SANTA CLARA UNIVERSITY

Department of Electrical and Computer Engineering

I HEREBY RECOMMEND THAT THE THESIS PREPARED
UNDER MY SUPERVISION BY

Emma Berry, Raquel Macias

ENTITLED

INTER-ABLED AND ADAPTABLE ARCADE CONTROLS AND CABINET

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INTER-ABLED AND ADAPTABLE ARCADE CONTROLS AND CABINET

By

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SENIOR DESIGN PROJECT REPORT

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the Department of Electrical and Computer Engineering

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Abstract

A considerable void exists in the digital gaming space, with a distinct lack of feasible control solutions for disabled gamers. The project aims to bridge this gap via a proof-of-concept arcade machine with interchangeable control surfaces, each catering to a different physical disability. In particular, the control boards aim to address the lack of accessibility of individuals with arthritis, as well as those with the use of only a single arm. To such an end, we design and implement STM32-based controllers which connect and interact directly with the host computer. Despite technical hardships, our results show that comprehensive control solutions for disabled gamers can be implemented with relative ease and low-cost materials. In addition, each controller is able to be swapped with another at any time, allowing for a single system to accommodate multiple users with differing disabilities. The designs presented in this paper can easily be developed into a commercial product, and gaming-centric companies have the ethical impetus to do so.

Table of Contents

List of Figures

1: Introduction

1.1 Industry Background and Motivation

As the digital age continues to evolve, technology is becoming more entrenched in our everyday lives. One of the sectors where this is most evident is in the realm of digital gaming. With its origins in the rudimentary games of the mid-20th century, digital gaming has transformed into a global phenomenon, serving as a source of entertainment, a tool for skill development, and a platform for social interaction. However, amidst the myriad of advancements in gaming technology, there remains a significant concern: inclusivity and accessibility for individuals with disabilities. This glaring lack of consideration for a substantial demographic is the impetus behind our project, "Inter-abled and Adaptable Arcade Controls and Cabinet."

In our initial research we had found only one large scale gaming corporation offering one controller geared towards the disabled, the Xbox Adaptive Controller[1]. Even in that single controller, it served as a hub, being advertised as such, showing users implementing their own add-ons. These add-ons were advertised alongside this adaptive controller but sold separately, meaning another purchase and disabled users still needed to assemble their own controllers to play the games. While it was a good step towards inclusivity, the end result is an incomplete controller that would be quite costly with all the additions to be functional. At the same time we found online forums where disabled individuals were constructing their own controller setups from scratch. These fully customized designs had similar performance results to the corporate solution while being fully tailored to the user's needs from the beginning. We found the Xbox solution to be no more accessible than the "DIY" approach as it still requires user customizations. Those who are inclined to build their own controller setup, can already do so without having to purchase the add-on kits that are sold in addition to the adaptive controller and the console itself. We saw this as an area of need for disabled gamers; there should be ready made devices that address the specific physical needs of the disabled. A disabled user that does not want to make their own controller will not be more inclined to do so with the Xbox; they should be able to approach a game and play with the same ease as able-bodied people.

Inclusivity in digital gaming is more than a technological challenge; it is a call to action for creating a more equitable society where everyone, irrespective of their physical abilities, can engage in the joy of gaming. Through our project, we hope to contribute to this ongoing dialogue, and stimulate a wave of change in the gaming industry.

1.2 Project Aims

The aim of this project was to design and construct an adaptable arcade machine with a set of interchangeable control boards, specifically tailored to accommodate individuals with specific physical limb disabilities. Our objective was not just to create a proof of concept for adaptive gaming, but to challenge the major corporations in the gaming industry, showcasing the feasibility of producing "ready-to-play" gaming for individuals with specific disabilities.

This arcade machine was to serve as a proof of viability for large scale, specified inter-abled gaming. Through research and ergonomic testing, we set out to provide the most comfortable and easy gaming experience for individuals with arthritic hands or joints, those with the functional use of a single hand, and those who are not physically impaired.

One of the main technical considerations for our project was the number of games the arcade machine could support. To keep the project manageable while showcasing the capability of our specialized controllers, we chose to integrate two games into the machine. These two games were selected based on their varied input requirements and gameplay styles, providing a comprehensive demonstration of our controller's adaptability and range of functionality. However, the principle of adaptability goes beyond just accommodating different games. Considering the diverse needs and abilities of the end users, our controllers needed to be adaptable not only in terms of game compatibility, but also in response to the users' specific requirements.

This project aims to showcase that, even with specific technical specifications and constraints, such as the number of games or the types of controls, we can design and build a gaming system that is inclusive and adaptable. The objective here is not merely to create a device that works within set parameters; we were aiming to push the boundaries of what's possible in accessible gaming.

In this thesis, we will delve into the additional technical specifications and functionalities of the arcade machine, the design and adaptation of the control boards for specific disabilities, and the ethical considerations underpinning our approach. In the process, we will critically analyze the social impact of our technology and explore its potential for scalability and future improvement.

2: Research and Planning

To ensure the decisions and modifications we made were truly effective in aiding the disabilities we were accommodating, the research and planning phase was given considerable time and thought. The goal was to build upon and improve pre existing solutions that proved to be effective, rather than reinventing the proverbial wheel. There were several areas to consider in our research: the input hardware, hardware to software communication, physical arcade construction, open source gaming, and medically documented disability needs.

When first tasked with the project, we settled on addressing two specific disabilities with the understanding of the time constraints of the project and the need to adequately address the physical needs of the disabilities. We chose arthritis as it generally affects an aging population who tend to not be as familiar with digital media. We wanted to provide the opportunity for this demographic to interact with the growing field of gaming while not being inhibited by physical pain. The second disability we chose was single-arm functionality, encompassing those who lack the full use of both arms for whatever reason ie. amputation, Parkinson's, ALS. This was chosen as many handheld controllers are specifically designed to actively use both hands simultaneously and PC gaming is worse as it maps multiple controls along a wider keyboard spread.

2.1 Disability Specific Needs

Our research on these disabilities was focused on understanding the symptoms/limitations of individuals within the group, how those impact their use of digital technology, and what accommodations or aids already exist. Outside of written medical documentation, we also took to looking at more personal accounts such as online forums relating to these disabilities and to gaming.

When considering the single-arm group, we observed several trends for controller design layouts, with many condensinging the inputs into a smaller area of reach. Having inputs such as buttons or switches be spread out showed to be significantly more labor intensive and strenuous for these individuals. Some solutions involved mouth based controllers, others showed foot or pedal based devices, and some included audio controls. One solution that seemed the most fitting was a flight simulator based controllers. Other solutions required stationary implementations or required a significant amount of set up when being changed out, both of which inhibited our goal of rapid adaptability within a single unit. The use of flight simulator style joysticks allowed for all button inputs to be within the reach of a few fingers and movement was controlled by the same handle. This ultimately was the design pathway we went with.

