California Institute of the Arts

Designing Platforms for Creative Expression

by

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Abstract

This thesis examines a series of projects made with the intent of facilitating creative acts to stem from them. The concept of a platform for creative expression is presented as a way of describing a tool or concept that an artist can use at a starting point for their own artwork to be developed upwards from. Three projects created by the author are explained in terms of their individual conceptual intent and the practical steps involved in their realization. The three projects: Roulette, a generative drum sequencer; Ticklers, a series of mobile electro-acoustic instruments; and Art Arcade, an interactive-art group show curated and technically directed by the author are vastly different from each other but they all explore the idea of facilitating creativity for an artist. A set of consistent considerations for creative platform design are defined from the experience drawn after each project's realization.

Acknowledgments

I would like to thank Caroline and Brian McNamara for their endless support, encouragement and belief. I would like to thank Emily, Sean, and Alyson McNamara for always offering a patient ear when I need to externalize my thoughts and for sharing their inquisitive perspectives on any problem I'm dealing with. Thanks to Tom Henderson and Elijah Clarke for making me grow as an artist by exploring music, art, and humor with me since we were twelve years old onto this day. Thanks to Nate Harrison and Simone Jones who exposed me to artworks and art forms I had no idea even existed, showing me that art and music can find a way to coexist in an artist's practice, helping me travel the world in the pursuit of the arts, and for fully supporting me in my application to CalArts. Thanks to Ajay Kapur for getting me to CalArts, introducing me to countless opportunities, and pushing me to grow as a professional. Thanks to Spencer Salazar, and John Baffa for your mentorship; you have managed to expose me to what feels like ten years' worth of learning experiences in two. Thanks to Ali Momeni for sharing his unbridled creativity, enthusiasm and intelligence with me and for giving me the opportunity to work a dream job in ArtFab. Thanks to Alkis Nicolaides and Niels Henrik Bugge for pushing me as a musician and artist and collaborating with me on extremely meaningful projects during my time at CalArts. Thanks to Gabriel Jimenez and Melanie Waingarten for being my first and closest friends at CalArts, you two have helped me think, grow, laugh, and explore California. And finally thank you to everyone at CalArts in the music, theater, dance, creative-writing, film, and art schools that I've had a chance to spend time with; I have a beautiful memory about everyone I've had the honor of working or even conversing with at this institution, CalArts is an extremely special place because of the people.

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Chapter 1

Introduction

The inception of an art project is a curious event. There is no definitive reasoning for when, why, or how artists find the ideas on which they feel compelled to pursue; but, it can be observed that artists have a point of departure from which they begin to create. This point of departure for a musician could be playing with a musical instrument, a painter may be experimenting with the materials in their studio, or a sculptor may observe the culture and symbolism embodied in an object from which they want extract. This point of departure for creation is the topic of exploration for this thesis. More specifically, this thesis explores the creation of interfaces that act as platforms from which creativity can begin.

A platform for creative expression can be understood as a physical tool or immaterial concept created with the intent of encouraging a range of artworks to be created upon it. A musical instrument is a simple example of a platform for creative expression; it is a tool specifically designed to facilitate the creation of music. A platform[1] in this case can be thought of in terms of how it is used in the technology industry: as a launching point from which development of products can occur. In the case of this thesis, the technology-industry definition of a platform has been adapted to better enable artistic intent; an essential concept or tool for artistic realization is the artistic equivalent of a standard platform's essential technology.

This thesis describes three projects pursued by the author in the pursuit of creating platforms for creative expression. Each chapter describes the conceptual intent of a project then, explains the

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1 Technopedia defines a platform as: a group of technologies that are used as a base upon which other applications, processes or technologies are developed. https://www.techopedia.com/definition/3411/platform

methods of design and realization implemented for the project's realization. Both concept and realization methods of each project are discussed as a means of understanding the creative intent of a project and offering the practical experience gained from making the project to future researchers pursuing similar work.

The three projects described in this thesis include Roulette, a generative drum machine; Ticklers, a series of mobile electro-acoustic instruments; and Art Arcade, a group show featuring interactive coin-operated artwork. Each project varies from one another but the common thread between them is their intention to act as platforms for creative expression. The first two projects, Roulette and Ticklers, are electronic musical instruments and the final project, Art Arcade, examines the development of a platform for interactive installations to be created.

Chapter 2

Inspirations

2.1 Nate Harrison: Can I Get an Amen?

Harrison describes Can I Get an Amen? (Figure 1) as a critical perspective on the arguably most widely-used drum sample in the history of recorded music. From this video piece questions of artistic authenticity and ownership that arise from appropriation art are presented.

The personal take away for the author upon seeing this video piece and subsequently discussing it with Harrison was a new gained adoration for the expansive potential for vastly varied ideas to grow from the same starting point. The starting point in the case of the video piece being the amen break, from which thousands of different kinds of pieces of music have been made with the same six seconds of audio. This same expansive potential beginning from the same starting point is a common line of exploration with each project pursued by the author.

Figure 1 - Can I Get an Amen?, 2004

2.2 Roulette: Contemporary Sequencer Design

The creation of Roulette has been informed by artists and designers in three areas: the use of the circle as a compositional tool, customized sequencer design, and generative sequencers.

2.2.1 The Circle as a Compositional Tool

The circle is used metaphorically to conceptualize abstract concepts such as repetition, perfection and/or imperfection, and the antithesis of rigidity. Musically a circle illustrates the exact idea of a sequence, but in common music notation, software, and hardware a sequence is designed within the rigidly of a square-influenced interface.

The circle is a common point of influence regarding reconsiderations to the paradigms of electronic music composition. Dan Trueman's *Cyclotron* [1] was designed in the pursuit of composing electronic music in the Norwegian Telemark style, a form of music that varies rhythmically in ways that cannot be achieved through standard tempo subdivision. Adam Places' *AlphaSphere* [2] was made as an investigation into the design and aesthesis of contemporary nimes; the *AlphaSphere* has a very prominent circular design as a way of investigating new and original modes of interaction. Trimpin's *Sheng High*, Daniel Gábana Arellano's Radear [3] and Spencer Kiser's *spinCycle* [1] both utilize the circle's inherent looping mechanic in order to create physical sequencers.

2.2.2 Customized Sequencer Design

In Rafael Arar's paper outlining the history of sequencers he traces their lineage of development [3]. He ends examining the current design paradigm of sequencers as well as showcasing contemporary experimental configurations. The current paradigm of commercial sequencer design is the grid-based model, originating from the Monome[2] and subsequently implemented in commercial products such as Ableton Push[3] and Novation Launch Pad[4]. The grid-based model is a hyper-rigid design comprising of a square with a nested matrix of squares. Although there is

2 http://monome.org/

3 https://www.ableton.com/en/push/

4 https://www.ableton.com/en/products/controllers/launchpad/

no doubt potential for expression, the grid-based model echoes the compromises that must be considered when designing for industrial production methods. In contrast to the current paradigm of commercial sequencers, Arar's paper also examines independently developed sequencers highlighting the potential for alternative experiences and interaction available from sequencers that aren't typically utilized.

2.2.3 Generative Sequencing

The idea of creating a sequence that is controlling thematic content as opposed to note specific content is discussed in Marcelo Mortensen Wanderley and Nicola Orio's paper on musical interaction devices [4]. In their paper, they propose contexts of musical control. They first define the concept of *note-level-control*; a one to one interaction with an instrument. They then define *score-level-control*, the idea of controlling music in a stance similar to a conductor's level of interaction.

Luisa Pereira Hors' *Well Sequenced Synthesizer* [5] explores a series of generative sequencers that "create music in dialog with the user, who is given varying degrees of control over the system."

2.3 Ticklers: Accessorizing Commercial Innovation

In the commercial scope of contemporary instrument design a common method of creation is to survey modern technical innovations for inspiration, and subsequently create an instrument that is novel in its use of new technologies. This could be a software implementation, new means of interaction (physical, mental, networked), or a combination of both elements. Two common threads to be observed in the examples provided are the user-friendly implementation of complex technology as well as the utilization of a consumers access to a smartphone to diminish the price of hardware development and increase the ease of initial exposure and subsequent access to the product.

2.3.1 Mogees: Machine Learning Made Easy

Mogees Ltd. is a startup company founded by Bruno Zamborlin. The product they develop is also named Mogees (Figure 2) and is a result of the research Zamborlin conducted over a fiveyear period while working at the Institute for Research in Acoustics/Music (IRCAM) in Paris and Goldsmiths University in London. Mogees consists of a physical interface, a contact microphone with adhesive gel to provide it the ability to connect to varied surfaces, and software that uses a combination of digital signal processing and machine learning to recognize patterns in the signals being sent from the contact microphone as well as resynthesize the signal.

In non-technical terms, Zamborlin says the goal of Mogees is to extend the capabilities of the objects around us that we regularly interact with[6]. With only a Mogee a table-top, bicycle, or teacup can be transformed into a musical interface[6]. The Mogee is presented in a simple way with its branding focusing on the creative capabilities possible instead of how the Mogee works. This highlights the intention of the Mogees project to implement modern technical innovation in a novel way that is easy to understand regardless of exposure and understanding of the technical qualities of the project. The small design and smartphone software of Mogees encourages users to take their Mogee anywhere and experiment with it in any environment.

Figure 2 - Mogees Play with Packaging

2.3.2 Smule: Accessible Networked Music

Smule is mobile app development company founded by Ge Wang and Jeff Smith that focuses on music performance apps. "The common aim of Smule's products is to prod nonmusicians into making music and to interact with others doing the same." [7] Smule is another company that implements complex concepts deriving from research in music technology and offers it to consumers in an accessible way.

The most predominate example of this can be demonstrated in the apps *Ocarina* and *Glee Karaoke* (Figure 3), both apps feature internet networking capabilities to allow for online solo or collaborative performances. Networked music is a complex field of research that is ever further burgeoning as internet technology increases to be a pertinent part of society. There are many technical problems that are constantly being addressed and investigated with networked music performance technology as to make it a more viable option for creative expression.

The elegant implementation of such a technically complex feature is a necessity for a consumer application with the goal of enabling anyone to perform with it. In their successful implementation of networked performance features, Smule enabled a larger audience to explore the creative potential that networked music performance facilitates. As most smartphone owners tend to always have their phones with them, Smule presents its users with a musical instrument that they will always have with them. This high level of accessibility further promotes Ge Wang's hope for more people to be active music creators instead of solely being music consumers[8].

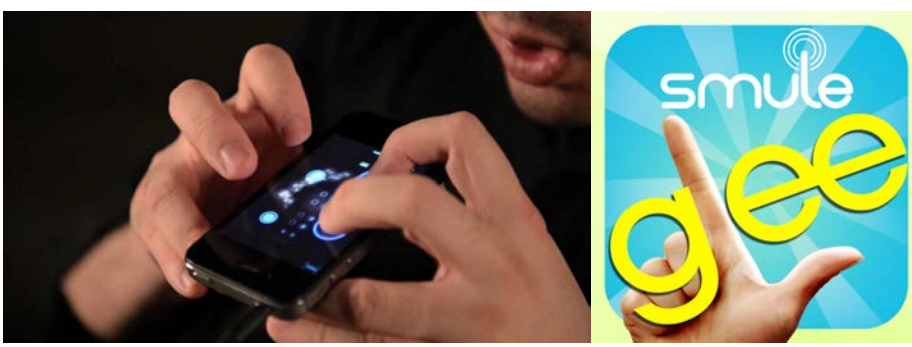


Figure 3 - Ge Wang Playing Smule Ocarina and Smule Glee Club App Logo

2.4 Art Arcade: Experimental Curation Methods

Experimental methods of curation were a large source of inspiration for the creation of the Art Arcade. Both shows mentioned, Bring Your Own Beamer (BYOB) and Non-Cochlear Sound, bridge the gap between curation and art creation in their own ways.

Non-Cochlear Sound was created by Kim-Cohen as a call for artists working in an art form he was working in and felt somewhat alienated in doing so. The exhibit was a direct projection of Kim-Cohen's writing in which proposed the idea of more conceptual sound art existing, and flourishing, in the contemporary art world.

Bring Your Own Beamer is an exploration in the application of open-source development to an art curation system. Instead of any one specific person curating any show, a method of realization for how to create a BYOB show was designed and distributed freely online.

2.4.1 Seth Kim-Cohen: Non-Cochlear Sound

Non-Cochlear Sound was a group exhibit curated by artist, and writer Seth Kim-Cohen. The show took place in 2010, following the release of Cohen's book In the Blink of an Ear: Toward a Non-Cochlear Sound Art; a book examining the conceptual merits of sound art and examining the perceived lack of attention paid to sonic arts holding conceptual intent, with instead the principle focus being dedicated to the phenomenological experience of sound. From an open-call multiple artists exploring the conceptual capacity of sound as a medium were selected to participate in the show alongside Cohen. Pieces were completely varied in medium but were part of a collective theme considered to be novel at the time in contemporary art.

2.4.2 Bring Your Own Beamer (BYOB)

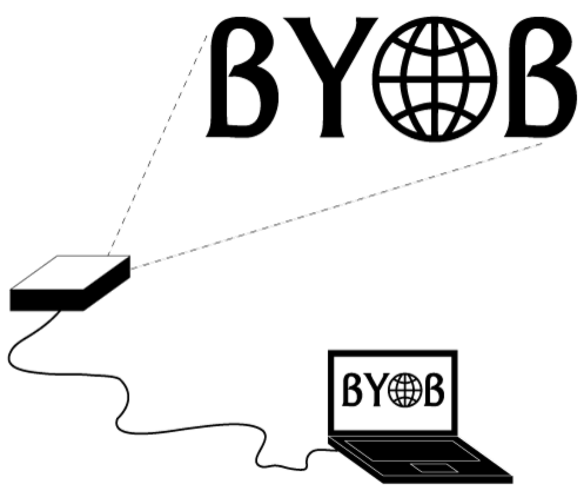


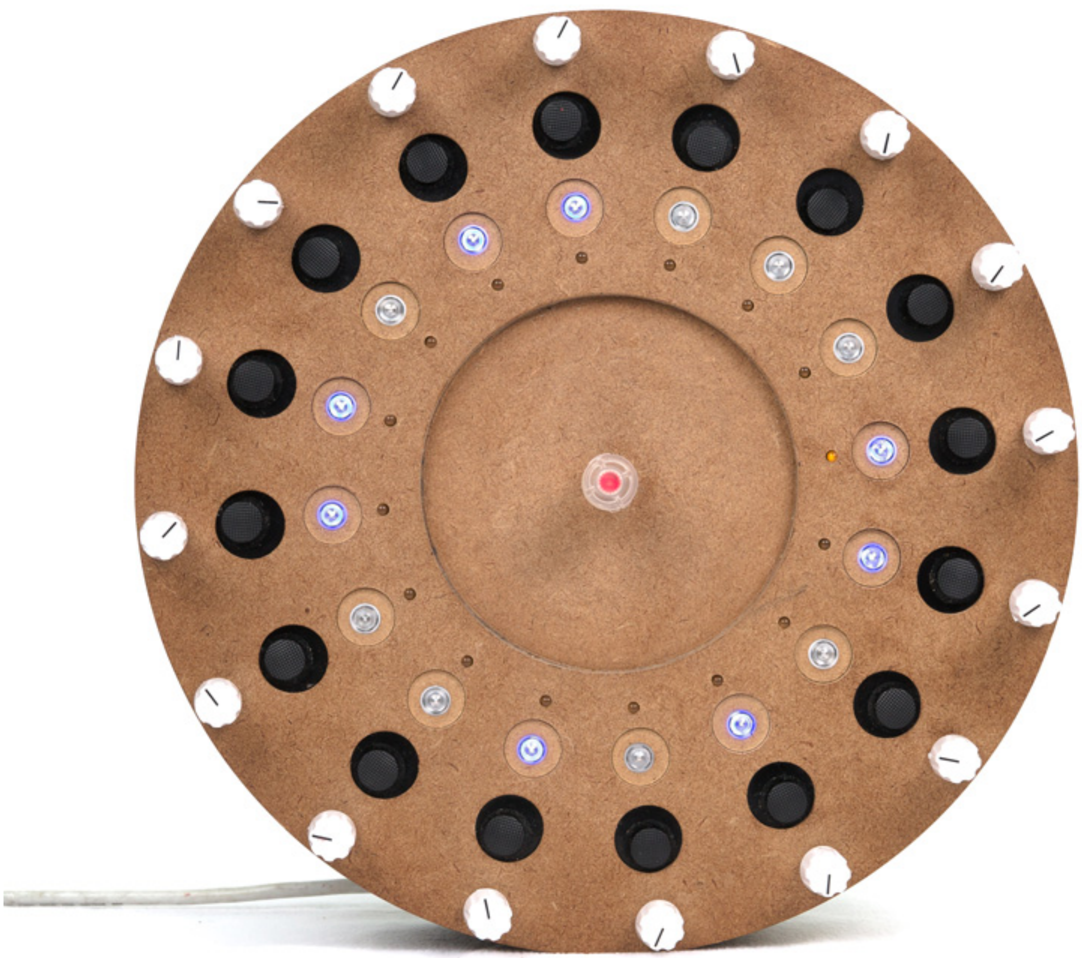
Figure 4 - Bring Your Own Beamer Logo (BYOB)

On Bring Your Own Beamers' (Figure 4) FAQ page the project is described as "… a series of one-night-exhibitions curated by different people around the world. The idea is simple: Find a place, invite many artists, ask them to bring their projectors. BYOB is a way of making a huge show with zero budget. It is also an exploration of the medium of projection." The original artists responsible for BYOB, Anne de Vries and Rafaël Rozendaal, consider it to be an open-source curatorial platform celebrating the expansion of new media from screen relegation.

