where they can then engage with the installation in ways similar to those of their predecessor.

FUTURE WORK

Moving forward, we will investigate new multi-modal experiences that can be generated using this installation as a case study for future work. In particular, we will continue to investigate methods of developing interfaces that evoke collaborative and participatory interaction between players. Our installation, and the insights we gained from observing those who interact with it, can be used to spark conversations surrounding the topics discussed. Further iterations will explore the methods of augmenting musical interaction in hopes of creating a delightful emotional experience.

Figure 13. Representation of different light environments.

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