The arthritic controller required more research as the symptoms manifest differently in each patient. We consulted with occupational therapist Ileen Cohen Ackerman of the Arthritis Society of Canada. We anticipated that the control board would be similar to our unaltered control board, consisting of a joystick for movement and separate switch based inputs, with accommodations to minimize pain or avoid painful movements all together. Based on this overall vision and the project goals, Dr. Ackerman made the following suggestions and guidelines for our controller:

- Low tolerances are preferred as patients tend to have decreased strength
- The less fine motor control required, the better
- Smaller ranges of motion require less movement or force
- Larger inputs as some patients cannot fully open or close their hands

With this in mind, we were able to design the first prototypes of our boards. We settled on a larger oval shaped joystick that could fit in the palm of the hand and large, spaced out, soft touch buttons as the constraints of the arthritic board.

2.2 Gaming Inputs

In designing each controller, important technical considerations had to be made. First, we had to make a decision on what compute logic each device would use, and how we would use it. To this end, we decided on the STM32F103 microcontroller, colloquially known as the “Blue Pill”.

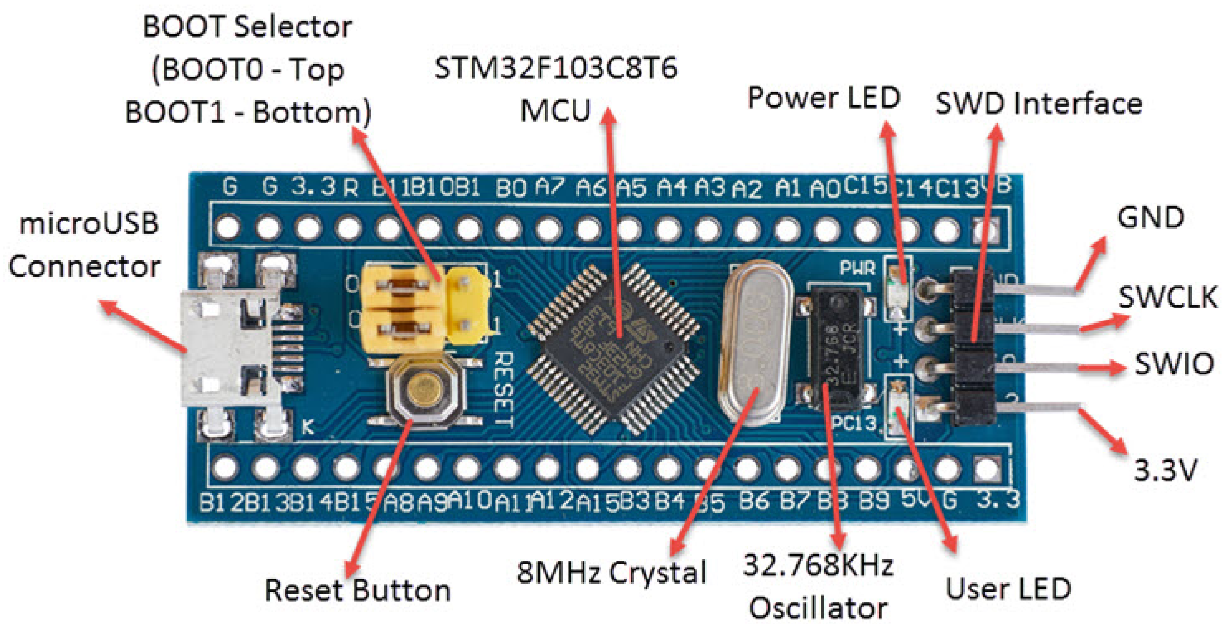

Figure 1: STM32F103 "Blue Pill"

This specific device was chosen due to our intimate familiarity with ST products, as well as its compatibility with an open-source controller configurator, FreeJoy. FreeJoy uses the USB-HID protocol to send user inputs to a host device, such as a Windows PC. Such a utility was chosen due to its ease of use, as well as our prior familiarity with the USB protocols.

Another critical decision we made in the development process was the selection of the control inputs. For this project, we chose to use 2-axis potentiometers, influenced by several factors. Firstly, 2-axis potentiometers are widely available and simple to use. Being common components in electronics, they can be easily sourced from various suppliers, contributing to the project's feasibility and efficiency. This ubiquity also ensures the sustainability of our design - maintenance and replacements can be handled with ease. Secondly, the granularity of control that 2-axis potentiometers offer was a defining factor. Unlike digital solutions, which typically only recognize binary (on/off) inputs, potentiometers can register a range of inputs. This continuous spectrum of control makes them ideal for gaming, where precision and nuanced movements can make all the difference. With the help of potentiometers, users can execute a broader range of commands. Finally, we considered cost-effectiveness. Implementing potentiometers is considerably less expensive than using alternative options such as Hall effect sensors. Keeping the cost of production low is not only beneficial from a manufacturing standpoint but is also important for making these specialized controllers affordable for the end users.

It's important to note that while there are other viable solutions for joystick inputs, each comes with its own set of benefits and drawbacks. The choice of 2-axis potentiometers for our project was based on a combination of their availability, the level of control they provide, and their cost-effectiveness, making them an optimal choice for our specific needs and goals.

In addition to properly configuring each controller, we also needed to consider what types of games would be available for our system. Initially, we contemplated the use of software emulation. In emulating an older arcade machine or game console via software, a large array of titles could be run and certain parameters could be tweaked. However, after initial testing, we realized that emulation software provided too much overhead in the software stack. From here, we decided to exclusively use open-source games. With the source code readily available, we would be able to configure each game as seen fit. For example, an open-source shooter game for the arthritic controller could be modified to give the player extra health or points, removing some potential difficulty. To that end, we ultimately decided on two titles: OpenSurge and Doom. OpenSurge, a simple platform game, utilized the single-arm controller, as well as a "default" controller we created as a reference. Doom, a classic shooter, utilized the arthritic controller due to its higher button count.

2.3 Arcade Cabinet Design

With the aim that the arcade cabinet is designed for the physically disabled, ergonomics and ease of use were at the forefronts of our minds. Our initial thoughts were to design a full length standing arcade cabinet and have individual flat panels be swapped in and out. As we looked more into existing arcade machine sizing specifications, we realized that many were designed for dual player usage and not optimized for single player. Those that were single player machines were made to be compact and not as comfortable as they could be. To ensure our machine did not suffer in the same manner, we measured the shoulder width of each member in our team and our peers to get a baseline for width and conclude that a 700mm width cabinet would be the most comfortable to operate.