The concept of an open-source curatorial platform where the relationship between the pieces featured is the technology being implemented informed the conception of Art Arcade. Art Arcade followed this idea by only requiring a proposed piece to feature a coin-mechanism. It also has encouraged the open publication of all code and hardware developments from the project.

Chapter 3

Roulette



3.1 Project Description

Roulette is a generative sequencer that uses probability algorithms to create rhythmically varied drum patterns. Compositionally the intent of Roulette is to enable its user to program drum patterns in a dynamic fashion, as opposed to the static nature of typical sequential composition. From the initial design of a rhythm, varied patterns are emitted outlining a principal musical form.

3.2 Conception

The current range of sequencers available to artists is staggering. However, a large amount of them – especially the commercially popular ones - consist of similar design principals and functionalities. With the rising popularity of custom musical software creation there is a plethora of new software sequencers that explore the expanded capabilities of the sequencer as a compositional tool. What is missing from these new soft-sequencers is an interface that properly reflects the interaction possible from the software. Due to the lack of custom hardware most experimental sequencers are ultimately controlled by mapping their parameters to MIDI-controllers; this dilutes the relationship between hardware and software. Creating both the software and the interface that controls an electronic instrument is a holistic approach that aims to underline its individual character and capabilities.

Compositionally, Roulette was designed to satisfy the writer's desire to have a drum machine capable of varying its drum patterns independent of interaction from a user. Additionally, a more natural – almost sloppy- amount of timing variance was desired by the writer to achieve a feel from a sequencer similar to what can be heard in music when a drum machine is manually played; music from producers the J-Dilla or MF Doom are prime examples of the effective quality of this timing variance.

3.3 Design and Implementation

This section will discuss the goals and design principals explored in Roulette's creation as well as how these concepts were physically executed.

3.3.1 Core Design Concept

Roulette's design processes focused on the implementation of a circular aesthetic. This decision was made to achieve an alternative user experience; one that strays from the typical experience derived from the square-centric designs that are prominent in commercially available sequencers. The circle aesthetic also reinforces the conceptual value of a generative sequencer. As a circle holds a specific shape but is void of points, Roulette has a musical form but is void of specificity.

Wherever possible, circles were implemented into the design they are a prominent feature in the ring-formed body, the knobs and buttons, and the combined rotary soft-pot and encoder in the centre of the sequencer that creates the concentric-circle master control module.

Roulette comprises of a specific module design that is evenly distributed in 16 steps around the ring of the sequencer.

3.3.2 The Module and Its Controls

Each module consists of several components for sequence development. An orange 3mm LED indicates which step the sequencer is currently on. A blue LED button indicates whether a drum hit is going to occur; the button gives the user the ability to cancel or initiate a drum hit event. A thumb-slider joystick that has been modified to have no spring recoil acts as a two-dimensional pot for setting two parameters: velocity range, and timing offset of the drum hit event; execution of the event can occur before, at, or after the proper 16^{th} note division event. Finally, the rotary potentiometer at the top of the module controls event probability odds.

All module components that define a range function by recording their position to two separate variables. To set each side of the range there is an alternative functionality assigned while the LED button is being held, depending on whether the alternative functionality is activated the change in position of the sensor is recorded as its ranges lowest or highest point.

3.3.3 Module PCB

Due to the size, scale of production, and the circular form of Roulette special considerations were required in the design of its circuitry. Printing circuit boards was a necessity, as the compact form factor of roulette would not physically allow hand-soldered perforated boards to fit.

With modularity in mind, an independent PCB was printed for each module instead of creating one PCB for the entire instrument. The modular PCB approach benefits the design in two ways. First, modules offer some leeway for a reconfiguration of physical placement during the design process if a change is necessary. The second benefit to modules is that they greatly reduce the price of production; this is because the pricing of PCB production is based on cubic material usage. Printing modules insures that PCBs only occupy the absolute amount space they need to (Figure 5).

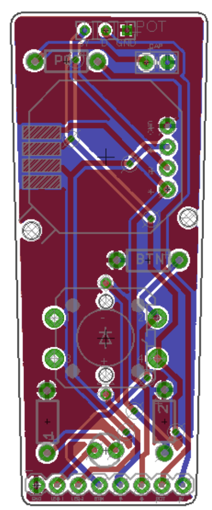


Figure 5 - A Rendering of an Independent Module's PCB with Optimal Form Factor Considered

All 16 modules are wired to a central shield consisting of multiplexers that parse the sensor data accordingly. Multiplexers are required due to the number of sensors implemented surpasses the available inputs on a Teensy++, the microcontroller that Roulette uses.

3.3.4 The Mother Shield

Roulette's small form factor and requirement for 64 inputs and 32 outputs capable of pulse width modulation (pwm) led to the design of a mother shield (Figure 7) featuring four 16-

channel multiplexers and two 16-channel pwm drivers. Additionally, the board required inputs for external power, inputs for the central encoder, and a breakout section for the Teensy++.

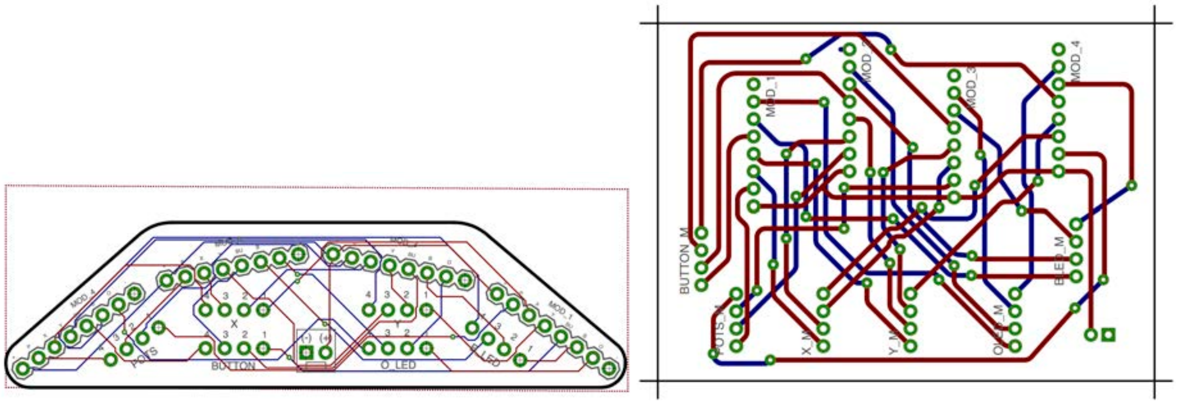


Figure 6 - Early Sub-Mother Board Designs: Shield 6.7 (left), Shield 4.6 (right)

As form factor was important, the final iteration of the mother shield utilized SMD parts to meet the size requirement of the board. A novel design factor is the angled collection of inputs surrounding the rim of the mother shield in which the modules plug into. Sixteen 8-pin female headers are evenly distributed to enable a modular relationship between the circle of modules and the mother shield (Figure 7). This radial distribution was a key factor in achieving the desired form factor as all prior designs required a cumbersome amount of jumper cables between multiple sub-mother shields (Figure 8).

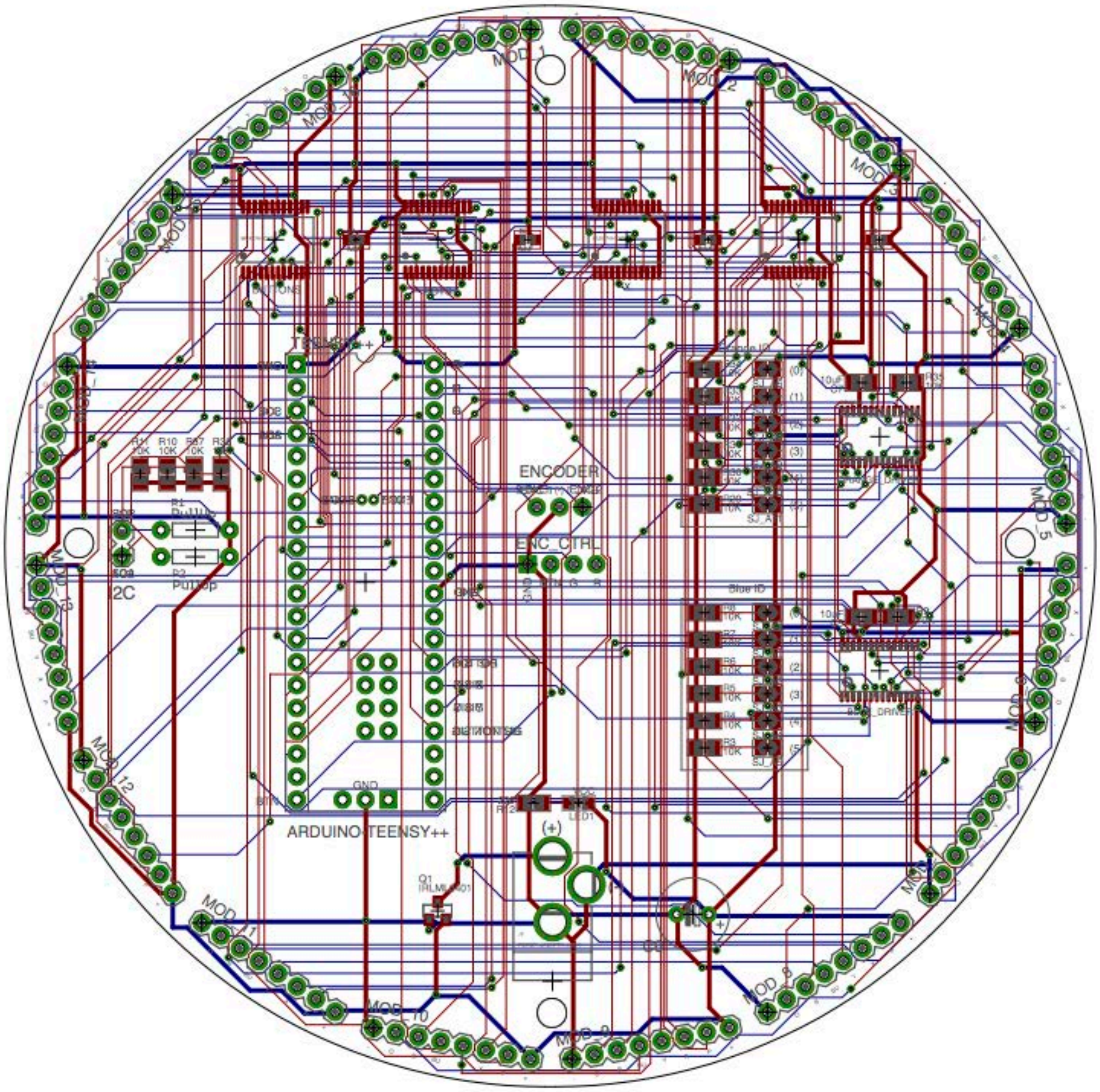


Figure 7 - Mother Shield Board Layout

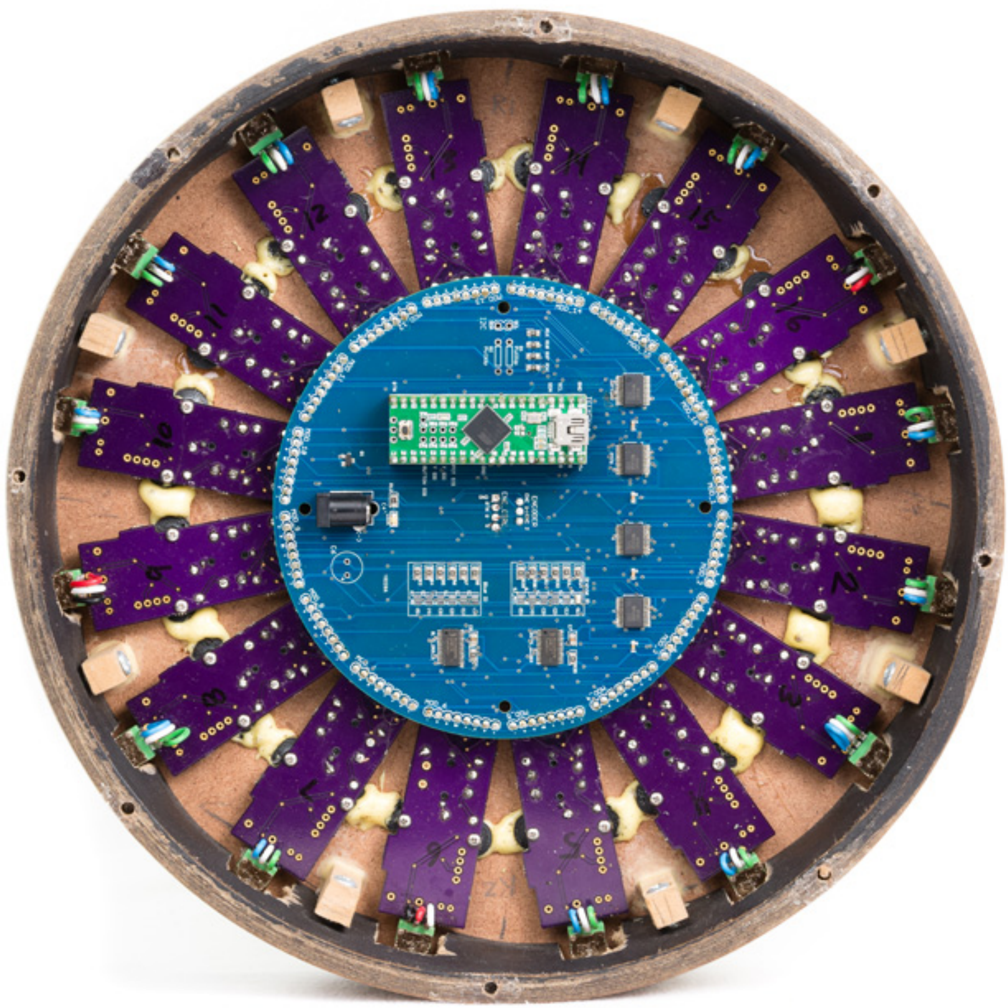


Figure 8 - Bottom of Roulette

3.3.5 The Central Encoder

The central encoder controls global Roulette's settings. These settings include: Tempo, and Track Selection. It resides in the centre of Roulette following a concentric-circle layout. The push button of the encoder toggles between tempo and track selection modes. The central encoder features a RG LED which is used to indicate which mode of operation Roulette is set to by either blinking to indicate tempo mode, or not blinking to indicate track selection mode. While in track selection mode, the colour of the encoder changes depending on which track is selected.

3.3.6 Fabrication Techniques

Multiple fabrication techniques were applied in the build process of Roulette to achieve the project's aesthetic goals while working within the monetary and time-based restrictions inherent in an independent project. The following subsections list the project's core fabrication techniques.

3.3.6.1 CAD Modeling

CAD modelling software was a critical tool from initial planning and fully through to the end of development (Figure 9). The use of CAD software was infinitely helpful as once ideas were fully developed, those same files could be used without alteration in the process of physically creating them.

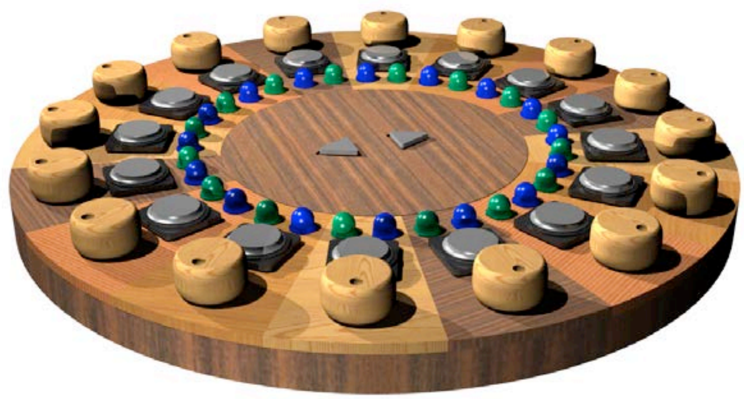


Figure 9 - Initial Rendering of Roulette Illustrating Principle Design Concepts

3.3.6.2 Paper Prototyping

Paper prototyping[5] was an integral development process used to save time and money before pursuing a full build. Paper prototyping helped in two key ways. Firstly, in the task of deciding on the module layout and sequencer size that felt the most comfortable. From surveying multiple diameters printed to scale on paper, a 10-inch diameter for Roulette was decided upon as the most comfortable and practical scale for the build (Figure 10).

5 https://en.wikipedia.org/wiki/Paper_prototyping

Secondly, paper prototyping ensured that the modular aspects of the circuit design fit properly with each other. As this task was a technically involved one (compared to the aesthetic intent of finding the proper diameter of Roulette) rigid paper prototyping was implemented to ensure the objects cut fit properly without being manipulated. This was achieved by laser cutting circuit board designs into hard-card stock. This saved a large amount of time as it alerted the typical workflow of board design by removing the pause in production that occurs when multiple iterations of a board design are required. By cutting rigid paper prototypes the physical requirements of the board could be refactored within minutes as opposed to weeks.

