DECO 7385 Research Paper – Musical Forest

Hezekiah Owuor
s4853937
Masters of Interaction Design
h.owuor@student.uq.edu.au
University of Queensland

ABSTRACT
This paper aims to present and discuss the significance of the work done over Semester 1 by the Team Maximum Chill for the Physical Computing Studio course

1. THE IDEA: MUSICAL FOREST
Musical forest redefines music as an interactive, multi-sensory experience. Using pressure sensors, dynamic lighting, and feedback through touch, visuals, and sound, we let users see, feel, and shape music. The concept revolves around the themes of data physicalisation and augmented collaboration. Through physical exertion and gesture-based interactions users can collaboratively create a musical piece in real-time. Even without musical experience, users can experiment, connect, and create together. Our goal is to make music-making more accessible, immersive, and social. We do this by combining Arduino, Ableton, ultrasonic sensors, bend sensors, and LEDs, ultimately creating an immersive feedback loop.

We envision Musical Forest being used by teachers in an educational setting with the following goals:

- Offer an engaging and multi-sensory experience for students that will enhance their learning through experimentations and participation
- Students can work on the teamwork and communication skills by collaborating to create a musical piece, highlighting the importance of collaborative learning
- Due to the low barrier to entry, it can serve as an accessible entry point for students to be explore musical concepts like rhythm, harmony and arrangement. This allows those without prior musical training to still learn effectively.

This is the main application of Musical Forest, but it could also be applied in the professional music industry to facilitate audience participation or encourage unique compositions by including this physical component.

2. RELATED WORK
There were two pieces of existing work that inspired the creation of our project. These works include the Piano Staircase and Incredibox. The rest of the concept came from a combination of ideation/brainstorming activities, feedback from the teaching team and working towards prototypes throughout the semester.

2.1 Piano Staircase
The Piano Staircase was a project implemented at a subway station in Sweden, in 2009, where designers transformed the stairs into a giant piano keyboard. When the user applies pressure to a step the staircase would play a musical note. The goal of this project was to change people's behaviour and encourage them to take the stairs instead of the escalator throughout the day [1].

Based on team skillsets, we initially brainstormed ways we can combine physical interactions with both audio and visual feedback to a user. With this macroscopic view in mind, the Piano Staircase provided an example of how this feedback loop can be achieved. Additionally, this case study was useful in understanding the role bodily movement plays in user experience. These can be categorized into embodied cognition and interaction. Embodied cognition is the role the humans body plays in understanding. An example of this is individuals understanding verbal phrases better than those who did not perform actions. Embodied interaction refers to physical and social interactions being integral in the meaning-making process. Studies have found that bodily action is not only a means for interaction, but it is also a source of conceptual mapping and key in facilitating a meaningful experience [2].

In the context of our project these finding was beneficial in design decisions. For example, knowing the significance of physical interactions led the air pumps being the first focus of design in the early stages. The theory is that if we could create intuitive physical interactions, it can create a meaningful musical collaboration/educational experience for the user. In the educational context we described, meaningful learning experiences has a range of benefits including increased understanding of concepts. Later in the project we added bend sensors as an additional interaction paradigm, with the goal of enhancing social collaboration and meaning.

2.2 Incredibox
Incredibox is an online interactive music game, developed by So Far So Good. The application provides a combined audio and visual experience where users can drag and drop icons onto avatars to make them sing, beatbox and ultimately compose your own music [3]. *Figure 1* below features one of the versions called *Sunrise.* Users can drag any of the coloured icons in the bottom half of the screen onto any of the avatars on the top half. Each of these sounds play in a loop and work together, but what makes it unique is that each user can only play a limited amount (7 avatars) of sounds, but has a choice for how long and what sounds are played. This means

Figure 1: Screenshot of incredibox Sunrise

that every creation is unique depending on the choice the user makes within these parameters.

In the context of our project Incredibox had a huge influence on our design decisions. Drawing the analogy, each of our plastic cylinders would represent an avatar that produces sound, with the drag and drop functionality being represented by how hard the user steps on a foot pump, subsequently changing the height of the ping pong ball. This application was the most similar representation of our idea; however, it was all digital. It was helpful in helping us understand how we can limit choice to the user yet still provide them with autonomy and an engaging user experience. It also served as a starting point to think about how we can combine physical and audio outputs with visual feedback to help the user make connections.