From there we needed to decide on the height of the cabinet. When we began to consider that a standing cabinet would need to be stable enough to handle constant movement and swapping, all while housing a mounted monitor and computer, we began to reevaluate the design. Our solution was to opt for a half cabinet or "table top" design and not mounting in the monitor but placing it within the cabinet to ensure the weight is all on the bottom. For further stability, we decided that the control panel should instead be a control box, only open on the bottom for access to the hardware. These boxes could then slide into place and be screwed into the sides of the arcade machine so that it would not move around as a player uses it. For reasons of price, light weight, and customizability, we also decided to use plywood to make up the body of the arcade machine.

3: HID Configuration

Each controller, once properly connected to a PC, follows a specified sequence for processing user input. Initially, both buttons and joystick send analog signals to the microcontroller. Subsequently, the microcontroller demodulates these analog signals and converts them into raw digital values. Once these values are obtained, Freejoy takes these raw values as inputs before converting them into game controller commands and forwarding them to the connected PC. Finally, the PC processes the commands and the game executes the user input successfully. This sequence ensures a smooth and responsive interaction between the user's controller inputs and the game's response on the PC.

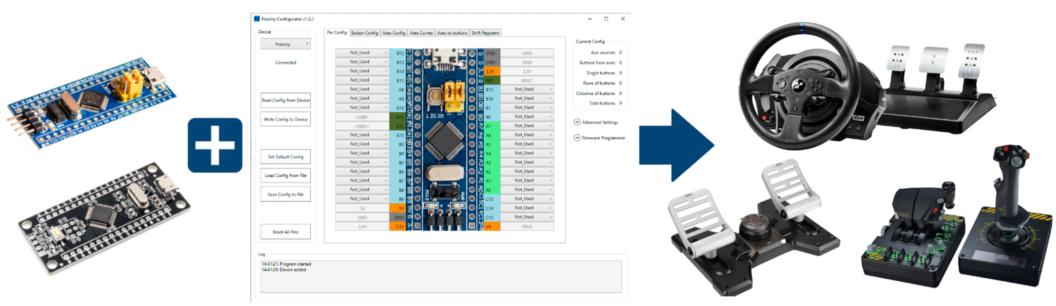

Figure 2: FreeJoy flowchart

3.1 Microcontroller Firmware

In the process of designing the firmware for our microcontroller, we had to adhere to several crucial design criteria. First, the firmware needed to be capable of recognizing user inputs, which would arrive in the form of signals from potentiometers and switches. This involved creating mechanisms to interpret these specific types of analog signals accurately.

Second, the received data had to be modified and formatted in a way that a host PC would identify and treat them as Human Interface Device (HID) inputs. Finally, our firmware was responsible for sending this HID-compatible data over USB to the host PC.

Originally, we planned to design and implement our own custom firmware for each ST device. However, we quickly found an alternative, FreeJoy. As mentioned earlier, FreeJoy is an open-source HID configurator capable of being flashed to STM32 Blue Pill devices. The software itself comes with two packages: the custom firmware and an intuitive front-end.

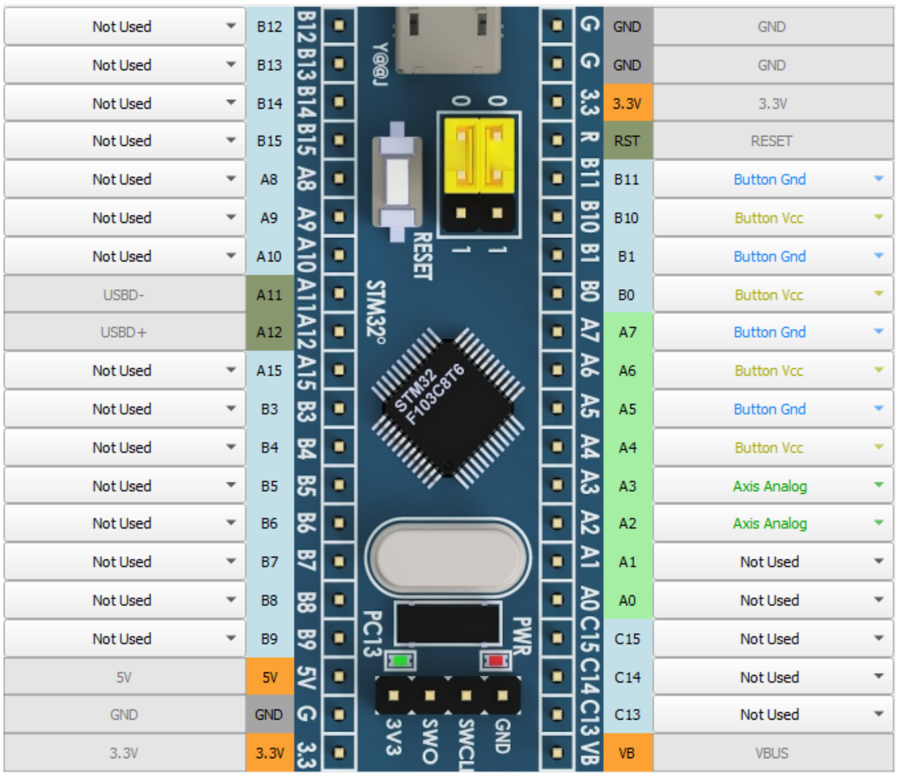

Figure 3: FreeJoy front-end application

While the firmware would be flashed directly to each microcontroller, the front-end would be used to interface with the firmware and configure the inputs for each device. Although this process only needed to be done for the initial setup, it proved nonetheless intuitive.

FreeJoy itself is designed to use the General Purpose Input/Output, or GPIO, pins on the microcontroller to connect to each input on the controller. In the figure above, we configured 8 GPIO pins to act as button inputs, and 2 more to act as joystick inputs. Upon the successful connection of inputs, the microcontroller was mounted to the underside of the control board, as seen below:

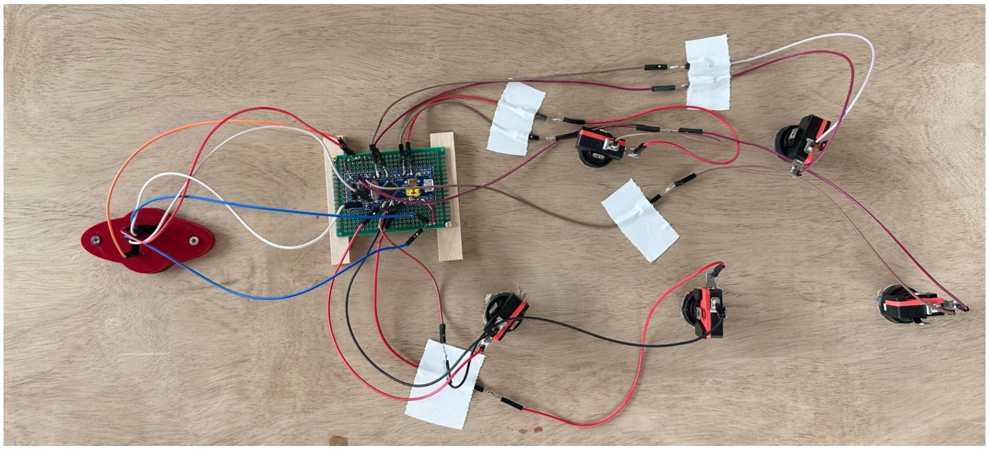

Figure 4: Mounting the microcontroller under the control board

3.2 USB Recognition

In order to maximize ease-of-use for the end user, we decided to implement an automatic program launcher. This utility would allow the PC to automatically boot into the correct game, depending on which controller was connected. We initially attempted to design such functionality via Windows Task Scheduler, a utility that allows the user to schedule the launch of programs or scripts at predefined times, or upon certain events. However, we quickly ran into issues with creating a "Task" that would properly launch any programs. As it turns out, Task Scheduler provides plenty of time-based triggers, but it does *not* natively recognize hardware events such as USB insertions.

After failing to implement a script via Task Scheduler, we changed our approach. Instead of using built-in Windows utilities, we decided to create our own Python script. This approach, which allowed us complete creative freedom, was ultimately successful.

Operating persistently, our final program had the following sequence of operations: Initially, in the absence of a connected board, the script continuously pings the USB input for a specific device ID. Upon connection of a board, the script scans the device ID and triggers the launch of the appropriate game. Lastly, if a board gets disconnected, the script automatically exits the currently running game and reverts to its idle state, waiting for another controller to be connected.

4: Control Board Design

4.1 Uniform Design Requirements

For the purposes of swapability in the same arcade enclosure, certain parts of each design needed to be standardized. Each board needed to utilize the 2-axis joysticks, STM32 boards, and have some configuration of button controls with all the wiring secured and hidden from users. The controllers needed to be the same 700mm width as the cabinet to be able to slide in and be secured into the machine. There also needed to be USB access holes in the back to the boxes to be able to plug in the controller to the computer directly. From there, the layouts would be customized to fit the usage of the different boards.

4.2 Unaltered Board Design

The unaltered board was designed to resemble generic arcade machines that already widely exist. This demonstrated how non-disabled users can operate on the same systems designed for disabled users. This board was designed to work with the game OpenSurge and was mapped to the appropriate buttons.

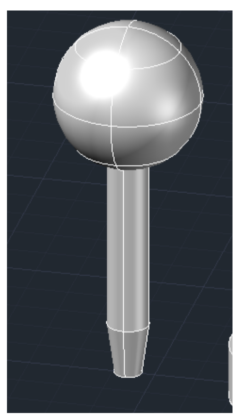

Figure 5: Unaltered joystick CAD model

The joystick on the left side of the board, controlling horizontal screen movement, features a 35mm diameter knob and totals to a height of 88mm, keeping in the 70-90mm height range of standard joysticks. The buttons used were 30mm arcade push buttons to control the quit, pause, jump, and switch character inputs required by the game.

4.3 Single Arm Functionality Board Design

The "single arm" board deviated greatly from the design of the unaltered board. While playing the same game, OpenSurge, this board uses a flightstick style joystick. It has two of these joysticks that are mirrors of each other to accommodate for right or left handed usage. Because of this, each joystick connects to its own "blue pill" board so that the buttons can be uniquely mapped. This also meant that only the side intended to be used would be plugged in and the other side would not interfere with the gameplay. The design also ensures that all the push buttons are all on the front face as to be easily reached.

The design itself was based off of a pre-existing, open source, flightstick design[2] with several modifications. The joystick functions on 2 axes with a potentiometer rather than the intended hall effect sensor. To adjust for this, the wires of the push button micro switches are much longer to move with the handle. The four micro switches themselves have solid 3D printed buttons that are placed into the faceplate. Then the switches are glued to the faceplate overtop. The user pushes the button which then pushes back onto the micro switch to register as an input. A separate adaptor was also designed and printed to fit into the base of the handle and fit onto the top of the joystick. Covers for the unused back trigger and thumb button were also created so as to not leave holes in the handle.

Figure 6: Single arm joystick CAD model

4.4 Arthritic Board Design

The arthritic board has a similar design as the unaltered board, with its own set of modifications. This board operates Doom to demonstrate that the same console should also be able to play multiple games and not just have certain games be disability accessible. This also required an additional button to map the run, confirm, pause, shoot, and interact inputs. The buttons themselves were changed to 100mm diameter push buttons to allow for finger, full hand, heel of hand, or side of hand presses. This allows for various levels of hand restrictions to use the machine as they need to fit their comfort. They are also spaced close enough together to lessen the range of motion between buttons.

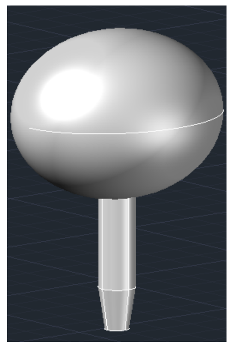

Figure 7: Arthritic joystick CAD model

The joystick itself is an oblong shape to accommodate either a loose, elongated, finger based grip or a comfortable palm based grip. This, paired with the sensitivity of the potentiometer, allows for the least amount of force or strain needed to move the player's view across the screen. Dimensions for the joystick were based on measurements of each team member's palm and designing around the median value, so as to not overstretch or over tighten the grip of a user, resulting in a large oval shape, 60mm long and 50mm wide. When 3D printing the joystick, the infill percentage needed to be lowered down to 30% as the uneven shape would be too top heavy and not be able to recenter itself when not in use at denser infill percentages.

<u>4.5 Joystick Modeling</u>

For each joystick, the 2-axis potentiometer only had a 7mm knob coming out of it and so the actual joystick needed to be custom designed and 3D printed to fit on top of this knob. The potentiometer also required an enclosure to hold it in place and be mountable in the wooden panel. Using AutoCAD to create the designs, several iterations evolved into the final joystick shape that each control board integrated. Utilizing Prusa i3 MK3S printers, several printer and design adjustments needed to be made. The final base design of the joystick featured a steep taper starting thin at the bottom of the knob and flaring out to the full circumference going up the joystick. This was done to allow for the joystick to reach the full range of motion the potentiometer allows for, as seen in figure 8.