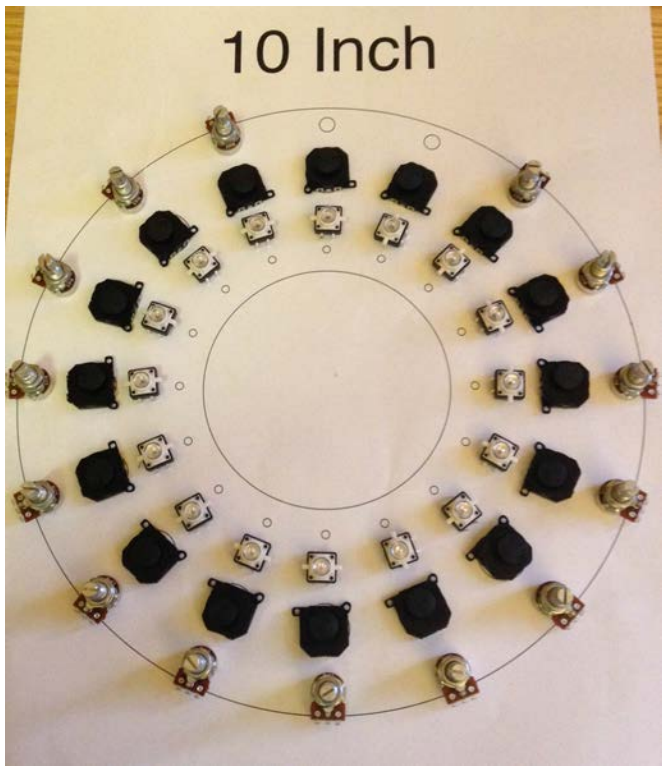


Figure 10 - Paper Prototype Testing the Distribution Scale of Modules On a 10-inch Faceplate

3.3.6.3 CNC Machining

After successful paper prototyping, CNC machining was used to physically produce the faceplate and centre module of Roulette (Figure 11). The geometrically complex pattern of Roulette's faceplate would have proven highly difficult to execute with standard shop-tools; the use of rapid prototyping technology enables aesthetic exploration of the tools typically used in commercial product design.

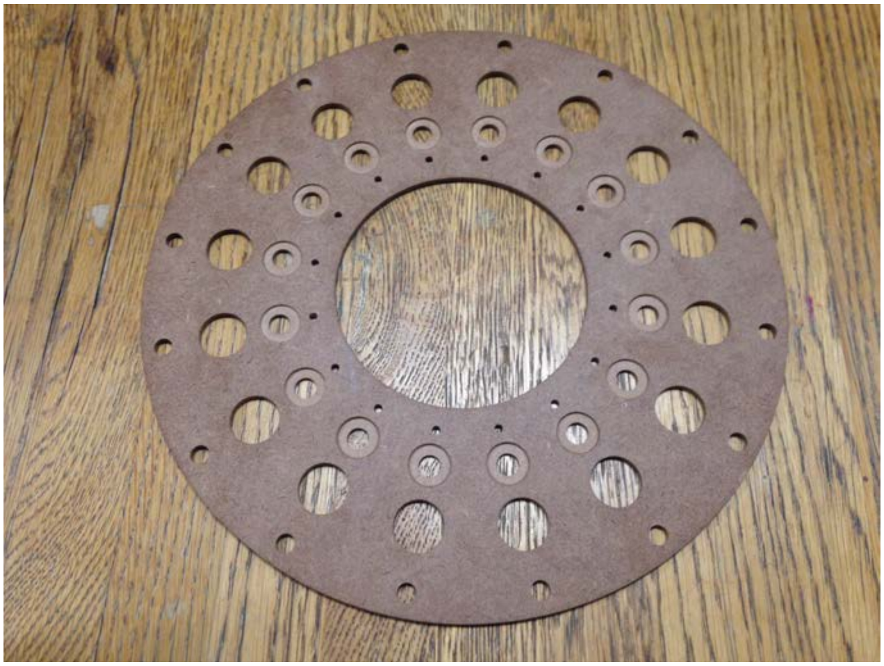


Figure 11 - 10-inch Faceplate Cut from a CNC Machine After Passing the Paper Prototyping Approval Phase

3.3.6.4 Prefabricated Materials

As Roulette required a cylindrical body a consideration of the most appropriate fabrication method to be used had to be made. The initial fabrication solutions to this were either layering rings cut with a CNC machine, or steaming veneers. Both solutions were less than ideal as they would be both expensive and time consuming. Especially in the case of steaming wood, as it would require a highly specific skill. Both initial ideas were dismissed after the realization that a repurposed drum shell would meet the criteria perfectly.

In addition to the structural requirements being met, an aesthetic harmony is achieved by drawing a connection between physical drums and Roulette's role as a drum sequencer.

3.4 Custom Software

This section will discuss the software written for Roulette to sequence in a probability-based fashion, its graphical user interface, and its Arduino-based communication architecture.

3.4.1 ChucK

The core functionality of Roulette is written in the ChucK programming language[6]. Chuck was chosen as its time-based functionality made it the most appropriate and effective in programming a sequencer.

ChucK is responsible for parsing the incoming serial data from Roulette; subsequently, it executes functions and sets parameters based on this data ultimately queuing noises to occur at semi-random times. As previously mentioned Roulette has input controls for note probability, velocity, drum hit notification, drum hit toggle, micro-sequence placement, tempo, and drum selection. Roulette also requires information to be sent from ChucK regarding LED states for user feedback regarding bar position and drum hit events. ChucK also translates the incoming data and outgoing data into meaningful OSC[7] messages which are sent to a GUI designed with Processing.

3.4.2 Processing GUI

A complimentary GUI for Roulette was designed to supply ample user feedback (Figure 12). The GUI was built with the Processing[8] programming language and receives OSC data via ChucK about the state of all sensors and settings on the sequencer. Users have the option to manipulate Roulette from either its physical interface or the GUI.

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6 http://chuck.cs.princeton.edu/

7 http://opensoundcontrol.org/introduction-osc

8 https://processing.org/

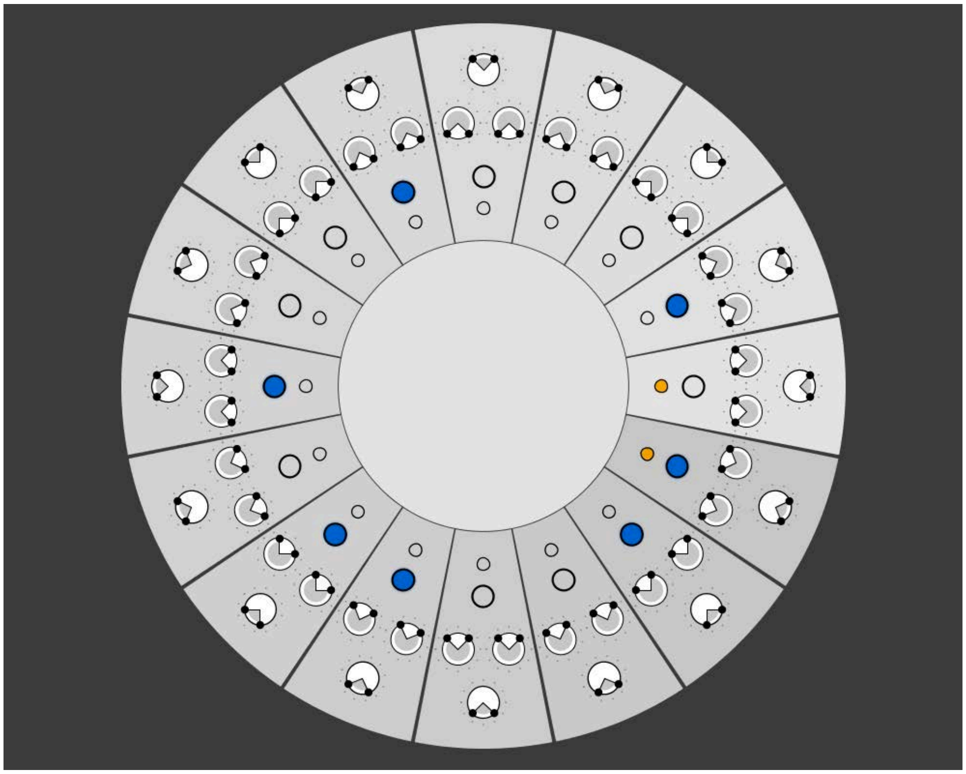

Figure 12 - Roulette's GUI Built in Processing

3.4.3 Teensy++

The Teensy++ [9] microcontroller is responsible for all sensor data parsing. A series of multiplexers routes all sensor data, then afterwards the software written on the Teensy++ uses a delta comparison system to only parse data over serial to ChucK if it detects a change in state. This saves energy greatly and makes it easier on the ChucK side to deal with incoming information, as serial data is only sent when a change occurs instead of a continuous flow of data pertaining to every sensors' state.

The Teensy++ also listens for serial data sent from ChucK. This data is used to set the states of the LEDs used to indicate drum state for each module, sequence position, tempo mode, and drum selection.

9 https://www.pjrc.com/store/teensypp.html

3.5 Summary

Roulette offers expanded capabilities for sequencing drum patterns; specifically, it offers a way to create dynamic drum patterns using the familiar interaction methods associated with standard drum machines and sequencers. Although a circular shape is not commonplace in interface design, conceptually it is highly referential to typical conceptions of time. This allows for reconsiderations of drum pattern creation.

Chapter 4

Ticklers

4.1 Project Description

Ticklers is an on-going project based out the ArtFab Lab of Carnegie Mellon University by Professor Ali Momeni. Research began in Summer 2016 with the author credited as a key-collaborator. The essential goal of Ticklers is to create a portable, user-friendly electroacoustic instrument. In its current state a tickler is a small electro-acoustic instrument that consists of a 3D printed body capable of attaching to a mobile phone, household noise generating items (hair-ties, screws), a piezo-pickup paired with a high-gain preamp, and software designed for both iOS and Android that manipulates the audio signal received from the hardware.

4.2 Conception

Ticklers is an expansion upon core ideas embedded in multiple former projects led by Momeni that investigated new means of expressive interaction with a computer for music performance.

4.2.1 Caress

The most previous and direct connection of origin for Ticklers can be seen in an instrument designed by Momeni from 2010 – 2015 initially called the Tipler (Figure 13) and subsequently evolving to be called Caress (Figure 14).

Caress is "an electroacoustic percussive instrument that blends drumming and audio synthesis in a small and portable form factor" [9]. It uses a collection of independently isolated piezo disk microphones to excite a multichannel audio resonator plugin. The effect of this configuration allows any interaction - be it scratching, rubbing, or tapping - to excite the software to sound as if a resonant chamber is being interacted with in that same manner. The name of the project itself is derived from one of the key intentions of the project; to caress sound from an electronic instrument rather than trigger it. The idea to caress sound stems from the desire of David Wessel, a mentor of Momeni, for there to be a more robust level of interaction with electronic music possible, past the binary results of triggers and the rigid specificity of most sensors' data output [9]. "While sensors tend to only sense what they are made for (e.g. force-sensitive resistors sense pressure, photo-resistors sense light, infrared-proximity sensors sense distance, etc.), microphones capture an enormous range of expressive gestures from tapping with the fingertip to scratching with the nails, to rubbing, and shaking, etc. Caress is designed around the hypothesis that a percussion instrument must leverage this range of expressivity as opposed to limiting it through its choice of sensing technology [9]."

Figure 13 - Momeni's *The Tipler* 2010

Figure 14 - Momeni's *Caress Version 5,* 2015

4.2.2 Microphone as Sensor

A wide variety of sonic information is available to be extrapolated from the output signal of a microphone. Information such as pitch, velocity, timbre, or proximity as opposed to most other sensors which are designed to offer information about one specific type of action. This is the reason that microphones were used in Caress as the primary sensor. More specifically, a piezo disk microphone was chosen as it is highly sensitive to physical interaction with the object it is attached to and less so to external sound sources not in direct contact with it.

4.2.3 ASMR and microsounds

Autonomous sensory meridian response, ASMR for short, "is a tingly experience characterized by a static-like or tingling sensation on the skin that typically begins on the scalp and moves down the back of the neck and upper spine, precipitating relaxation"[10]. There are multiple communities online focusing on ASMR; these communities differentiate depending on the type of sensory excitation, be it visual, tactile, olfactory, or sonically. The sonic community of ASMR is highly present on YouTube, where a plethora of channels devoted to sonic ASMR content can be found. Most of these channels offer a type of relaxation therapy in the form of videos that feature a person interacting very closely with binaural microphones to capture very subtle, minute sounds that are pleasing to the listener. Binaural microphones are used as they mimic how a human physically hears in space; some binaural microphones even feature silicone ears (Figure 15) which the video makers interact with as well to create certain sounds that trigger ASMR (Figure 16). Gently clicking, rubbing, and tapping on various textures very closely to the ears of the microphone is a typical method of ASMR sound creation.

The methods of sound creation in sonic ASMR videos parallels a form of interaction intended with Caress instrument. A similar listening experience is possible due to the level of sonic detail that can be collected from the extreme sensitivity level of contact microphones when paired with a preamp capable of a large level of clean amplification. With the proper circuitry, a contact microphone can act as the sonic equivalent of a microscope; cleanly presenting the world of sound that is created from the slightest graze of the finger on an object. From the way in which a performer experiences what they hear versus how much energy they are investing in that action a reframing of a typical cause and effect relationship of interaction occurs. Playing music with such a subtle form of interaction provides a novel method of play, granting a different perspective of musical thought.

Figure 15 - A Binaural Microphone with Silicone Ears

Figure 16 - A YouTube ASMR Personality Interacting with a Binaural Microphone

4.2.4 Lifestyle Integration

"Imagine a cell-phone case that transforms the phone into a nuanced electroacoustic instrument. Imagine a world where people use their mobile phones to make noise to please themselves and those around them. Imagine a bus or subway car filled with people softly caressing and tickling their mobile phones, instead of playing Sudoku, Angry Birds, or Candy Crush [11]."

An ideal Tickler is one that anyone can enjoy playing anywhere, anytime. The following subsections outline key conceptual design principles that support a Tickler in being easily and enjoyably integrated into any user's lifestyle.

4.2.4.1 Portable Instruments

On the Ticklers webpage Momeni describes the way in which several consumer products that have been released over the past thirty years can be attributed to the way musical experiences have become increasingly personal, intimate, and based on acts of consumption and curation rather than creation. "The Sony Walkman and the Apple iPod normalized the intimate listening experience that is now pervasive in public and private spaces alike. iTunes, [Podcasts], Spotify and the like allowed listeners to develop into collectors (the personal library), curators (the published playlist) and creators (the podcasts)[12]." The Ticklers project aims to work from this current paradigm of personal music experience and append the roster of available interactions to include the playing and performance of music.

In the past decade, mobile technology has been consistently increasing in computing capability. It is now at a point where the typical consumer-grade mobile phone is equipped to handle the computing power necessary for manipulating audio with sophisticated digital signal processing and audio analysis tools. This can be exemplified in the large number of apps available on Apple's App Store or the Google Play Store that feature sound synthesis, sound analysis, and machine learning (notable contributors: Moog[10], Smule[11], and Mogees[12]).

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10 https://www.moogmusic.com/products/Apps

11 https://www.smule.com/apps

12 https://itunes.apple.com/us/developer/mogees-ltd/id923417854

When comparing Ticklers to Momeni's prior project Caress a significant difference can be observed in the choice of software and the computer running it as well as how the instrument interfaces with the computer. Caress requires an audio interface to send its multiple audio signals to a computer. Once the signals reach the computer Caress depends on a custom designed Max for Live[13] plugin to function sonically as intended by the artist. In terms of lifestyle integration this poses a large issue as it requires the user to have a laptop or desktop computer, both Live[14] and Max[15] installed on that computer, and an audio interface with at least eight audio channels. The amount of equipment required for Caress makes the project too cumbersome to be portable; the amount of professional equipment and software makes the project too expensive and specialized to be approachable by all skill-levels. A mobile phone negates these issues as it comes standard with the required computing ability, a built-in analog to digital converter (most commonly used for the microphone on headphones), and software that is easy to access and more affordable than fully-featured digital audio workstations such as Live and Max.

4.2.4.2 Phone Cases

A phone case's initial intention is to be an extra level of protection. However, in addition to this a phone case is increasingly becoming an important accessory – along with clothing, hair, and jewelry- in defining personal style. "Because your iPhone is so visible, whatever you use to encase it becomes a defining personal statement [13](Figure 17)." This observation of phone-driven fashion helped inform the choice to design Ticklers with a form that can act as a phone case. As creating music is inherently an act of personal expression, making a Tickler a phone case is an opportunity to let users express their personality as a musician, maker, experimenter and overall creative type of person with their choice of fashion accessory. An intention of the project is to manufacture Ticklers independently with various colors and materials while at the same time keeping the project open-source so anybody can make a Tickler from scratch. This will allow numerous tastes and identities to be satisfied, including the Do-It-Yourselfer who prefer to start from the ground-up when expressing their personal style.