3. TECHNICAL DESCRIPTION

Our project can be divided into two broad components which were connected, these are a physical components and digital components. In this section I will describe the details of each as well as how they were connected.

3.1 Physical Components

Figure 2 shows the final physical makeup of our design. There are 6 transparent cylinders that each have a ping pong ball inside, foot air pump attached, LED strips stuck on and an ultrasonic sensor at the top. As mentioned, each cylinder represents an instrument. The ultrasonic sensors and LEDs are connected to an Arduino Leonardo in the central black box. When the user steps on an air pump the sensors will read the height of the ball and send the data to the Arduino to be processed programmatically.

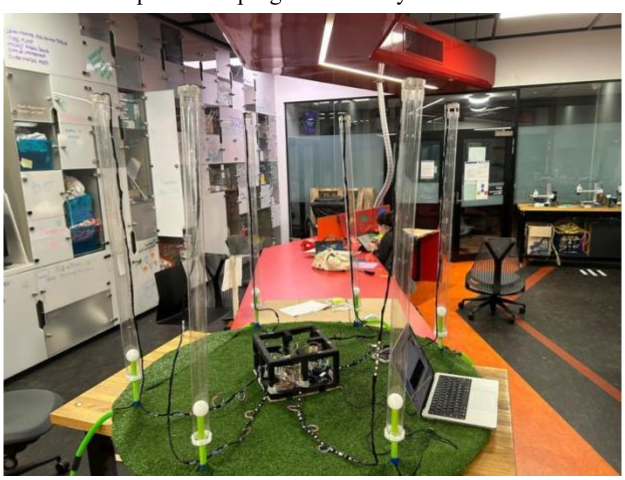

Figure 3: Image of final protoype

Figure 3 shows the bend sensors which were attached to a box to mimic a keyboard. Bend sensors are connected via wires to the other Leonardo to convert resistance data into sound programmatically.

3.2 Digital Components

There were relatively few software components in our design, but the complexity and purpose of each in the interaction flow was significant.

Figure 2: Bend sensors

3.2.1 Ableton Live 12 Suite

Ableton Live software was the second central point of our design. The purpose of Ableton was receiving ultrasonic sensor data from the Leonardo and triggering the appropriate tracks. Ableton Live was selected for three reasons. First Ableton is made with a live performance setting in mind which is where our project is made to be used. Second, Ableton has support for native USB inputs, like our Leonardo, which allowed us to use code to send MIDI inputs via USB. Thirdly, I had a full suite license with Ableton and various instrument plugins which allowed the creation and coordination of different sounds. *Figure 4* is shows a screenshot of the Ableton view with each group representing a clear cylinder. The sessions plays in a continuous loop from bar 5 to 21. Depending on the height of the ball in the “Bass” cylinder, for example, one of either track 30, 31, 32 will be armed. If no change in height is detected tracks in that group are muted. Six effects were also placed on the main channel that were changed based on resistance values of the bend sensor.

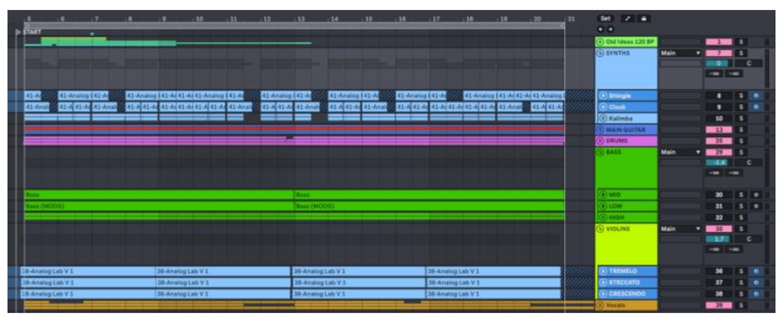

Figure 4: Screenshot of Ableton view

3.2.2 Arduino Code

Code written for the Leonardos was used to control all sensor data and timing. We had two code files for our project, “_LED_MUSIC_FINAL” and “_bendy_updated.” Each file was uploaded to one Leaonardo. The first took the ultrasonic sensor data, converted the distances into midi notes and sent those midi notes to Ableton which would play music. Additionally, it used the distance data to change the colour of the LED strips on the cylinders base on height. The second file took the resistance values from the bend sensors and performed math’s operations to map the resistance data into MIDI data to send to Ableton sliders. At the maximum value of resistance, the slider in Ableton would go to is maximum value and change the effect of the song with reverb, for example.