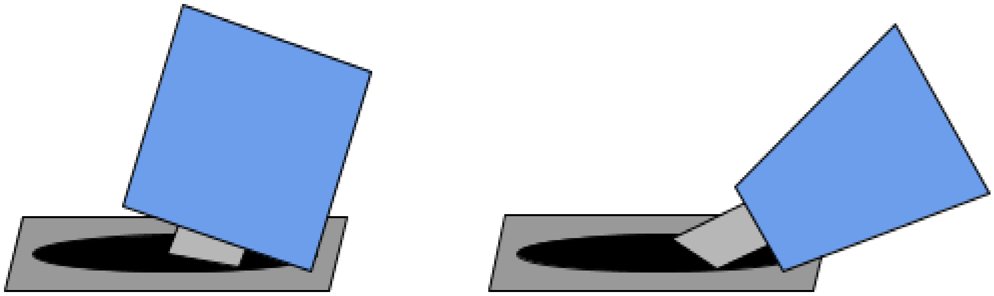

Figure 8: Joystick base range of motion

For every new iteration of the design, only the base of the joystick was being printed and adjusted. This was done to allow for this base to be imported into different files to then be built upon and integrated into the different joystick configurations. For the arthritic and unaltered joystick, this base design would then be stretched to fit the desired height and the balls on top could be built off of it. For the single arm joystick, a rectangular prism was added on to to fit in the bottom space of the flightstick.

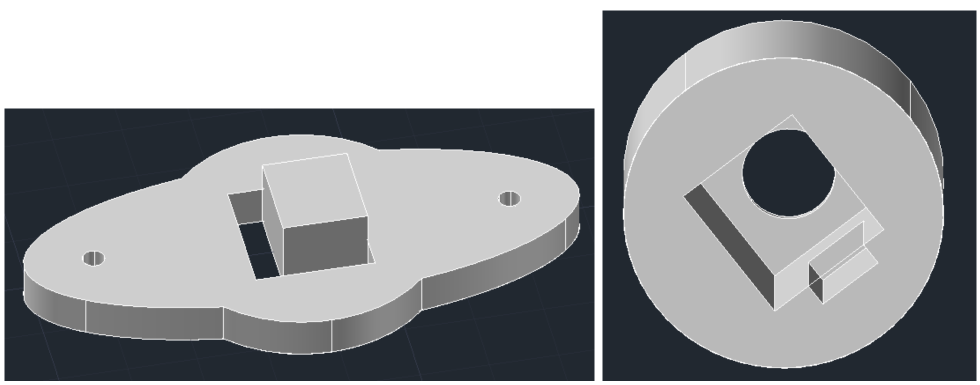

Figure 9: Potentiometer enclosure bottom (left) and casing (right)

The enclosures for the potentiometers were constructed in two parts, the surrounding casing and the mountable bottom. The final casing design was 18mm tall, to match the thickness of the wood, and 40mm in diameter. It had a hole in the top to allow the knob to stick out and had a recess in the center that fit the dimensions of the potentiometer. The bottom part of the enclosure was a flat 6mm thick oval shape. It has holes for screws so that it could be secured from the bottom and an extrusion in the middle to push up the potentiometer, as it was not as tall as the wood thickness. It also has a “L” shaped opening to let the wires and pins through to the other side. The casing would be pressure fit into the board, the potentiometer could be placed inside, the bottom secured, and then the joystick tops could be glued onto the potentiometers from the outside.

5: Arcade Cabinet

With the cabinet being decided as a half cabinet, the design process could begin. The design was adapted from an existing bartop arcade cabinet[3] with several modifications to meet the needs of the project. The original design utilized 12mm thick wood however, we opted for 18mm wood as it would be heavier to provide more stability and the surface area at the contacting edges would be larger to allow for a stronger bond when assembled with wood glue. The cabinet design was altered in AutoCAD to adjust to the dimensions of the new control boards as those were the most vital components to the design. The control board panel was changed from angled to laying flat for the purposes of swapability between boards, the control board panel and front panel became an isolated box that could be screwed in to provide structural support as the control panel would endure various forces and interaction. The cabinet base was extended to fit the new 700x300mm control boards. Once the design was finalized, the side panels, monitor frame, and the control boards were precision cut on a computer numerical control(CNC) machine and the rest of the pieces were measured and cut with a table saw.

The construction of the cabinet needed to be changed entirely to accommodate for the modularity of the machine. Rather than having small wood blocks nailed to the inside of the side pieces and having the other face pieces put on top and nailed to the blocks, we adhered all the pieces directly to the sides and each other. We did not want to risk the wood splitting or cracking as this original method would require us to screw or nail into the grain of the wood. Instead all the middle pieces were wood glued and clamped together, occasionally using L-shaped brackets to reinforce the connection. Then the middle pieces were glued to the side panels to complete the cabinet.

To ensure the safety and stability of the machine, certain design additions were made. Due to the cabinet enclosing both a computer and monitor, vent holes were cut into the side panels to allow for airflow and ensure neither overheated and posed a risk. The tabletop size itself was chosen as a safety measure as we did not want to risk the cabinet tipping over due to any weight imbalances as control boards were moved in or out. Handles were screwed onto the faces of the control board boxes to allow for ease of removal and not risk dropping the box. And alignment holes were drilled into the sides of the cabinet and the sides of the control boxes so that they could be held in place, and not move as it is being used, with 4 separate threaded knobs from the outside.

6: Conclusion

In summary, we have successfully proven the viability of disability-specific game controllers, both from a consumer perspective and a manufacturer perspective. By overcoming design and implementation challenges, we've tailored each controller to a specific disability, enabling consumers to simply plug in and play.

A significant achievement of our project was the creation of all three controllers and the arcade machine for under $750. This budget-friendly model proves that such specialized devices can be designed and produced at a low cost. These simple yet critical modifications, like larger joysticks or softer buttons, are cost-effective solutions that make gaming more accessible. There is no reason why peripheral manufacturers should not be pursuing development on disability-specific gaming controllers. These controllers are not only easy to design and implement into existing video game ecosystems but also introduce a potential new market for these businesses.

The real significance of this project extends beyond commercial viability. These controllers provide a tangible benefit to the disabled community and gamers as a whole. The introduction of these devices could instigate a transformative change in the gaming industry, making it a more inclusive space.

The ethical impact of this project is considerable. By focusing on creating accessible gaming tools, we contribute to inclusivity and equal opportunity in gaming. It also raises questions about the responsibilities of the gaming industry in making their products more accessible.

Civic engagement plays a crucial role here. Public organizations, governmental or non-governmental, can promote or support such initiatives. They can help raise awareness about the need for accessibility in gaming or even fund projects that aim to make gaming more inclusive.