13 https://www.ableton.com/en/live/max-for-live

14 https://www.ableton.com

15 https://cycling74.com/products/max

Figure 17 - High-Fashion Phone Cases

In addition to the expression of personal fashion, enabling a Tickler to be a phone case mandates the design process to observe standards that greatly increase its functionality and accessibility. With a Tickler acting as a phone case the form must be able to attach to a phone, fit in a pocket, and (along with the hardware) not interfere with any interactions with the phone that doesn't pertain to playing the Tickler. With the Tickler being always attached to the phone in this way, a user will be more inclined to play it as they don't not have to spend time setting it up. These rules ensure that the final design will support a seamless experience with an instrument that isn't cumbersome and is easily accessible whenever and wherever a user decides they would like to play with it.

4.2.4.3 Extended Physical Interaction with Mobile Technology

As the Tickler is an evolution of Caress, a main intention of the project is still to caress sounds from objects rather than trigger them. This is especially interesting when considering the ecosystem of sonic mobile apps, as there hardly any that come with physical interfaces that generate sound acoustically. The possibility to generate sound acoustically then subsequently digitally manipulate it with a mobile instrument that fits in your pocket is a rare experience that is not offered commercially very often. Porting the level of sonic expression Caress offers to a mobile platform offers mobile-musicians another means of musical expression that depends less on the triggering of events.

The audio input from the physical interface of a Tickler can also be used for the control of higher-level parameters by using acoustically varied control gestures. Most mobile sonic apps offer you the ability to control parameters or launch events by swiping and tapping gestures, in more novel cases the built-in gyroscope allows shaking the phone or pointing it in a certain direction to output different types of control data. Rubbing, plucking, scratching, and tapping are all physical interactions that differ greatly, especially sonically. However, despite being able to enact them upon one, these different actions mean very little to a standard touchscreen as it was not designed to discern these actions from one another. Consider if a standard app could interpret the difference between these sonically varied actions and have independent responses to them; much more options for interaction would be available without having to add more knobs, sliders, and buttons into the GUI of said app. Ticklers are intended to be interacted with using these sonically varied actions as to provide their respective software with interactions that go beyond the standard touch screen. This is possible by using audio analysis and music information retrieval tools in the software of Ticklers; different control data can be produced based on the timbre, tempo, pitch, and volume of the incoming audio signal from the piezo microphone attached to the Tickler.

4.3 Phase 1: Design and Implementation

Ticklers is an ongoing project that currently has gone through two phases of research and development. The following subsections outline the work conducted during the first phase of research and development during the Summer of 2016. All work was produced in the ArtFab Labs at Carnegie Mellon University after Momeni procured a grant to hire the author as research assistant.

4.3.1 Practical Application for the Modes of Interaction

After forming the theoretical outline of the modes of interaction (rubbing, plucking, scratching, and tapping), the next task was taking these essential interactions possible with a piezo pickup and finding concrete applications for them within different instruments. Four instruments were proposed as they each had unique modes of interaction available to them that highlighted different aspects of the palate of interactions available.

4.3.1.1 Bow

The Bow is a practical application of rubbing and plucking with an underlying emphasis on the act of exploration through its association with the expansive history of musical experimentation with bows.

The Bow is inspired by extended bowing techniques used by musicians to coax sound out of any resonate object with a standard string-instrument bow. Although a bow is primarily designed to be used with stringed instruments such as cello, violin, viola, or contra bass it can be clearly observed throughout the cannon of music history bows have been used in numerous way past this initial intention. In experimental music, it is commonplace to see a bow being used on cymbals, vibraphones, and electric guitars. A specific point of inspiration for The Bow comes from the nail violin[16](Figure 18), an 18th century invention in which player produce sound by bowing or rubbing a tuned array of nails. This history of diverse usages and experimentation with a traditional string bow acts as a conceptual queue for The Bow to encourage exploration as to what can be bowed.

16 https://en.wikipedia.org/wiki/Nail_violin

Figure 18 - Godfried-Willem Raes Playing a Nail Violin

Initial research for The Bow began with Momeni and his student Sydney Ayers during a Hybrid-Instrument design class creating an instrument called iPhone Violin Case. For the class Momeni and Ayers designed and fabricated a phone case with a small bow attached to it that uses a preamp and piezo microphone to send audio to a mobile phone (Figure 19). The entire case was 3D printed along with some additional fastening material and a small machine screw used ingeniously as a tuning peg for fishing wire which acted as the actual bow. The preamp used originates from a design of Momeni's used for a final iteration of Caress; a standard practice in ArtFab is to open-source any hardware project created in the lab, therefore said preamp was available to the entire Hybrid-Instrument class to use. Using Pure Data and MobMuPlat, Ayers designed a three-track sound sampler[17] capable of recording three different short audio clips with the option to loop or trigger the sample while adjusting the pitch or start and stop times of the sample.

17 A clip of Ayers playing iPhone Violin Case https://youtu.be/rKu03VScTCQ

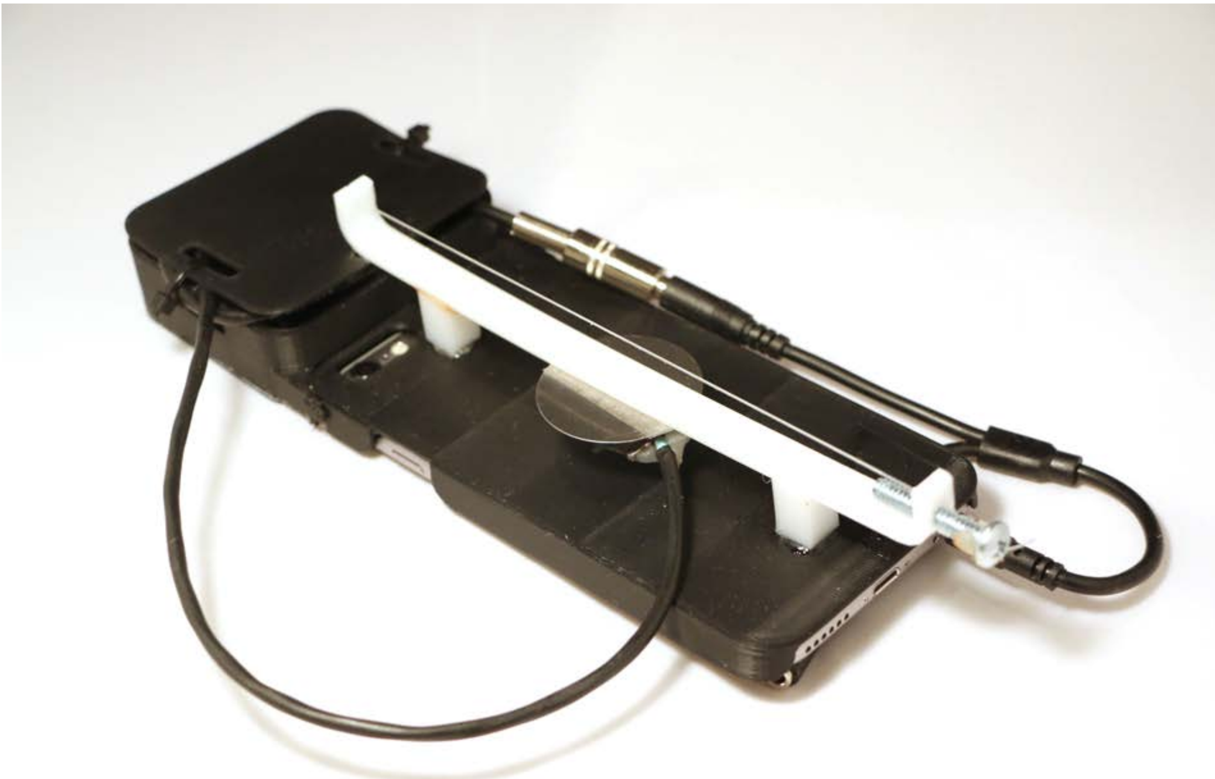


Figure 19 - iPhone Violin Case

Issues with the iPhone Violin Case were that the hardware components took up a lot of space and significantly altered the size and shape of the mobile phone. Also, although the electronics worked most of the time, the preamp didn't offer a pristine signal and sometimes audio cutout would occur due to issues with the way in which the signal needs to be buffered to work properly with a mobile phone.

4.3.1.2 Ektar

Ektar is a practical application of plucking, an exploration of the physical act of manipulating the case itself to alter pitch, and a modernization of a traditional Indian instrument that goes by the same name.

The ektar is an Indian instrumented traditionally made from a gourd and some bamboo (Figure 20). A piece of bamboo is split down its middle and attached to either side of a gourd, a guitar string is then attached from the bottom of the gourd to the top of the piece of bamboo; the ektar resembles a simple guitar with only one string "…ektar literally means "one-string [14]." The ektar is played by plucking its string and bending the two pieces of bamboo; when bending the bamboo, the tension of the string lessens thus lowering the pitch produced by the string. The ektar can be played melodically but, due to its monophonic nature and timbre it also has a very rhythmic quality and it is not uncommon to hear long phrases consisting of a single note being strummed in an intricate rhythm.

Figure 20 - A Traditional Ektar

Ektar also started in the same Hybrid-Instrument design class taught by Momeni with a project called The New OS or One String. The project was conducted by Momeni and his student Samir Gangwani with the goal of turning an Ektar into an electro-acoustic instrument by adding electronic components to alter the sound of the standardly acoustic ektar. The final product from this project was an ektar made using rapid prototyping tools (the body cut from plywood and malleable arms cut from flexible acrylic all using a laser cutter), a piezo pickup, a teensy microcontroller, and custom software (Figure 21). Physically speaking the One String instrument acts in the exact same way a traditional ektar would but, the use of rapid prototyping tools (as opposed to adding electronics to a preexisting ektar) is a conscious effort to conceptually establish the act of modernizing a traditional Indian instrument.

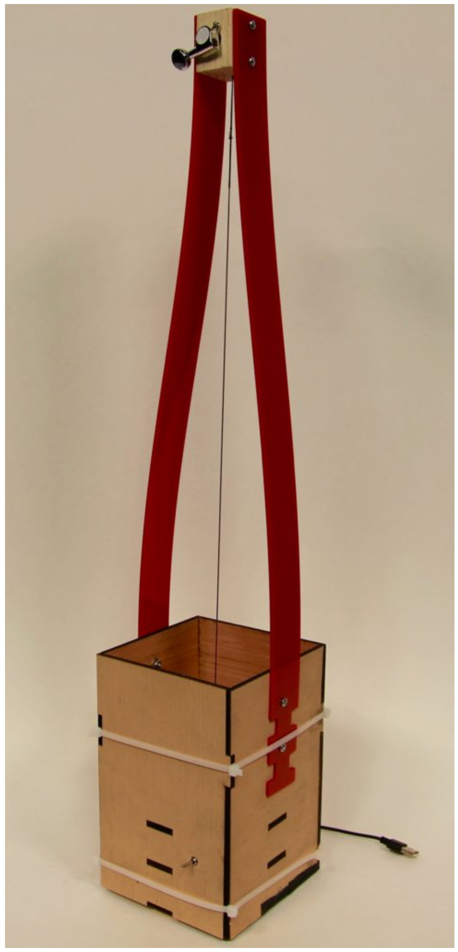


Figure 21 - The New OS or One String

The electronic components of One String consist of a piezo pickup, the same preamp used with iPhone Violin Case, a two-channel USB audio interface, and a Teensy microcontroller connected to a gyroscope. The acoustic sounds of the One String are captured and amplified from the piezo microphone and preamp, they are sent through the USB audio interface to a computer running Max, then Max manipulates this incoming audio signal with a group of audio effects. The parameters of these effects are controlled by the gyroscope attached to the One String and sent to Max using serial communication from the Teensy. Depending on the orientation of the One String the effects in Max are changed to create varied sounds without having to interact with a GUI[18].

18 A clip of Gangwani playing One String https://youtu.be/P0515xutgMM

The One String project was very successful and it was clear that a Tickler version of an ektar was a worthwhile pursuit. From the One String project the factors to be considered consisted of how to scale an ektar to be a viable attachment to a mobile phone, and how to transition from the USB audio interface to a reliable preamp that a mobile phone can receive audio from.

4.3.1.3 Caress Mini

Caress Mini is the seventh iteration of Caress. It is a practical application of rubbing, scratching and tapping. The concepts developed by Momeni while creating Caress still apply to Caress Mini; creating an electroacoustic finger drumming instrument that uses resonance synthesis as it is "… a highly efficient way to synthesize percussive sounds with sharp attacks and exponentially decaying amplitude envelopes."[9]

The main goal for Caress Mini was similar to One String; transitioning from the preamp and USB audio interface combination towards a preamp that can interface directly with a mobile phone. The size of Caress v6 (Figure 22) was already at a point of size that would work well as a phone case however, the electronics took up too much space. The method of sound isolation from Caress v5 and forward is a prominent feature that carried through to Caress Mini as it was very effective and takes up minimal space.

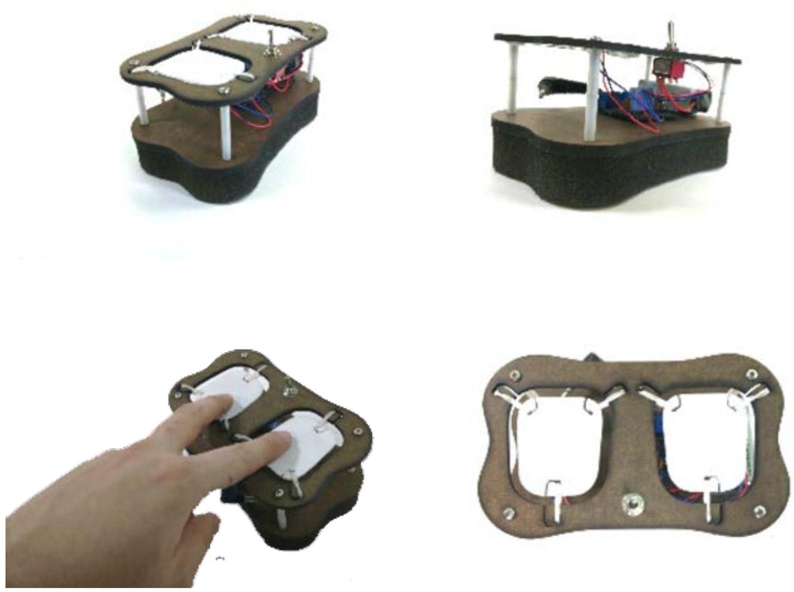


Figure 22 - Caress Version 6

4-pin 3.5mm Headset Connector Pinout

Nokia, Lenovo mobile		
Pin Number	**Pin Name**	**Description**
1	Tip	Left Audio Out
2	Ring-1	Right Audio Out
3	Ring-2	**Microphone**
4	Sleeve	**Ground / Common**

iPhone, Samsung, Blackberry, HTC		
Pin Number	**Pin Name**	**Description**
1	Tip	Left Audio Out
2	Ring-1	Right Audio Out
3	Ring-2	**Ground / Common**
4	Sleeve	**Microphone**

EpsilonTheGreat

Figure 23 - Pinout for Different Phone Model's TRRS Jack

A problem with Caress Mini that no other instrument in the Tickler roster has comes from the need for two audio signals, one for each finger drum. The USB interface that Caress v6 uses is a stereo device, so each piezo microphone signal can be sent independently to a computer. Due to the way Ticklers send their audio signal to a mobile phone, by using the microphone input located on the TRRS (Tip Ring Ring Sleeve) jack (Figure 23), only a mono signal is capable of being sent. This problem is yet to be solved but ideas have been discussed. The current potential solution is to make an additional aspect to the hardware capable of summing two encoded audio signals, then decoding the summed signal software-side to recover the two original independent signals. This is not a small task and more research needs to be invested before multiple signals can be sent to a mono channel. A simpler working-solution is to sum two piezo signals with no encoding; the incoming audio to the phone will consist of the sounds created on both finger drumming pads, the downside of this being only one resonance model can be applied to both finger drums.

4.3.2 Circuit Design

As Ticklers deals with the idea of playing with subtle microsounds, a reliable preamp capable of creating a sonically-clear and high gain signal from the low signal provided by the piezo microphone is a necessity. An additional requirement of a Tickler's hardware is the ability to buffer the audio output signal to match the impedance a mobile device expects to receive. This is due to the decision to send the audio signal of a Tickler to a mobile device's microphone input located on the TRRS jack; sending audio this way requires the signal to be conditioned in a specific way or else a mobile device will not be capable of receiving it.

This combination of preamp and buffer was chosen as it stands to be a versatile and cost effective solution to sending audio from a Tickler to a mobile device. An alternative solution that was considered but not explored with Ticklers was the idea of developing an audio interface compatible with mobile devices. This idea stems from the method of interfacing with a computer in the prior electroacoustic instrument projects Caress v6 and One String; a small, commercially available USB audio interface handled buffering and digital conversion of the piezo signal. This idea was abandoned as it was decided that utilizing an already existing audio input was a more practical and cost efficient method of interfacing a Tickler with a mobile device.

Upon commencement of research for Ticklers Momeni had already developed multiple piezo preamp and signal buffer circuits. Although both designs worked in some capacity a circuit was yet to be designed that successfully combined both a preamp and a buffer circuit. In addition to this lack of combination Momeni was curious the potential for developing a better version of the two component circuits in the process of combining their required functions into a singular circuit board.

Research for a new preamp design and buffer design happened in tandem, as each new design was finished for either aspect of the larger circuit testing occurred to see if they worked with each other. The order of iterative testing for each design is as follows:

- Does the preamp's direct audio signal sound good (clean, loud signal that grabs minute details of the Tickler's microsound-interaction palette) through speakers?