4. PROTOTYPE EVALUATION

We evaluated the success of our prototype in two ways. The first was a technical evaluation, simply by how many of our planned components could we get working. These components included a mechanically functioning foot air pump system, 6 different instruments able to play simultaneously, LEDs providing visual feedback to users and 6 bend sensors that further controlled audio. Out of these the LEDs and bend sensors were stretch goals that the team aimed for. In the end we achieved all our technical goals deeming our project a major success.

The second way we evaluated our prototype was through user testing. We had a QR code up during our exhibition with a survey that users could fill out. Question focused on the interactivity of the system and the propensity for repeated use. Although I cannot go into all responses the results indicate a positive reception towards our project. For example, *Figure 5* shows that most users felt engaged when using our system. Additionally, questions asking about integration and ease of use averaged around 4 out of 5 positive rating. There were concerns about setting the system up and accuracy of feedback with LEDs for example.

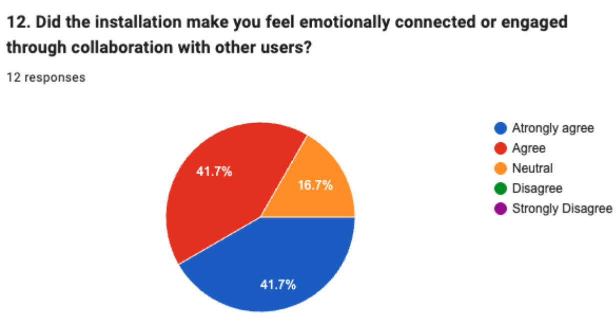

Figure 5: User feedback graph

5. REFLECTION AND CONCLUSION

Throughout the development and implementation of Musical Forest, we have successfully created a novel interactive experience that combines music with physical interaction, highlighting the themes of data physicalisation and augmented collaboration. The iterative process of ideation, refinement, and technical implementation was predominantly influenced by mechanical and material constraints, such as the responsiveness of sensors, accuracy of physical components, and limitations inherent in integrating Arduino hardware with software platforms like Ableton Live. These limitations guided our iterative refinements, pushing us to optimize the interactions for consistency and user experience.

Our project reveals significant insights about the future of work, particularly in educational and collaborative settings. By providing an accessible, immersive, and engaging way to interact with music, Musical Forest underscores the potential of physical computing to enhance collaborative learning and creativity. Its significance lies in its capacity to democratize music-making, making it approachable for users without prior musical training, thereby broadening opportunities for educational and creative expression.

Teamwork was crucial to the success of Musical Forest, with each member contributing uniquely to different components of the project. My role, focused primarily on the technical integration of sensors and software, highlighted both my strengths and limitations, particularly in managing intricate hardware-software interactions. Collaborating within these defined roles allowed us to maximize individual expertise while emphasizing the need for clear communication and task delineation.

The project was a technical success, achieving all initial and stretch goals, including the functional integration of foot air pumps, LEDs, ultrasonic sensors, and bend sensors with Ableton Live. User evaluations were largely positive, indicating that our project succeeded in engaging users and providing a meaningful, interactive musical experience. Nevertheless, areas for improvement were identified, such as enhancing LED feedback accuracy and simplifying system setup.

Technically, this project marked a significant learning curve for me, notably with Arduino programming and MIDI integration. Exploring and implementing the MIDIUSB library expanded my technical repertoire, reinforcing skills crucial for future interactive and physical computing projects.

Moving forward, further improvements could involve refining sensor accuracy, simplifying the physical setup, and enhancing visual feedback to provide clearer real-time user interactions. Moreover, expanded user testing, particularly in educational environments, would provide deeper insights into usability and engagement, further validating Musical Forest's potential as a meaningful tool in future educational and collaborative contexts.

6. REFERENCES

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