As for areas for further development, there's still much to explore. Testing these controllers with people who have disabilities and getting user feedback could lead to improvements in design and usability. There are a number of smaller technical changes that could be made as well, such as a reworked alignment system, more durable joysticks, and better overall fit & finish. Future projects could focus on designing controllers for a wider range of disabilities, expanding the inclusivity of gaming even further.

This 'proof of concept' project has not only demonstrated the ease of accessibility and setup that such controllers can offer but also illuminated a path forward for a more inclusive gaming industry. We strongly believe that disability-specific controllers can - and should - become an integral part of the gaming landscape.

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[2] Akaki. (2020, August 22). *Flight SIM joystick with hall effect sensors and Arduino by Akaki*. Thingiverse. https://www.thingiverse.com/thing:4576634

[3] Holbrook. (n.d.). *Bigger bartop arcade build*. Holbrook Tech. https://holbrooktech.weebly.com/bigger-bartop-arcade-build.html

Appendix A: Python-based program launcher

```
import os
import time
from pywinusb import hid
import subprocess
import psutil

# Add your device's USB name and corresponding game executable here
DEVICE_GAMES = {
    "FREEJOY_TEST":
r"C:\Users\Arcade\Desktop\Games\Doom_Retro\Doom_Retro_exe\doomretro.exe
-iwad C:\Users\Arcade\Desktop\Games\Doom_Retro\Doom_Retro_exe\DOOM.WAD",
    "FREEJOY_ONE-HAND": r"C:\path\to\OpenSurge.exe",
    # Add more devices as needed
}

def find_target_device():
    all_devices = hid.HidDeviceFilter().get_devices()
    for device in all_devices:
        try:
            device.open()
            product_name = device.product_name
            if product_name in DEVICE_GAMES:
                return product_name
        except Exception as e:
            print(f"Error: {e}")
        finally:
            device.close()
    return None

def get_child_processes(parent_pid):
    parent = psutil.Process(parent_pid)
    children = parent.children(recursive=True)
    return children

def terminate_process_and_children(pid):
    process = psutil.Process(pid)
    for child in process.children(recursive=True):
        child.terminate()
    process.terminate()

def main():
    game_process = None
```

```
    while True:
        target_device = find_target_device()
        if target_device and (game_process is None or game_process.poll() is not None):
            game_path = DEVICE_GAMES[target_device]
            print(f"Launching {game_path}")
            game_process = subprocess.Popen(game_path, shell=True)
            time.sleep(5)
        elif not target_device and game_process is not None and game_process.poll() is None:
            print("Closing game")
            terminate_process_and_children(game_process.pid)
            game_process.wait()
            game_process = None
        else:
            time.sleep(1)

if __name__ == "__main__":
    main()
```

Appendix B: Cabinet assembly guide

Includes:

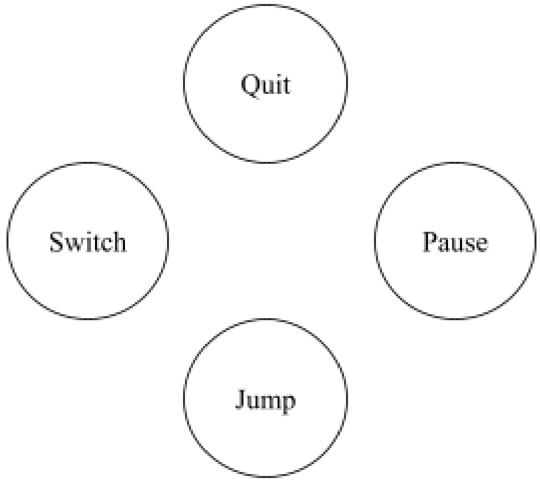
Tabletop cabinet
3 Control panels
Monitor
PC (small Intel NUC)
Mouse
Keyboard
Audio connector (tied with yellow wire)
Monitor power connector (tied with blue wire)
PC power connector
USB hub (tied with white wire)
Display port to mini display port connector (tied with purple wire)
4 screw knobs

Set-Up Instructions:

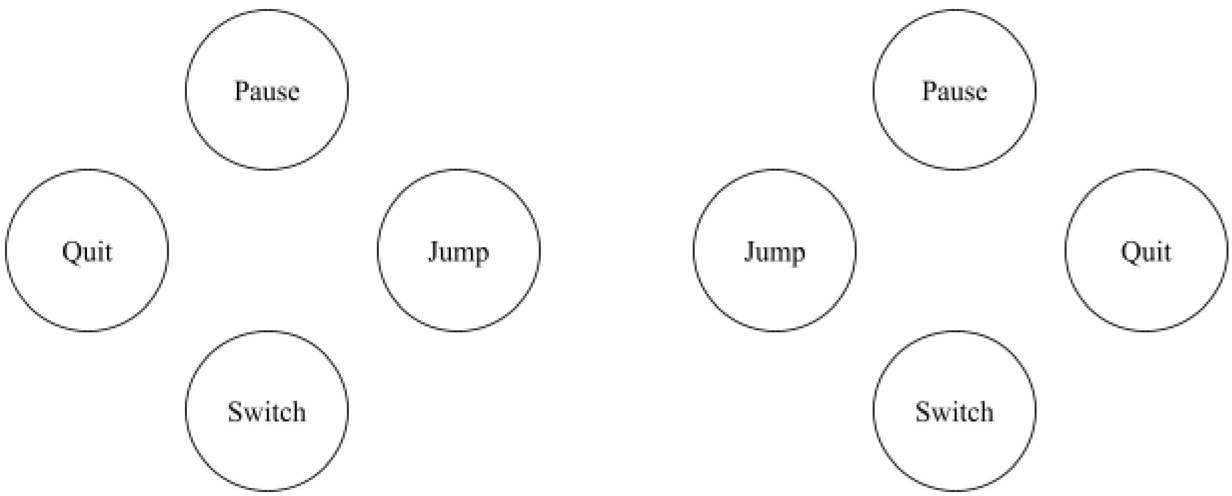
1) Open the back hatch of the cabinet and place the monitor inside, adjusting height and angle to best view from front. The PC can be placed inside where it fits best.
2) Connect the PC & monitor to power. Connect PC to monitor via display port connector and audio connector (Audio port for PC is found on the front side). AUDIO MUST BE CONNECTED, OTHERWISE GAMES WILL NOT RUN.
3) Connect the USB hub to the front ports of the PC. Turn on PC and monitor
    a) Keyboard and Mouse can be plugged in for the initial powering on of the PC but should be DISCONNECTED BEFORE plugging in any control boards.
4) Slide any control board in halfway and connect USB coming out of the back of the control board into the USB hub.
    a) The single-arm board has two USB cables, connecting to the left or right side, ONLY PLUG IN ONE AT A TIME, DO NOT HAVE BOTH PLUGGED IN AT ANY TIME.
5) Slide in the control board the rest of the way until the front face is flush with the bottom. Screw in the 4 knobs from the outside sides of the cabinet (two on the left and two on the right) to secure the board in place.
6) BE GENTLE WHEN USING THE JOYSTICKS, THEY ARE SENSITIVE CONTROLS AND ARE PLASTIC NOT METAL.
    a) If new joystick parts need to be 3D printed, the files can be found on the PC in a desktop folder named “3D Prints”
    b) A text file with links to the hardware used will also be found in the “3D Prints” folder