- Does the buffer allow the mobile device to at least recognize that the preamp is connected to the phone?
- Does the signal in the phone sound correct? Ideally, does the converted signal sound the same as it did while testing the direct audio-out into speakers?

4.3.2.1 Preamp

Several different designs for preamps were sourced online and tested. References were made to the last standard ArtFab project preamp called Buffer Preamp Supreme (Figure 24). The choice to move on from using Buffer Preamp Supreme was based on the lack of quality in the gained signal and the buffer aspect did not work with mobile devices.

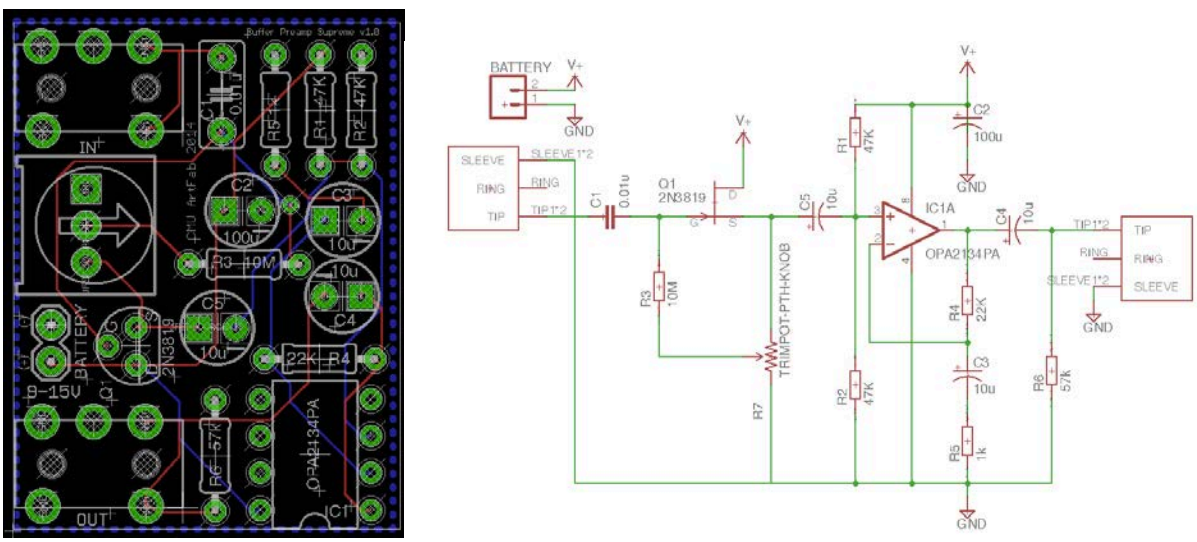


Figure 24 - Buffer Preamp Supreme

Also prior to research for Ticklers began, an alternative preamp design sourced from Martin Nawrath of Lab III[19] at The Academy of Media Arts Cologne was experimented with as an alternative to Buffer Preamp Supreme in ArtFab. Nawrath's design (Figure 25) proved to be highly effective in creating a clear and loud signal from the piezo. Testing this preamp with a buffer had not occurred yet.

19 http://interface.khm.de/index.php/lab-log/piezo-disk-preamplifier/

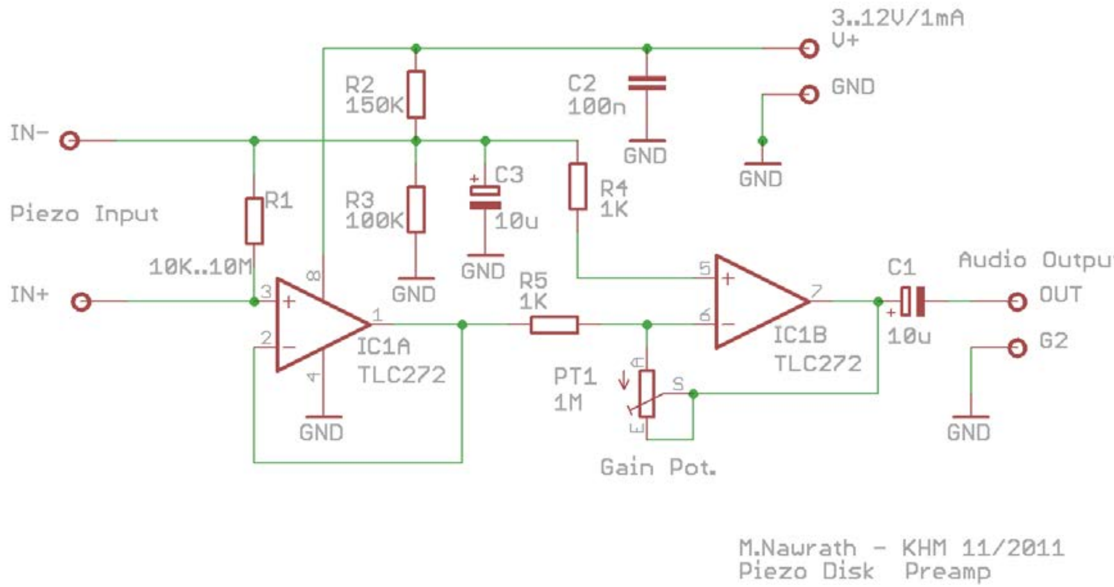
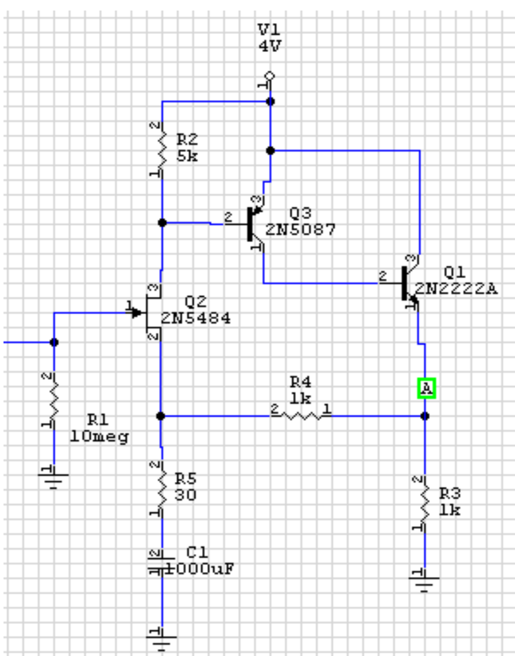


Figure 25 - Piezo Disk Preamp (Nawrath, 2011)

A significant amount of time was invested in a design from Terry Ritter for a "simple, relatively low-noise, JFET-input, 3-transistor audio preamp [15] (Figure 26)." This design was abandoned as it had inconsistent DC offset on the output, creating issues when attempting buffering. This would cause the mobile phone to sometimes not accept the audio signal from the preamp.



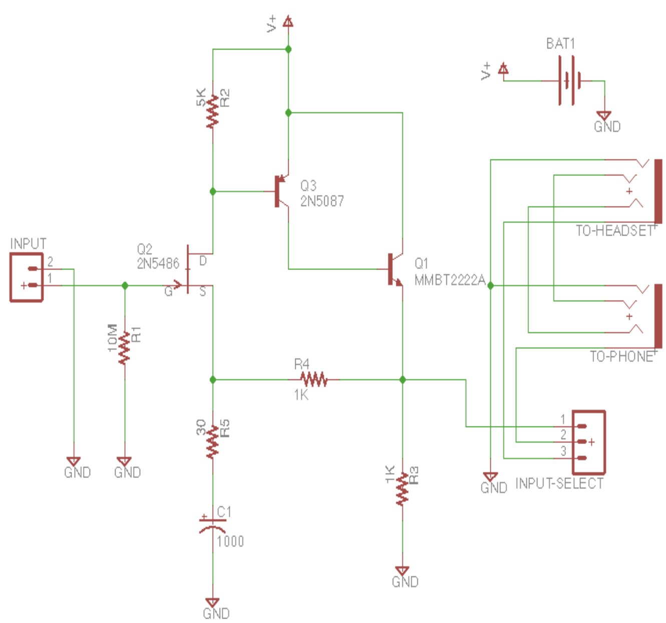


Figure 26 - Ritter's Preamp Design (left)

Figure 27 - ArtFab Implementation of Ritter's Design (right)

After failed attempts with the Ritter design, research shifted back towards using the op-amp component used in Buffer Preamp Supreme: the OPA2134PA[20]. As an OPA2134PA's datasheet describes it as an ultra-low distortion, low-noise operational amplifiers fully specified for audio, it made sense to continue trying to make a preamp that utilized one. A return to Nawrath's preamp design was made but with the slight variation of using an OPA2134A instead of a TLC272[21] which is a cheaper, more general purpose op-amp with very similar specifications to the OPA2134A. Testing was successful with this circuit (Figure 28) as it sounded great; a large amount of gain was available without distorting the signal; and when paired with the latest buffer component developed, the audio signal could be sent sonically unchanged to a mobile device.

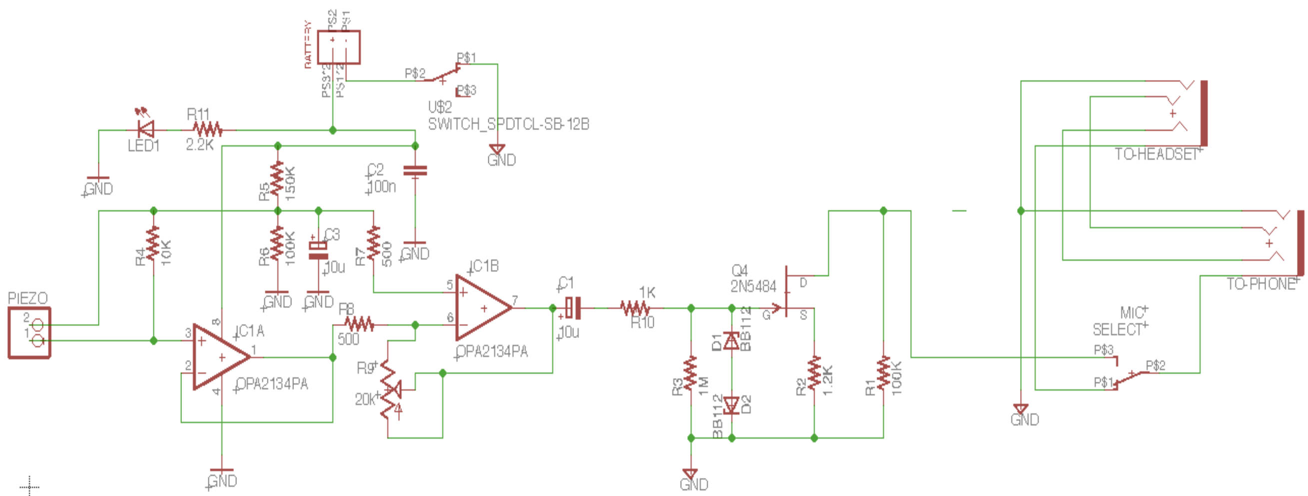


Figure 28 - Ticklers Preamp v9 (Most Current Working Iteration)

4.3.2.2 Buffer

As a mobile device has the option of connecting a microphone to it through the TRRS jack, it is standard to find a 2.8-volt power signal being output from the sleeve of the jack as a means of powering the microphone preamp in pairs of headphones that have a microphone in them [16]. This 2.8-volt power signal can cause negative effects on a circuit if not considered in the design such as distortion or an overall change of the expected functionality of a circuit. Therefore, a

20 http://www.ti.com/lit/ds/symlink/opa4134.pdf

21 http://www.ti.com/lit/ds/symlink/tlc272.pdf

buffer is needed for the Ticklers preamp to ensure the audio signal created in the preamp aspect of the circuit remains preserved as it is sent into a mobile device.

When beginning research for Ticklers, ArtFab already had one buffer circuit in their collection. The main problem with this buffer circuit (Figure 29) is that it features a variable resistor in the design; requiring the user to manually impedance match by turning a trimpot until the mobile device paired with it accepts the input signal. This is an unfavorable feature in the buffer design as it introduces an opportunity for the buffer to not always work properly; the trimpot could be set in the wrong place due to negligence or from the challenge to find the proper resistance value. This is an especially significant problem as the Tickler is intended for a wide range of users, not all would be willing to experiment with a trimpot to get the buffer to working properly. The ideal buffer would be one that does its job with no interaction from the user required.

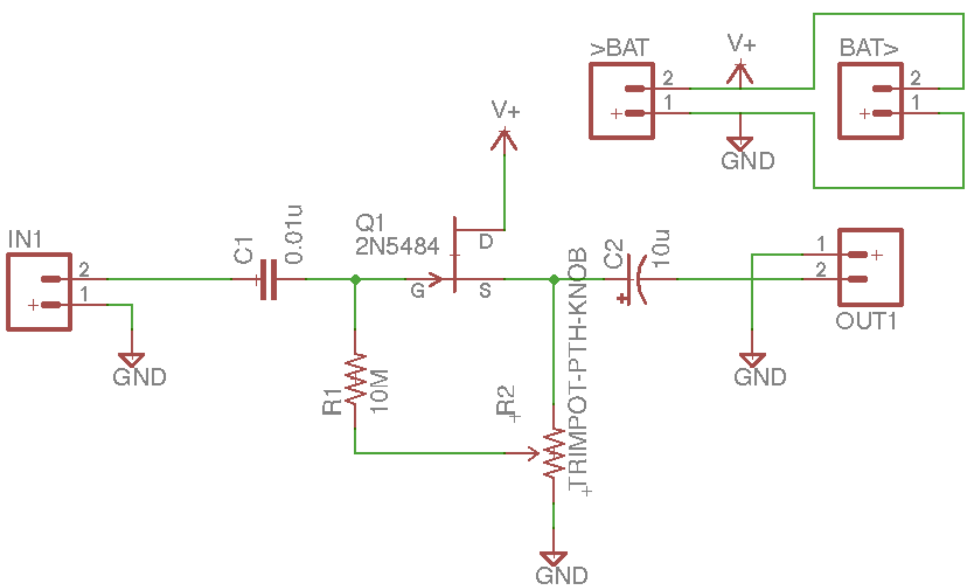


Figure 29 - JFET Buffer with Trimpot

A series of video tutorials created by a software designer named John Cooper addressing why a buffer is required when sending an audio signal to a mobile device and how to make one were reviewed and subsequently a buffer was fabricated in ArtFab using Cooper's design (Figure 31). Cooper explains in his video that his buffer design is a variation of a common JFET amplifier circuit but with modifications due to the drain resistor being embedded inside a mobile device and out of reach (Figure 30). Without access to the drain resistor, the circuit design can only choose a proper source (RS) and R2 (see Figure 30) value to properly bias and set the gain of the buffer [16]. Cooper's designs properly buffers the signal, is compatible with numerous mobile devices, and requires no adjustments to be made by a user for it to work properly. When connected to ArtFab's iteration of the Nawrath preamp design the clarity and gain of the audio signal created in the preamp is maintained and successfully transferred into a mobile device. The two components can be connected with no modifications between the two necessary. When observing the Ticklers preamp (Figure 28), everything to the left of C1 is the preamp aspect of the circuit and everything to the right of C1 is the buffer.

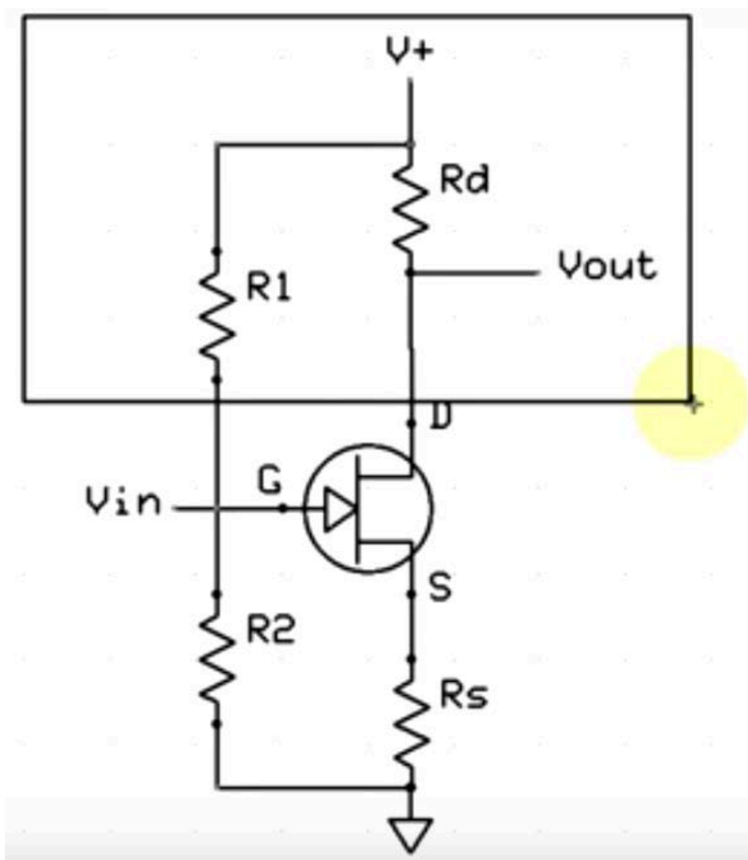


Figure 30 - JFET Amplifier Circuit: Box Outlines Embedded Components in Mobile Device

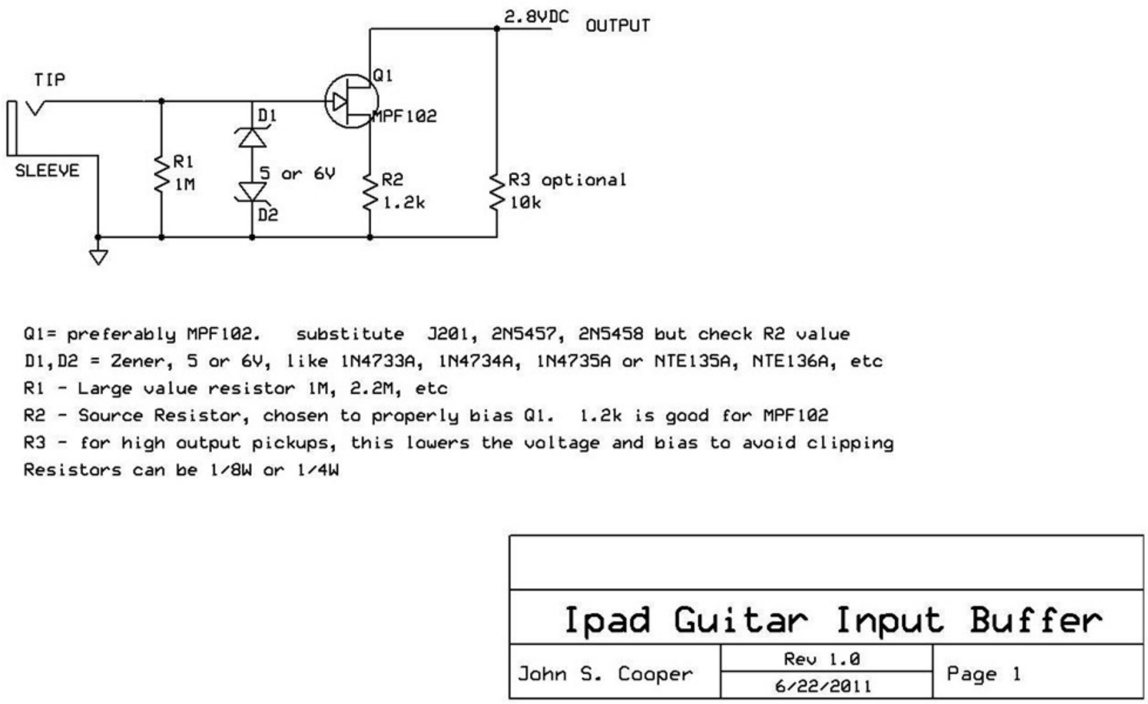


Figure 31 - John Cooper Input Buffer for iPad

4.3.2.3 Additional Features

Additional features to enhance the functionality of the circuit are as follows:

- On/Off switch to conserve battery energy when Tickler is not being played.
- Toggle switch for selection audio input to mobile device. Either the signal from the piezo or the microphone from a headset can be sent to the mobile device. If the headset microphone is chosen, the Tickler preamp and buffer is disabled and doesn't affect the signal of the headset microphone.
- TRRS output jacks to simplify interfacing with a mobile device. A standard male-male TRRS cable can be used to connect a Tickler to a mobile device.
- The shape of the board (**Error! Reference source not found.**) caters to the specific dimensions of a Tickler's physical interface. The gain knob, toggles, and TRRS jacks have been placed in functionally appropriate spaces. This requires a high amount of coordination and cross-reference between the circuit and case design.

4.3.3 Instrument Design

4.3.3 Instrument Design

During the first phase of the ticklers project, the goal for the design of the case was in the pursuit of function rather than form. The essential function of a Tickler case is one that can both act as a playable instrument and be mounted to various mobile phones.

Fabricating standard phone cases comparable to consumer-level products was not a realistic option; the means of production required for that would have led to a lengthy research project. Instead, all instruments were designed to be compatible with a selfie stick clip (Figure 32). The selfie stick clip was chosen because of its ability to hold numerous sizes of mobile phones. It also features two threaded holes which were used as mounting points for all cases.

Figure 32 - A Selfie Stick Clip

Three instruments were created: bow, ektar, and caress mini; each as a development of the prior mentioned practical applications of interaction. Due to the use of a selfie stick clip for every instrument, the mounting aspect of every instrument was designed once and reused with only slight alterations when needed. Bow and Caress both already existed in a scale and form that worked well with a mobile device. Their designs were refined, not overhauled. Ektar required a completely new design as its scale was much too large. The primary focus of ektar's design was finding the proper shape of neck that was malleable and offered the largest range of notes (Figure 33).

Figure 33 - Renderings of Ektar

Figure 34 – Iterations of Ektar (left), Bow (center), and Caress (right)

All cases were physically created using 3D printing (Figure 34) and some additional prefabbed components. Both ektar and bow required a taut string; fishing line was used to high effect, and caress required a shock mount[22] system that utilized orthodontic rubber bands. Specialty components in the printing process include a threaded tuning peg (Figure 36), and a hinge system for Caress (Figure 35).

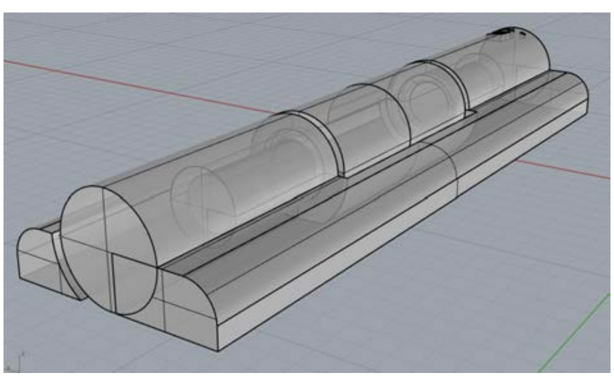


Figure 35 - Caress Hinge (left)

Figure 36 - Tuning Peg (right)

22 https://en.wikipedia.org/wiki/Shock_mount

4.4 Phase 2: Form Refactor and Software Design

Phase two of the Ticklers project occurred during a ten-day residency of the author at Art Fab in Carnegie Mellon during the month of January 2017. The goal of this residency was to finalize one working prototype of a Tickler and begin a Kickstarter campaign for it.

Figure 37 - Bowto Paired with a Mobile Device

4.4.1 Bowto

The Tickler chosen to be the focus of the project from that point forward was bow, as it seemed closest to completion and featured the most varied interaction capabilities. Between the summer of 2016 and January 2017 bow's form had been highly redesigned to better act as an extension of a mobile phone with the least obtrusion. Bow was now significantly smaller and no longer required a selfie stick clip to attach to a phone.

During the process of testing the new iteration of bow three largely significant changes were suggested and subsequently implemented (Figure 38): a series of movable bridges, thick rubber bands instead of fishing wire, and the option for multiple strings.

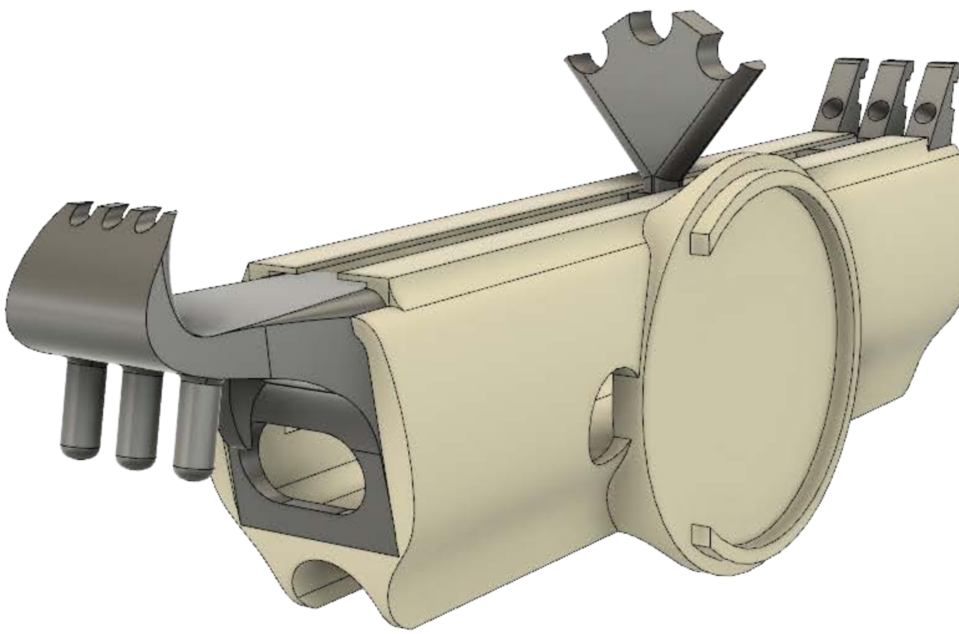
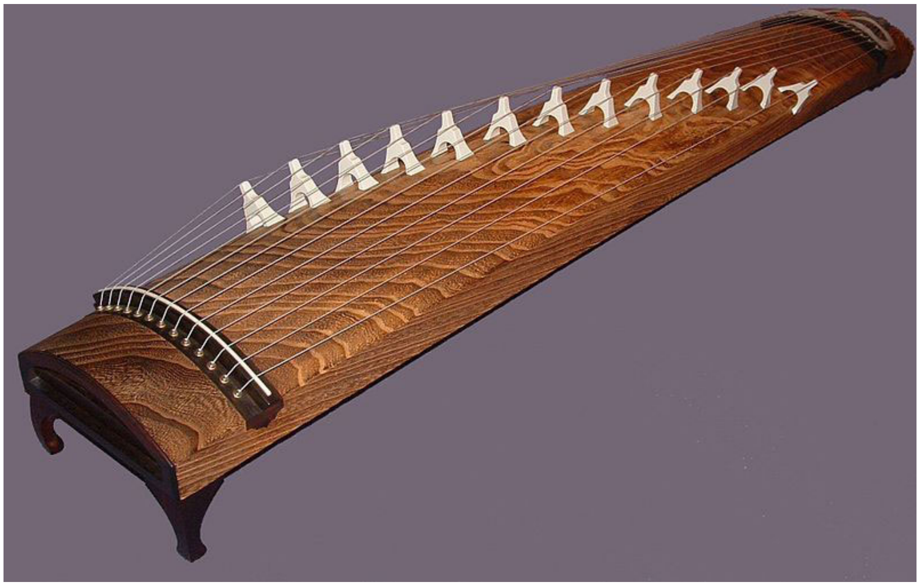


Figure 38 - Rendering of Bowto

Plucking the bow string during testing was observed that as the more common, and musically obvious form of interaction with bow. The desire to vary the pitch created when plucking lead to the implementation of a bridge system comparable to how a koto (Figure 39) functions. This was done by adding a rail system along the length of bow between the two points that the string is draw taut, within the rail fit a removable bridge piece capable of sliding along it and being held in place by the pressure of the taut string (Figure 40). The bridge features space for three strings to be placed across it, this adds a potential for multiple pitches to be played.



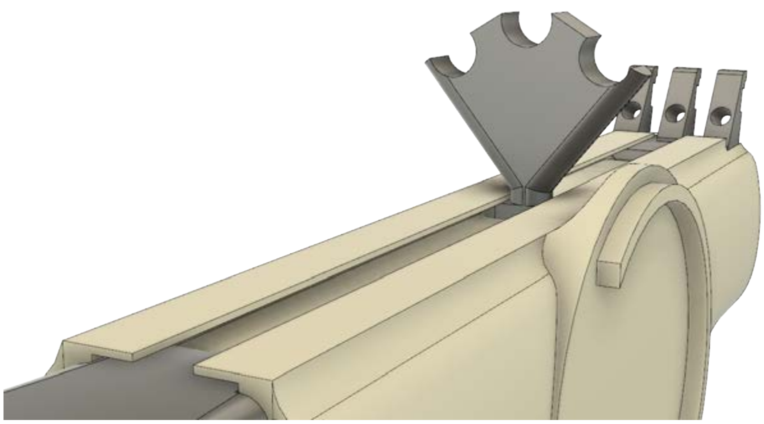


Figure 39 - A Koto (top)

Figure 40 - Bowto's Movable Bridge (bottom)

The final major change was the switch from fishing line to thick rubber bands (Figure 37). Using rubber bands fostered a richer tonality and resonance, as well as removed the need for a mechanical tuning system; the elasticity of the rubber band allows for it to be strung by being wrapped around pins on either side of the bowto. When amplified, the pitch range of the rubber band is much lower than the fishing line, this bass-range inspired the name bowto: a bass-koto.

4.4.2 Pure Data and MobMuPlat

The combination of MobMuPlat and Pure Data was chosen as the software-side workflow as it offered the fastest turnaround from idea to testable prototype. "MobMuPlat is a standalone iOS+Android app which hosts and loads from a list of available works. Creating your own work consists of two parts. First, creating a graphical user interface (GUI) with the MobMuPlat Editor (OSX and Java versions available); second, creating the audio engine using the graphical programming language Pure Data (PD)." [17] Like the use of rapid-prototyping tools when making physical objects, the plug and play nature of the visual-programming languages Pure Data and MobMuPlat enable ideas to be investigated faster than if they must be created from scratch using a text-based coding language.

There was no specific goal for a final interface when software development began. Instead, experimentation was encouraged; the development process consisted of playing with a Tickler and considering how the experience might be heightened or altered by additional software. Through this experimentation process specific projects became defined that mixed ideas of note-level control with aspects of generative-accompaniment. Projects included: bassMasta, a summed audio signal of the original audio signal of a tickler pitch shifted combined with a bass synthesizer pitch following; loopy, a multitrack loop recorder; arpy, an arpeggiator with either a looping or pitch-tracking mode; wahWah, a tilt-controlled wah-wah filter; and rezDrummer, the mobile reinterpretation of Momeni's resonators Max for Live plugin.

As projects developed, so did a design standard to maintain an aesthetic and functional cohesion between each interface (Figure 41). This design standard supported the goal of keeping the interfaces simple but capable of enabling expression, and fun:

1. A color pallet and font style was maintained for each interface.
2. Aspects of interfaces used in multiple interfaces were not changed and placed in the same place.
3. Preloaded presets as examples of how the interface can be used.
4. An interpolation matrix to ease new users into experimentation by interpolating between presets to find new sounds.

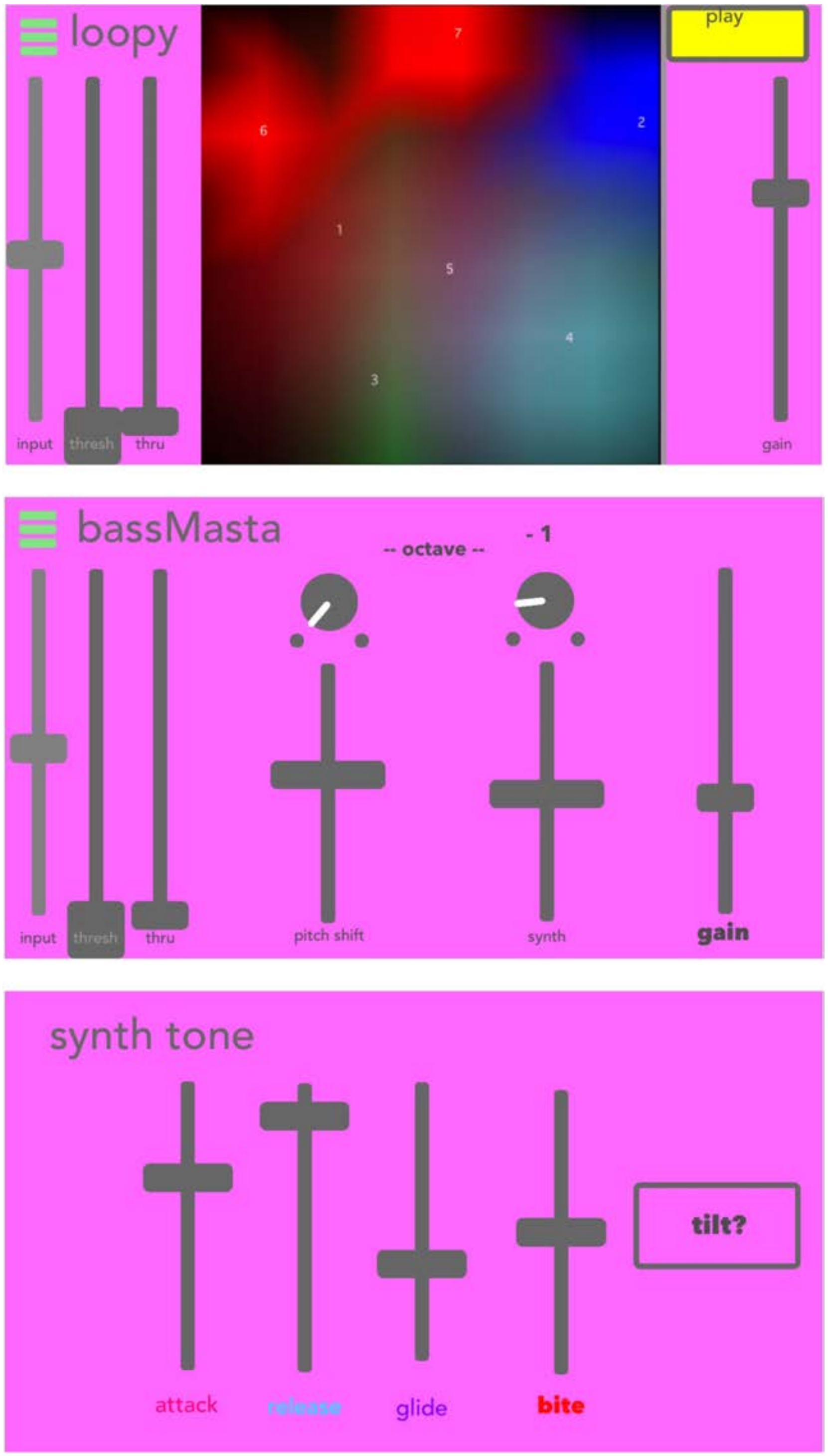


Figure 41 - Ticklers GUI

4.5 Summary

A large amount of technical research was required to create the core hardware component of the piezo preamp-buffer combination circuit. In concluding this technical research creative research and experimentation was then possible.