Appendix C: Button control assignments

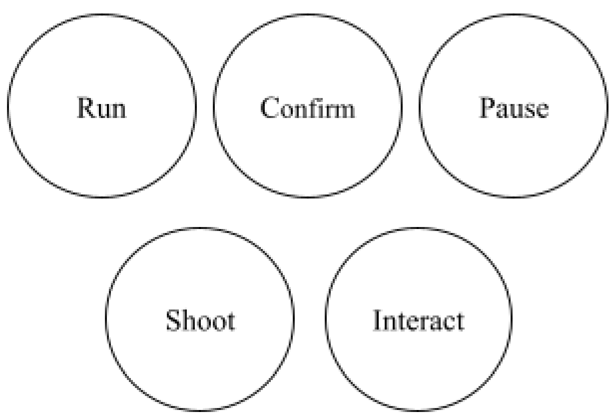
Unaltered Board Buttons:



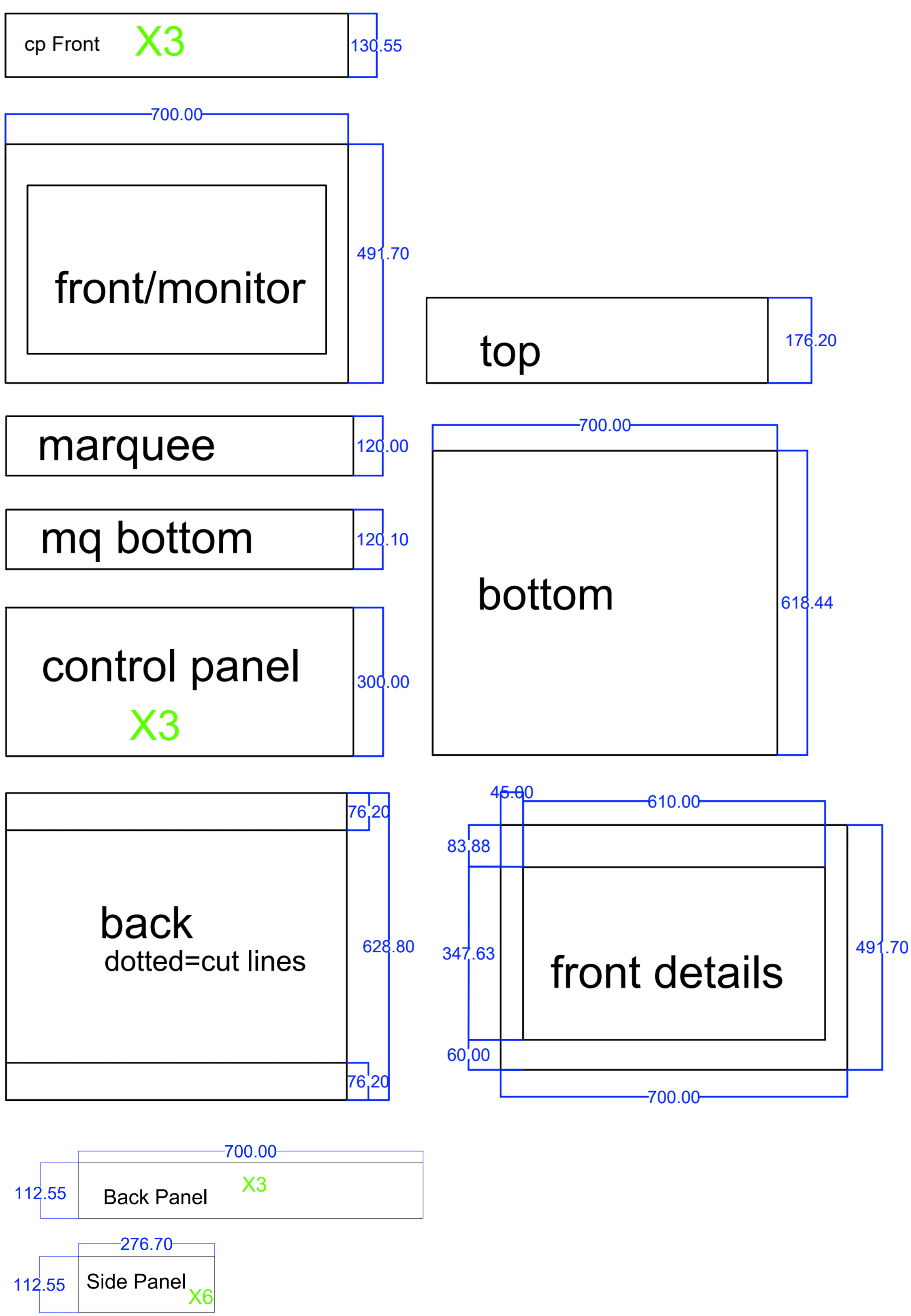
Single Arm Functionality Board Buttons (Left and Right Hand Configurations):