A refined design for both the hardware and software of Ticklers is slowly being reached with each iteration of prototype. Successful components enabling the act of "caressing sounds" [9] from each prototype have been integrated into subsequent designs. This combination of successful components has led to the latest instrument Bowto, which meets the goal of a Tickler in being both ergonomic and rich with capacity for musical exploration. Experimentation with the first iteration of Ticklers' software has helped develop a design standard that produces an approachable, fun, and creatively-satisfying user experience. A beta prototype will soon be finished and demonstrated in a Kickstarter campaign to raise funding to finish the project.

Chapter 5

Art Arcade

5.1 Project Description

Art Arcade was a group show led by the author, Niels Henrik Bugge and Ana Pérez López spanning the Spring 2017 semester. The show focused on the use of arcade-entertainment technology, most specifically the use of coin mechanisms (Figure 42). Nine artists participated in the show including the three project leaders and were chosen after an open-call for proposals.

Figure 42 - A Coin-Mechanism

5.2 Conception

The critical aim of Art Arcade was to present a platform to question the conventions surrounding interaction with art at present; exploring the potential for work to exist at the intersection between high and low culture.

The implementation of arcade technology, specifically coin-operated mechanisms, is an attempt to rethink the typical form of interaction with gallery-based artwork; coin-operated pieces are a novel occurrence in contemporary art. The coin-mechanism was chosen to be the primary interface to create art from as it represents the essential experience from arcades that the author wished to appropriate into a fine art context: a small monetary sum in exchange for an experience. Placing this exchange in the forefront of each piece presents the audience with the chance to consider how the value of an artistic experience is applied, and if it is altered by the monetary value associated with it.

From the pairing of the high culture associated with fine art and the low culture associated with arcades, it was the hope of the author that unconventional modes of thinking and art-making would be encouraged. The Art Arcade project aimed to convolve these two perceptions and form a synthetic, cross cultural understanding and appreciation for art as a whole. In addition to this crossing of cultures, arcade technology presented a collection of technical and conceptual initial working points from which artists could draw inspiration from.

5.3 Call for Proposals

The range of directions an artist could explore under the theme of using arcade technology was what dictated to the decision to make Art Arcade a group show with an open call for proposals (Figure 43). Prior to the open-call, when considering the idea of a coin-operated piece of art numerous points of entry such as political, surreal, humorous, or philosophical were already being proposed for pieces by the project leads. It was apparent that from the breadth of artistic response possible, an open-call for proposals would generate a collection of conceptually-varied pieces and would less-constrain this potential for ideas to the specific interpretations and thoughts of the three project leads.

Figure 43 - Poster Design Advertising a Call for Proposals

5.3.1 Technical Assistance

To further encourage varied artistic response, the call for proposals noted that technical assistance from the project leads would be available throughout the project[23]. By disregarding the technical ability of the artists and instead focusing on their concept it was hoped that artists lacking a technical background but presenting a strong idea would be able to successfully participate if selected. The project leads acting as technical directors eased the typically steep learning curve associated with the integration of new media arts skills such as programming, electronics, and mechanics into the participating artists' practice.

5.3.2 Workshops, Critiques and Meetings

Bi-weekly workshops and critiques while creating the show were planned as an opportunity for logistics, technical problems, and project ideas to be discussed between everyone participating. The workshops, meetings and exhibition were considered equally important components to the intent of the project.

The workshops and meetings functioned to instill a sense of belonging to a temporal collective that existed through the duration of the project. Several important ideas for the show were conceived during this time. Some notable creative advances from these round-table discussions include Roksana Pirouzmand's need for a machine capable of dispensing numerous currencies being solved with the suggestion of a pop can dispenser, Gavin Mottram being encouraged to have his own call for submissions for his video gallery, and Noah Malone pivoting on his piece idea; switching from a drawing automata to a mechanism for dipping tortilla chips.

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23 A detailed project synopsis and call for proposals can be found at http://www.artarcade.net/

5.4 Design and Implementation

The requirements for the realization of each piece in Art Arcade varied. For much of the pieces some combination of fabrication, programming, electrical engineering and graphic design was needed. During the group meetings, each participating artist worked in tandem with the lead artists to arrange a plan as to what needed to be done and who could execute each task. Specialty equipment was sourced for aspects of projects that required it for conceptual reasons or as it made more sense than building it from scratch.

5.4.1 Enclosures

A minimalist design for the enclosures of pieces was used to maintain a cohesive, pure-white aesthetic between them. The enclosures looked comparable to the simple plinths found in any contemporary art exhibit (Figure 44). This aesthetic was referential to the environment of a fine art gallery, where almost everything but the artwork is painted white as a means of not diverting attention from the featured art. In Art Arcade specifically, this was intended to direct attention to the essential interaction possible with the piece instead of the technical components of it.

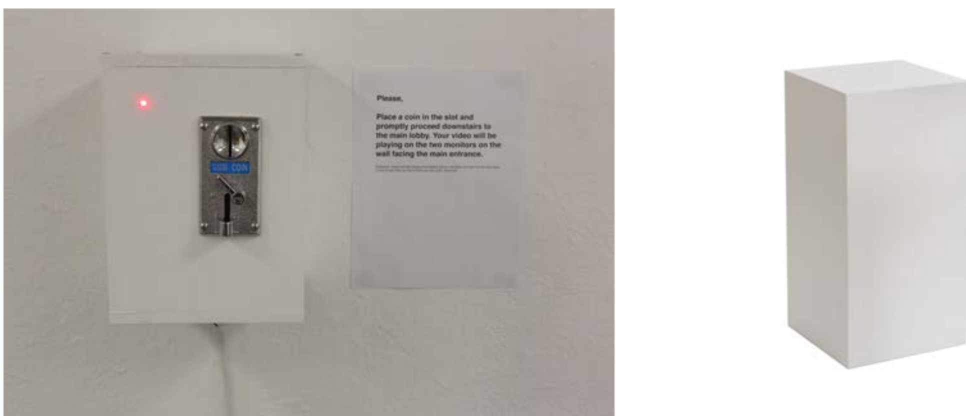

Figure 44 - Art Arcade Enclosure Compared to Exhibit Plinth

5.4.2 The Coin Mechanism

The same coin mechanism was used for every project built for the show. The coin mechanism works by using a reference coin (Figure 45) to compare against coins being inserted. If the coin tests successfully, then the actuator (Figure 46) opens and allows the input coin to pass through the bottom of the mechanism instead of being returned to the refund platter. In addition to the actuator being activated, a five-volt pulse is sent from the "Counter Meter" output line (Figure 45). By wiring this pulse line with a pullup resistor and an input of a microcontroller, communication signaling a successful coin exchange has occurred is achieved.

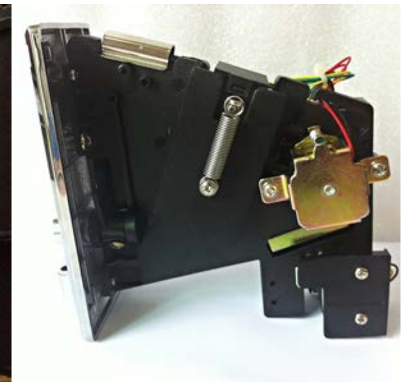

Figure 45 - Side of Coin Mechanism (left)

Figure 46 - Side of Coin Mechanism with Actuator (right)

A slight modification was made to the pinout to achieve the ability to control when the coin mechanism was functional. From observing the schematic in Figure 47 a TIP122 can be seen; this transistor's job is to allow the Arduino the ability to disable the coin mechanism's actuator from getting power. This modification was implemented to negate the event of money being eaten by a piece. After a successful coin insertion, the coin mechanism can be disabled from accepting anymore coins until the sequence activated has finished.

When designing the circuit boards for each piece a core functionality was defined then built upon. Every circuit required communication between an Arduino and a coin mechanism, an external power input to power the Arduino and coin mechanism, and the previously mentioned transistor modification. Specific functionality was then considered for each piece. Additional circuitry per individual piece consisted of:

- Relay control for Double Dipper and Phenakistoscope.
- Button input and stepper motor control for Peep Show.
- A red indication LED for CalArts Lobby Remote Video Content Release Mechanism

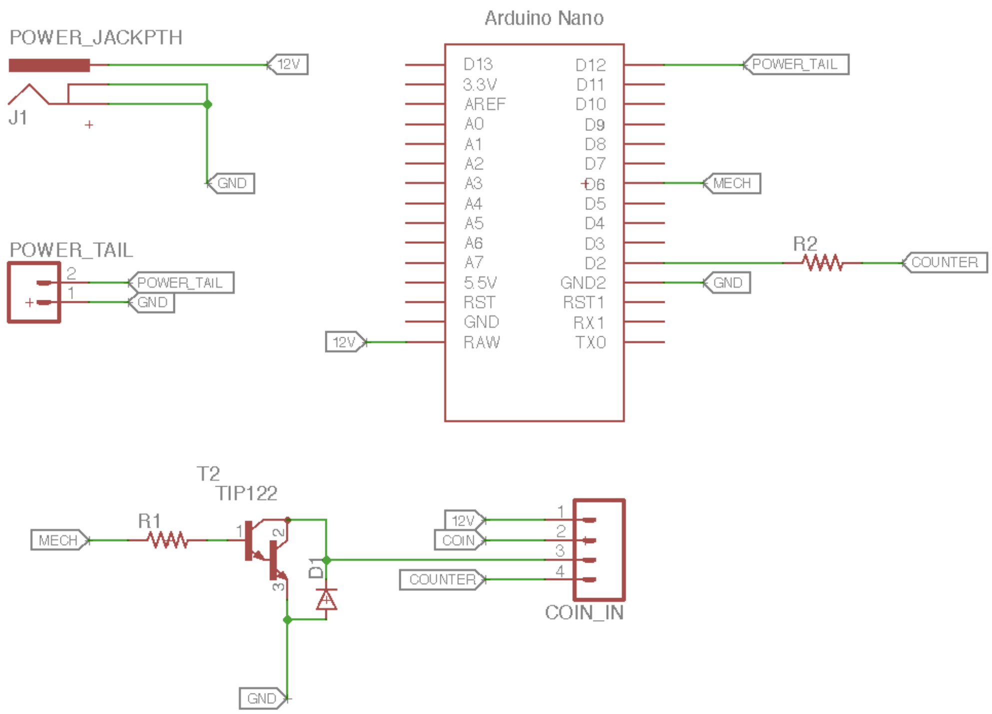

Figure 47 - Schematic for Interfacing Coin-Mechanism with Arduino

The one-off nature of these circuits made the use of rapid prototyping tools the best method of realization. A miniature CNC machine designed to route circuit boards made it possible to create boards more reliable than permanent protoboard and faster than ordering them to be externally fabricated (Figure 48). Within the same day of designing a circuit a structurally-sound and functional board was ready to be used.

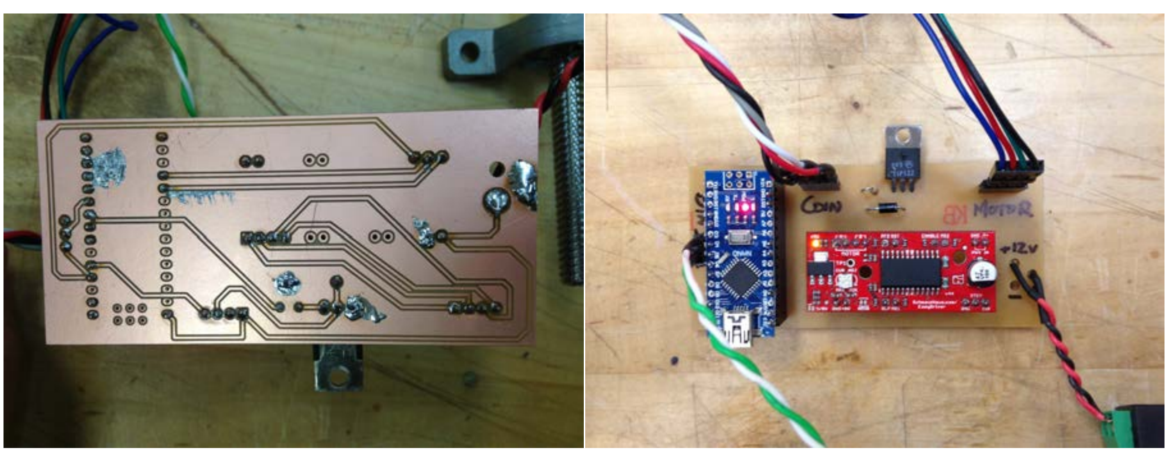

Figure 48 – Both Sides of Routed Circuit Board for Peep Show

5.4.3 Recycled Mechanisms

Several mechanisms were repurposed for the Art Arcade. This was done for the practicality of sourcing objects already made as opposed to building them from scratch, or as a tactic to utilize the cultural connotations associated with the mechanism.

5.4.3.1 Record Player

A hacked record player was the main mechanical component of the Phenakistoscope. This project followed the instruction of Drew Tetz's article in Make Magazine on creating animations with a record player and mobile phone[18]. Tetz design specifically calculates the number of frames needed on the animation disk using the RPM of a record player and the frame rate at which mobile phone's camera functions. Hacking a record player removed the need to design a motor system with accurate RPM control. Instead, the motor and circuitry were removed from a commercial record player and integrated into the rest of the circuitry of the Phenakistoscope.

5.4.3.2 Claw Machine

A commercial claw machine was initially desired but was anticipated to be too expensive. However, a claw machine was sourced at a very affordable price on Craigslist. Calculating the price of building a claw machine determined that it was more expensive and time consuming than purchasing one. The commercial fabrication style of the purchased claw machine also added a level of authenticity and surrealism to the experience of interacting with the piece.

5.4.3.3 Pop Machine

A pop machine was used to satisfy Roksana Pirouzmand's need for a mechanism capable of exchanging an American quarter for that value in the currency of one of the six countries sanctioned by the United States. A commercial currency exchange machine was not affordable, so instead it was decided to use a pop machine as it would be capable of dispensing bunched rolls of coins.

5.4.3.4 Gumball Machines

Vending machines selling candy and toys are highly associated with arcades. This cultural association in combination with the constraints of scale and creating multiples[24] tied to using a gumball machine encouraged the author to suggest in the call for proposals that artists consider

24 A term for small-scale, three-dimensional works conceived by artists, and often produced commercially, in relatively large editions.

submitting pieces using gumball machines. Three pieces were chosen: one offering pharmaceuticals from Tijuana, one offering a book on USB written by the artist, and one offering gumballs with existential quotes on the wrapping paper. These machines were placed at the entrance/exit of the arcade in a row, just as they are placed in regular arcades, to entice visitors to buy something when entering or before leaving the show.

5.5 Featured Pieces

This section will briefly describe the pieces created for the Art Arcade. Text from the artist explaining their work is featured when available.

5.5.1 Molly Surazhsky: Free Medical Dispenser (Tool of Weaponry and Resistance to the Medical-Industrial Complex)

Free Medical Dispenser (Figure 49) examined border relations and healthcare rights. A gumball machine that only accepts Mexican pesos was filled with medication purchased in Tijuana. The medication was free to visitors; after signing a liability form they were granted a peso to retrieve medication.

Figure 49 – Free Medication Dispenser (left) Closeup of Medication Capsules (right)

Surazhsky explains in her proposal that "Americans visit Tijuana daily to receive prescription drugs for much cheaper and reasonable prices. In an act of resistance towards the domination and market profitability of Big Pharma, I propose to challenge through the act of illegality, Americans' access to medicine and extend the notion that healthcare is a human right. Additionally, by crossing the border, I want to interrogate the rise of neonationalism in the act of moving across and between borders."

5.5.2 Hande Sever: The Existentialist Bubble Gum Dispenser

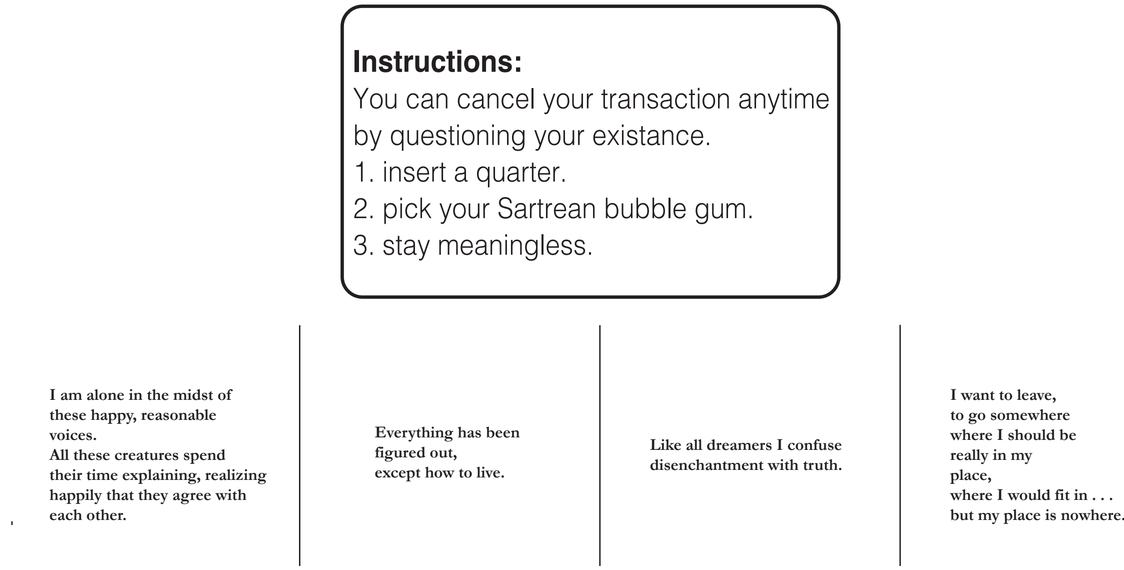

Figure 50 - Existentialist Instructions (top) Samples of Quotes for Gumball Wrappers (bottom)

Sever explains in her proposal that "*The Existentialist Bubble Gum Vendor* is a bubble gum dispenser that vends bubble gums wrapped with existentialist texts inspired by works of Sartre, de Beauvoir and Camus. These texts will be based on the listed authors' works written as a response to the horrors of Nazi occupation of France such as *The Blood of Others*, *Dirty Hands* and *The Myth of Sisyphus*. Because of the politics of contemporary memory manipulation, we have become accustomed to spitting out disturbing news and history from our minds as we would spit out a bubble gum when its taste goes away; therefore, *Your Existentialist Bubble Gum Vendor* references our daily habit of forgetting while reminding us of the past horrors."

5.5.3 Jack Taylor: Loplop Drives

Loplop Drives was a gumball machine that dispensed copies of Jack Taylor's book Loplop on USB stick. Loplop discusses ideas pertaining to the virtual versus objective reality in the realm of contemporary art and art theory. As the book was originally distributed in a limited number of prints, Taylor was interested in the potential for digital distribution with the gumball dispenser being the starting point.

5.5.4 Roksana Pirouzmand: Sanctioned (Out of Order)

Sanctioned (Out of Order) (Figure 51) examines the relationships between the United States and the six countries sanctioned by it; Iran, Cuba, The Ivory Coast, North Korea, Burma, and Syria.

Originally, the project intended to dispense an exchange of an American quarter to the currency of one of the six sanctioned countries. Difficulty attaining these foreign currencies led to the machine being set to "Out of Order"; an appropriation of the term commonly associated with broken machinery to communicate to the piece's audience the lack of interaction possible with these countries, and therefore lack of interaction possible with the piece.

Figure 51 - Sanctioned (Out of Order)

5.5.5 Ana Pérez López: Phenakistoscope

Phenakistoscope is an experimental animation project which syncs a record player's RPM and the frame rate of mobile phone's camera (Figure 52) to create an animated loop from a spinning disk of separate animation frames (Figure 53). Instructions prompted users to take out their phones, set them to camera mode, insert a coin, and enjoy. On insertion of a coin the record player's motor and a lamp illuminating the animation engaged, allowing users to investigate the activated animation with their mobile phone.

Figure 52 - Mobile Phone Animating the Phenakistoscope Disk

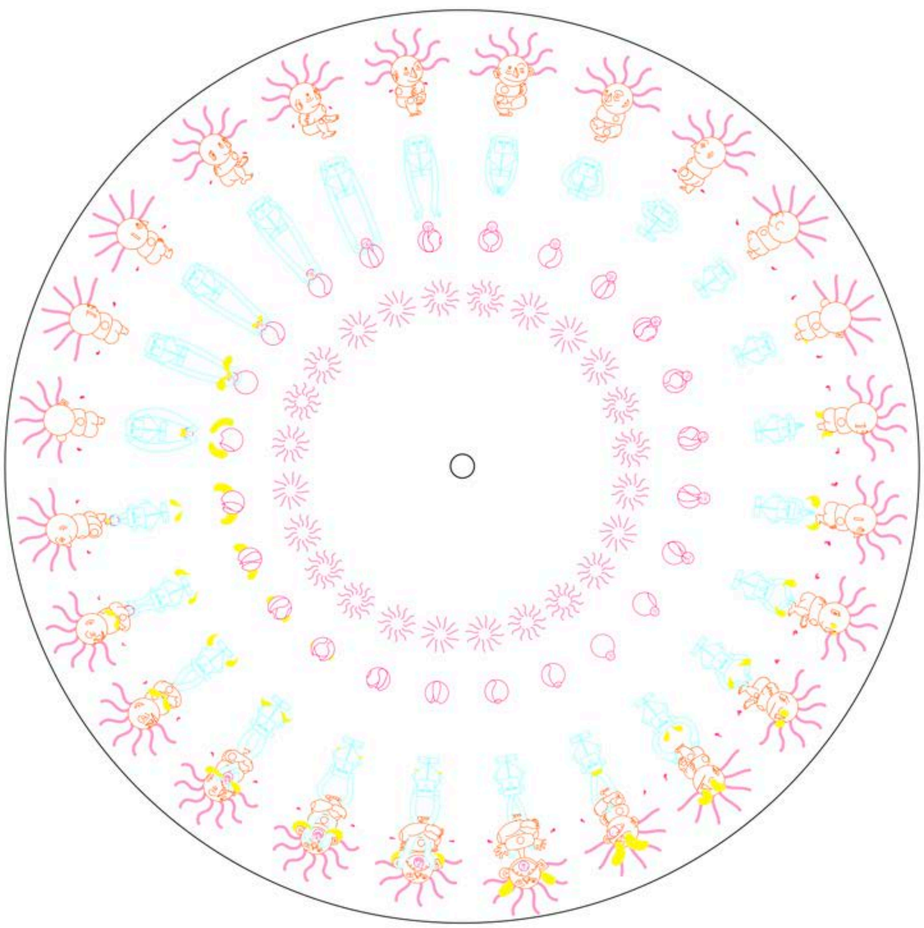

Figure 53 – Pérez's Animation Broken into Separate, Radially Distributed Frames

5.5.6 Noah Malone: Double Dipper

Double Dipper (Figure 54) is a mechanism that automates the action of dipping tortilla chips into salsa. Users are presented with a set of instructions explaining how to prep the machine by clipping in two chips to either side of the machine, and then activating the dipping process with a quarter. When dipping has concluded, users may eat the chips or pay an additional quarter to continue dipping the chip to their liking.

Figure 54 - Double Dipper

5.5.7 Gavin Mottram: CalArts Lobby Remote Video Content Release Mechanism

CalArts Lobby Remote Video Content Release Mechanism (Figure 55) consists of a coin-operated video controller installed in the main space of the Art Arcade and a video gallery installed on a different floor of CalArts. When users insert a coin the red light on the video controller turns off to indicate that a new video is playing in the lobby of CalArts. Users have the option to run downstairs to try and catch the video, coordinate a system with a partner in which one person pays and the other person watches, activate a video for strangers in the lobby, or to be confused as to what they just paid for. An open call for submissions was made by Mottram asking for short video pieces or found footage evoking a sense of obscurity and the feeling of channel surfing.

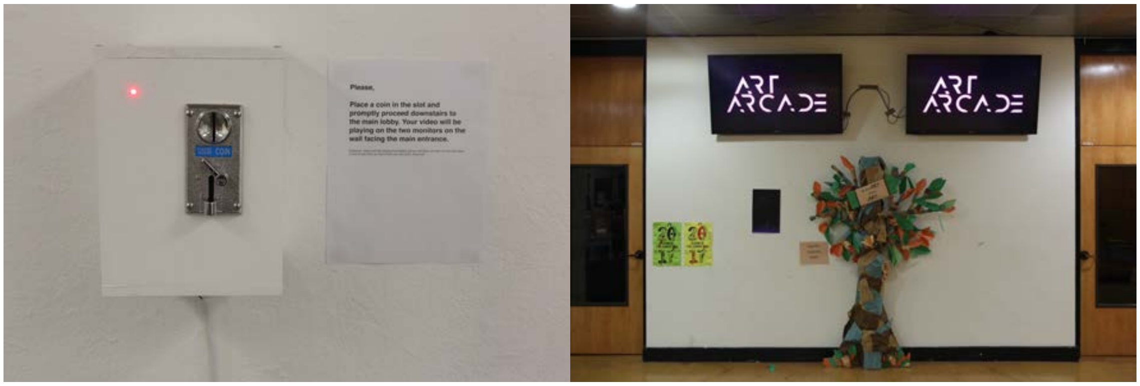

Figure 55 - CalArts Lobby Remote Video Content Release Mechanism (left)
Lobby TVs Displaying Idling Art Arcade Logo (right)

5.5.8 Niels Henrik Bugge: Peepshow

Bugge describes in his proposal that "Peepshow is mechanical sculpture activated by a coin operated mechanism. It is a 6-foot-tall rectangular structure with a window and a coin slot on the front panel. The window is obscured by a curtain behind the glass. When a coin is inserted, the curtain comes up and reveals a mask on a rotating display. After a short time period, the curtain comes back down again. Since the display stand is rotating slowly, only a limited view of the object is afforded to the viewer before the curtain comes down again. What becomes apparent after multiple activations is also that the curtain only opens at the same rotation interval each time, revealing the same side of the mask each time the mechanism is activated."

Figure 56 - Peepshow

5.5.9 Daniel McNamara: Claw Machine

Claw Machine (Figure 57) is a commercial claw machine filled with porcelain and glassware. Users are invited to interact with the piece just as they would typically with a claw machine, the only difference being that a prize won will inevitably be destroyed from the drop into the prize bin of the machine (Figure 58).

Figure 57 - Claw Machine

Figure 58 - A Visitor Collecting Their Broken Prize

5.6 Summary

Art Arcade is an exploration in making a platform for artists to create interactive pieces of art. Creating a platform for Art Arcade differed from Roulette and Ticklers as the creative capacity desired from the platform was not specifically musical; instead a range of artistic response in no specific medium was desired. The coin-mechanism was selected as the point of departure for artists as it was accessed to hold queues to topics of response such as cultural stratification, entertainment technology, and economics; it was also anticipated that additional topics would be considered by the selected artists participating. A call for proposals generated a collection of project ideas that while all featuring a coin mechanism, greatly differed from one another. The technical direction provided by the lead artists of the project informed the practicality of selecting a proposed piece, offered a learning experience for artists interested in expanding their skill-set, and ensured the technical requirements were met for each piece selected.

Chapter 6

Conclusion

6.1 Summary

This thesis examines a thematically related selection of work by Daniel McNamara during his time as a MFA candidate at The California Institute of the Arts. A platform for creative expression is the arts equivalent of the tech-industry definition of a platform; instead of a set of hardware and software from which products can be developed, a platform for creative expression is a concept or tool that acts as a starting point from which artistic creation can stem. The author's interest in tools that facilitate the creation of artwork led to three distinct projects varying in scope of users, and medium of expression. This difference in scope of users and medium of expression informed the design process for each project to best facilitate a satisfying creative process. Each project-chapter discusses the conceptual intent and the transition from design to actual realization. The design and realization methods are noted for two reasons: they informed conceptual development of each project and to act as a reference document for future research that may find this technical information useful. This thesis represents the author's interest in the act of creating art; specifically, defining a point from where it can begin. The act of creating art and the defining moment of why a project is pursued will always be hyper-specific to an individual artist's process; a platform for creative expression is an attempt to act as one point of departure for creativity to begin and grow onwards from.

6.2 Primary Contributions

A core method of project realization has been outlined in this thesis. The projects described have highly different applications: generative drum pattern control, consumer-friendly electro-acoustic design, and coin-operated interactive artwork. Despite the large difference between the creative goal of each project the design process for them featured the same starting point of considerations. While working on all projects, the first step was to make considerations of:

- Conceptual intent; asking in what way will the project will act as a platform for creative expression.
- Method of expression; what type artwork is anticipated to be created with this platform.
- Scope of users; considering how a platform would function best based on the range of artists intended to create with the platform;

Once those considerations were understood, a practical design and realization method for each project could be executed. The practical design aspects of each project shared a lot of the same tools: rapid prototyping, electronics fabrication, and repurposing readily available technology.

6.3 Future Work

Refinement of design for both Roulette and Ticklers is in the process. The immediate goal for those projects is to set aside time for using them in the writing and performance of music; the problem with building instruments is that it sometimes takes a long time before they can be fully playable.

In the long-term, a second version of Roulette's module is currently being conceived featuring an RGB LED, an encoder instead of a trimpot, and an embedded microcontroller making communication with a module possible using I2C. Subsequent changes accommodating this new module will be made to the mother shield. It is the hope of the author that these changes will allow for better feedback between the software and hardware of Roulette when played by the author.

The first beta prototype of Ticklers is almost ready to be presented to the world via a Kickstarter campaign; this campaign aims to raise funds for subsequent research to occur in making a commercially-ready Tickler. Experimental research has also been proposed for the second version of Ticklers. Highlights include: a tone generator and additional contact microphone for a feedback loop from which a system using machine learning can deduce points of contact a user is making with a Tickler by observing the change of resonance in the generated tone as touching occurs, a multi-channel version of the Ticklers hardware, and a new case design using fingers as the core point of inspiration (Figure 59).

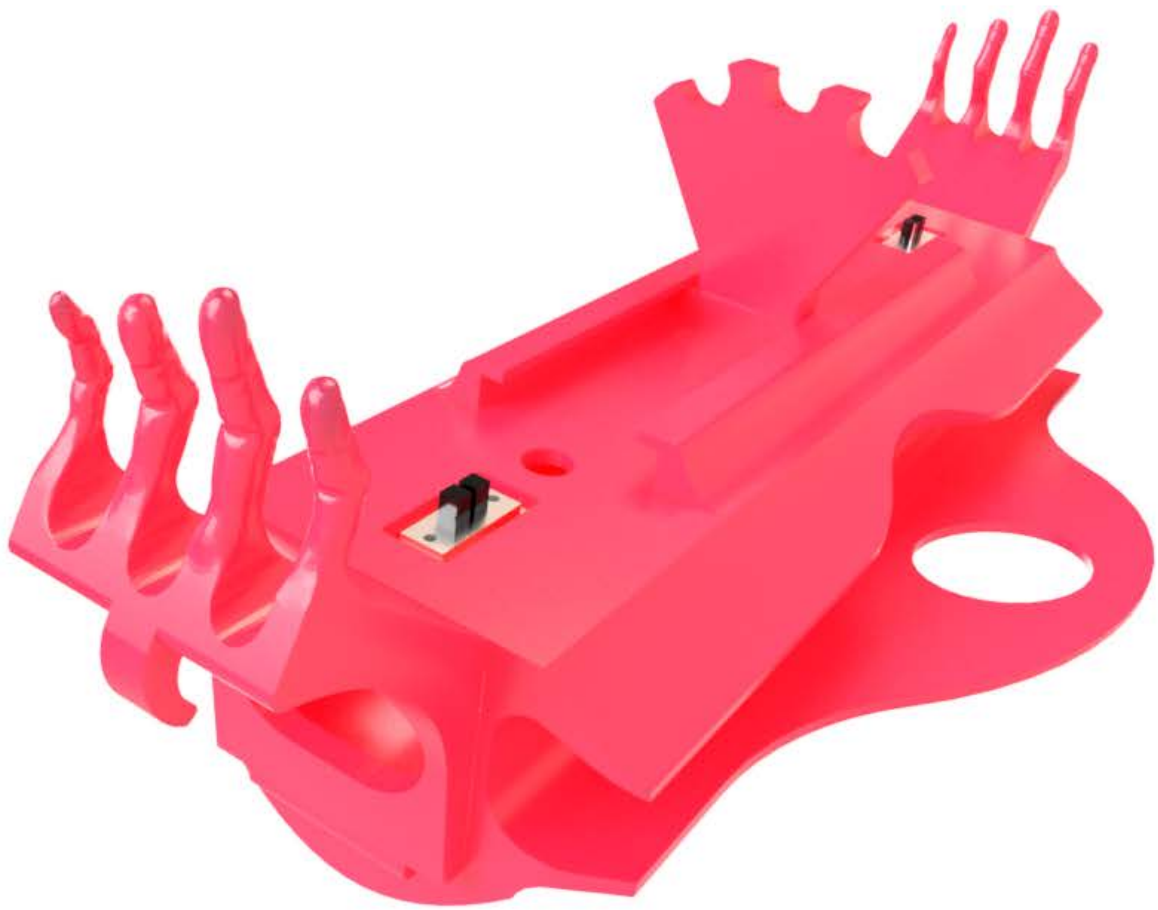

Figure 59 - Rendering of Future Tickler Case Design

A website noting the technical details of all projects in the first Art Arcade is being planned currently. A second showing of Art Arcade is being proposed to several Los Angeles galleries. The project leads are also working with a curator in the hopes of having a pop-up show in Downtown Los Angeles during 2017, and potentially afterwards in the arts district of Toronto, Ontario.

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