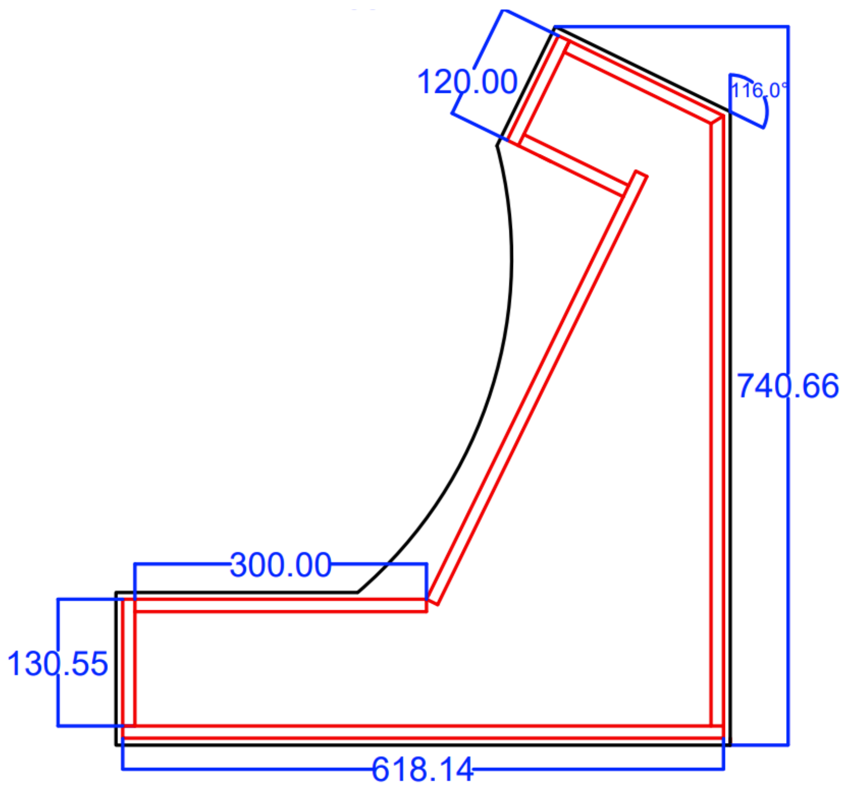


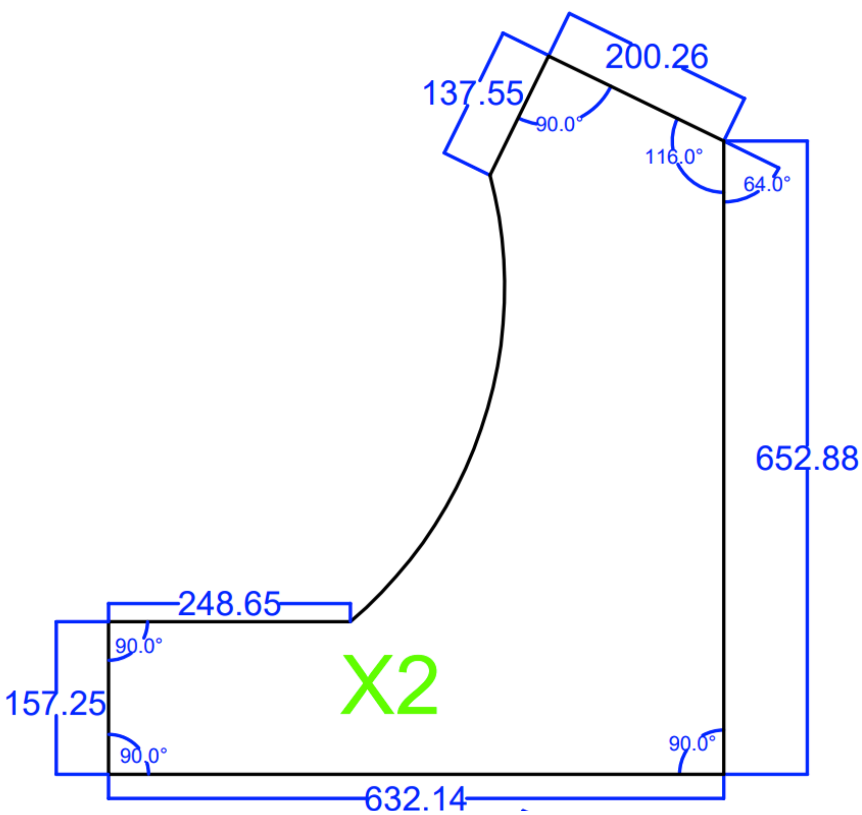
Arthritic Board Buttons:



Appendix D: Cabinet CAD designs

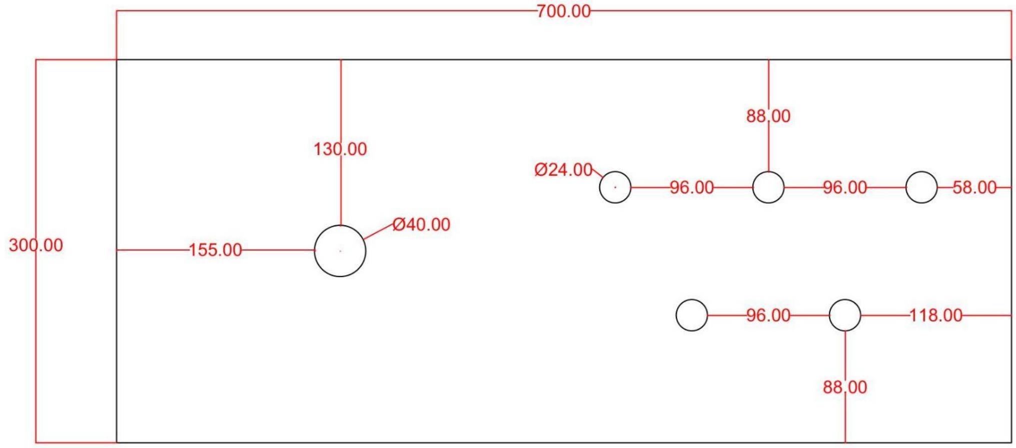



120.00
116.0°
740.66
300.00
130.55
618.14

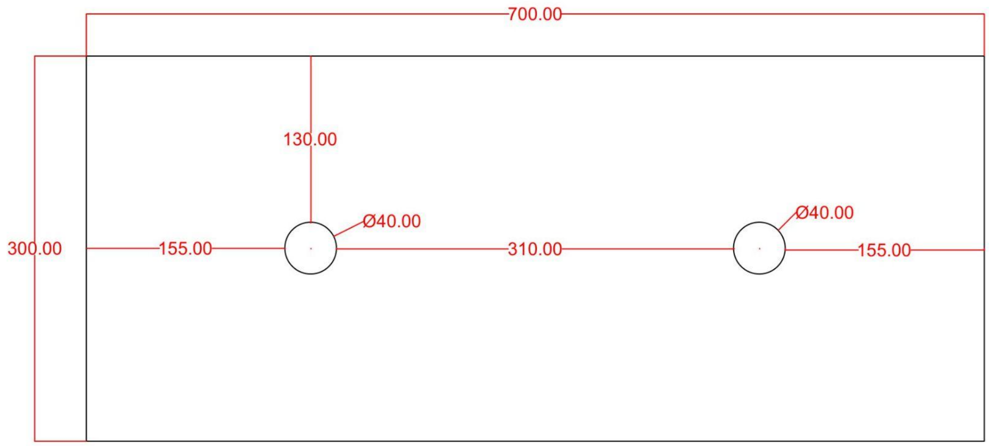

200.26
137.55
90.0°
116.0°
64.0°
652.88
248.65
90.0°
157.25
X2
90.0°
90.0°
632.14

Appendix E: Control board CAD designs

Unaltered Board:



Single Arm Board:



Arthritic Board: