Project Closeout Summary

CD Tower Interactive Music Controller

Ethan Hirsch	hirschet@oregonstate.edu
Alexander Baird-Appleton	bairdapa@oregonstate.edu
Will Dodge	dodgew@oregonstate.edu

Table of Contents

1.0: Design Impact Statement **2**
1.1: Public Health, Safety, and Welfare Impacts 2
1.2: Cultural and Social Impacts 2
1.3: Environmental Impacts 2
1.4: Economic Factors 2
2.0: Project Timeline **3**
3.0: Scope and Requirements Summary **4**
4.0: Risk Register **6**
5.0: Future Recommendations **7**
5.1 Add compatibility with other media server implementations 7
5.2 Add compatibility with other media types 7
5.3 Update workflow to Agile 7
5.4 Switch to and issue + branch based development strategy 7
5.5 Improve battery design 8
5.6 Make PCB design more approachable for hobbyists 8
5.7 Design with different switches/sensors 8
5.8 Come up with a more modular design 9
6.0 References **10**

1.0: Design Impact Statement

1.1: Public Health, Safety, and Welfare Impacts

The COVID pandemic has put a spotlight on the ways in which diseases and viruses are transmitted. Though it is not one of the primary transmission modes, the CDC reports that commonly touched surfaces can act as a vector for the virus [1]. Our design revolves around touch-based interaction; a user will press on a CD in the tower to initiate playback. If one user of our system was infected, this could pose a risk to other users. In this way, our design has a potential impact on the health of its users, and in the right circumstances could increase the risk of infection.

1.2: Cultural and Social Impacts

Many of the materials used in electronic devices are sourced from developing countries using dubious work conditions. For this section, I will focus on the example of lithium ion batteries, which act as the power source for our CD Tower. The Lithium metal required by these batteries has its own environmental and social caveats, but the largest offender is the secondary ingredient Cobalt. According to an article by WIRED, many cobalt mines are "artisanal" which means the toxic metal is extracted by hand, often without sufficient safety precautions and often by child laborers [2]. The use of unethically sourced materials is unavoidable in the realm of technology, but it is something that engineers should be aware of and attempt to minimize.

1.3: Environmental Impacts

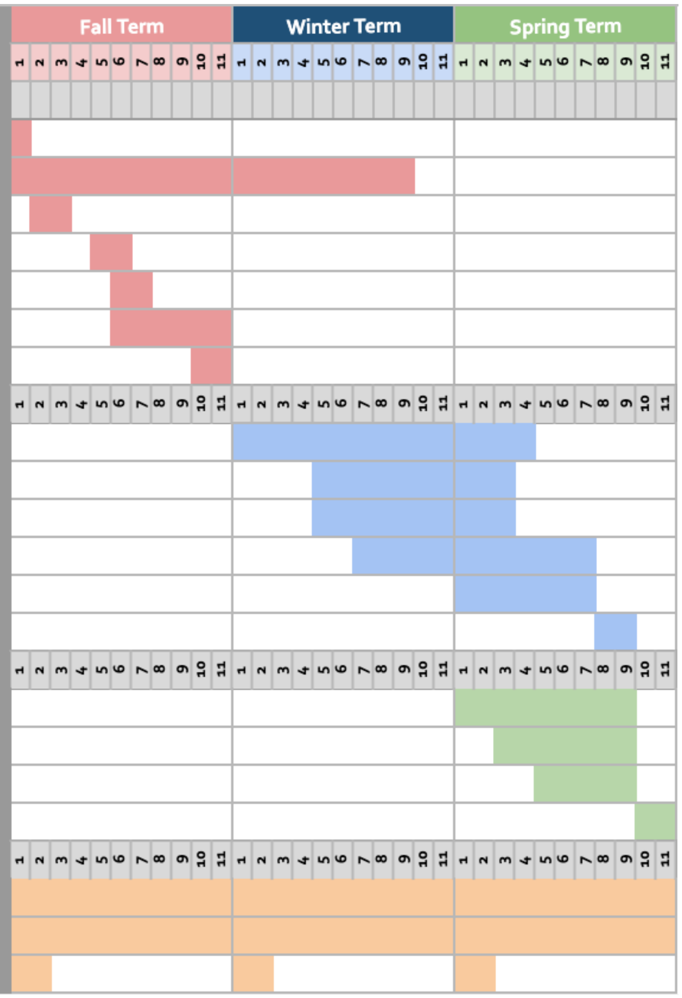
A negative environmental impact of the project is the generation of electronic waste, and by extension the effects of recycling methods used in developing countries. The crude methods of recycling used in countries like India, Philippines, and Ghana leach harmful chemicals such as Lead, Cadmium, Nickel, and Lithium directly into the soil [3]. According to the EPA, cleaning up electronic waste is an international effort of utmost importance [4].

1.4: Economic Factors

Our project is open source and in the world of open source licenses, there are two main types. The first is a permissive license, like the MIT license. These licenses primarily serve to clarify that "...THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND…" [5]. The other type of license is a "copy-left" license, like the GNU GPL license. Copy-left licenses stipulate that any derivative works also be copy-left. If our project partner chooses to license the project under a copy-left license, it would impact the ability of other parties to use our work for profit.

2.0: Project Timeline

Task Name	Task Owner(s)
Fall Term - Pre Planning	
First Project Partner Meeting	XA, WD, EH
Research	XA, WD, EH
Engineering Requirements Draft	XA, WD, EH
Block Diagram Draft	XA, WD, EH,
Project Charter	XA, WD, EH,
Tech Demo	XA, WD, EH,
Testing	XA, WD, EH
Winter Term - Project Development	
Block Development	XA, WD, EH
Hardware Interface Testing	WD
Software Interface Testing	XA, EH
System Assembly	WD
Software Integration	XA, EH
Polishing System	XA, WD, EH
Spring Term - Refinement and Eval	
Bug Fixes and Refinement	XA, WD, EH
Ensure Engineering Requirements are met	XA, WD, EH
Usability Testing	XA, WD, EH
Final Presentation	XA, WD, EH
Project Communications and Meetings	
Weekly Team Meeting	XA, WD, EH
Project Partner Update Meeting	XA, WD, EH
Per-term Preplan	XA, WD, EH



3.0: Scope and Requirements Summary

Name	CR	ER	Verification Method	Test Process	Test Pass Condition	Evidence Link
Battery Life	Must be able to hold a charge for the duration of a Murder Mystery Dinner Party	The system must be battery powered with a minimum 8 hours battery life/operational time.	Demonstration	1. Power on the system with a fully charged battery. 2. Play a different CD every 30 minutes (this is considered "standard operation") 3. Repeat step 2 until the device has been operational for at least 8 hours	If the system is still running after a minimum of 8 hours of operation on the single battery, this requirement has been met.	https://youtu.be/bDIHt2m618I
CD Capacity	The system will be able to fit project partner's CD tower, with a capacity of 80 CDs	The system will have the capacity for at least 80 CDs	Demonstration	For each of the 80 CDs in the initialized library, show that each CD plays the corresponding album when selected.	All 80 CDs play their corresponding album correctly	https://youtu.be/anusCh0GY74
CD Library Initialization	Adding CDs to the library should be easy	The system's Initialization process should take a max of 3 steps per CD	Demonstration	1. Initialize a new CD collection 2. Add a CD to the music tower, following the instructions provided by the system interface 3. Count the number of steps involved	Number of steps does not exceed 3	https://youtu.be/bdVIFN0WbVs
Discrete Design	New users should be surprised when they touch a CD and the album starts playing.	The system's appearance must be sufficiently discrete such that 9/10 users describe it as a normal CD tower	Test	1. Present a minimum of 10 test subjects with an image of our system. 2. Ask them to describe the image. 3. Record answers and see how many describe it as a normal CD tower.	The proportion of subjects who describe our system as a normal CD tower meets or exceeds 90%.	https://youtu.be/esR0bDtY_Uc
Modular Design	The product should be able to be retrofitted on an existing CD rack, and should fit with a variety of sizes and designs of CD rack.	The system must be modular and low profile, to allow retrofitting to at least one contemporary CD rack/tower	Demonstration	1. Mount the system to an existing rack 2. Demonstrate that the system can be properly mounted	The system can be properly mounted on a storage system	https://youtu.be/_lpl2BU_j7c
Music Server Compatibility	The system must be compatible with at least one music server implementation	The system must be compatible with at least one music server implementation. Compatibility constitutes the ability to send all the playback control commands to the	Demonstration	1. Verify access to kodi's library using the add CDs page from the webserver 2. Issue a play command to the webserver for a random album 3. Issue a queue command to the	If the music server responds appropriately to each of the playback command, and the view of the library is complete and accurate, the test will pass.	https://youtu.be/5OZIYv9ppvE

		music server and to access the music server's internal library of albums.		webserver for a random album 4. Issue a stop command to the webserver		
Playback Controls	Users should be able to remove or press in a CD to play that album. Songs should be able to be skipped by pressing a CD again.	The system must have at least 3 unique gestures enabling playback functionality (play, queue, pause, skip song, skip album)	Demonstration	1. Perform gesture on one of the sensors 2. Show that gesture was received and handled properly 3. Repeat step 1 and 2 for at least 3 unique gestures (tap, long tap, double tap)	The 3 unique gestures are handled by the microcontroller and received by an endpoint correctly	https://youtu.be/rASjXEIUR-w
Wireless Communication	The system must be wireless	The system's CD sensors must wirelessly communicate interactions with the webserver.	Demonstration	1. Set up the system between 20 and 30ft away from the wireless receiver. 2. Interact with the sensors. This will cause the system to wirelessly communicate the interactions. 3. Examine the signals received by webserver.	If the webserver successfully receives the playback commands from the physical system, the wireless communications pass the verification	https://youtu.be/eCdc0b7_ylw

4.0: Risk Register

Risk ID	Risk Description	Risk category	Risk Probability	Risk impact	Performance Indicator	Responsible Party	Action Plan
R0	Vendor Delay	Timeline	0.20	M	Parts do not arrive when expected.	Ethan	Retain
R1	Absent Group Member/Project Partner	Timeline	0.20	H	A group member is unable to attend meetings/contribute to the project for multiple days.	Ethan	Reduce
R2	Hardware is DOA	Technical	0.05	M	Hardware does not function.	Will	Retain
R3	Critical Software Bug	Technical	0.30	H	Software testing will reveal bugs.	Xander	Reduce
R4	Price Change for Critical Hardware	Cost	0.05	L	The price of the hardware changes (increases).	Will	Retain
R5	Damage or Loss of Equipment	Cost	0.10	M	The equipment is damaged or lost.	Will	Transfer
R6	Late Stage Requirements Change	Timeline	0.05	H	Project Partner indicates new/different requirements.	Xander	Retain
R7	Deliverable Incomplete by Deadline	Timeline	0.15	M	Development Progress/Status of individual members.	Ethan	Reduce

The risks that we identified which ended up having the most substantial effect on our project were vendor delay and an absent group member. The risk impact for vendor delay should have been high, rather than medium, and the probability should have also been much higher. Almost all parts that were ordered had some sort of delay. On the other hand, the loss of a group member ended up having minimal effect on our timeline or the quality of our final project. There weren’t any risks that occurred that we didn’t anticipate.

5.0: Future Recommendations

5.1 Add compatibility with other media server implementations

Currently, the system is only compatible with Kodi. This is in line with our original goal to be compatible with one media server implementation, but did not meet our stretch goal of compatibility with multiple. Adding support for multiple media server implementations would improve usability.
Recommendation:
Add a line to the settings table that allows the user to select between a number of music server implementations. Modularize the music server api component of the server automatically select and use the API of the selected server. Surface these options in the user interface. Ideally, add support for the most popular media server implementations to maximize potential benefit to the end user.

5.2 Add compatibility with other media types

Currently, the system only interacts with albums. This is in line with our original goal, and with the original vision for the project. That being said, adding support for other media types would increase the range of applications for our system.
Recommendation:
Kodi supports other media types including games and video. Other media server implementations are similarly versatile. Thus, with minimal change to the existing API, support could be added to allow users to launch any media type using the system. This could include playing albums (current functionality), playing videos, and launching games.

5.3 Update workflow to Agile

The workflow used by the team this year was guided almost entirely by the cadence of the ECE 44X series of classes. While the classes provided guidelines for the system, this did not lend itself to the development of our system.
Recommendation:
Switch to a higher performance project management strategy, for example, Agile. Using interactive design and splitting development into sprints with retrospectives would improve the workflow in several ways. First, it would allow for smaller, more discrete chunks of progress. Second, it would improve tracking of issues and goals. Finally, it would allow us to identify issues and plan solutions more rapidly.

5.4 Switch to and issue + branch based development strategy

The work done on the project so far was done either with no version control (in the case of the engineering work on the physical system) or using few branches with only a loosely defined structure.

Recommendation:
Use version control to track all changes, both to code and to design documents for physical aspects of the system. Enforce a protocol for branches, commits, pull requests and reviews. Organize work using numbered issues and bugs, and corresponding branches. Only merge with dev when discrete chunks of the project are complete

5.5 Improve battery design

The battery design is currently very shoddy. It was thrown together very quickly to meet one of the engineering requirements after we lost one of our group members, who was responsible for the block. It meets the requirements for how long it can be powered by the battery, but the voltages and currents are not well regulated which could cause problems.
Recommendation:
A proper power delivery circuit/PCB should be designed, which would have a voltage regulator and maintain a safe current. This will most likely increase the battery life of the system, as well as prevent any damage from occurring.

5.6 Make PCB design more approachable for hobbyists

The PCB was designed using the original requirements for this course. These requirements stated that there must be a certain amount of surface mount parts. However this is counter-productive to what our project partner wanted, which was a hobbyist friendly design, which could be sold as a kit for someone to assemble in their home
Recommendation:
A redesign of the PCB using through hole components would make more sense for the target audience of the project. This should be doable without having to expand the PCB size too much. The hardest part about this will be designing a PCB with larger components and trying to keep the footprint small to avoid increasing manufacturing costs. This may be a good thing to work on in tandem with implementing different sensors.

5.7 Design with different switches/sensors

The current switch design used tactile switches which were easy to source and design around for prototyping purposes. This a minor issue for functionality, and more a matter of preference. The switches used currently click and offer a lot of feedback to the user, a more discrete sensor or switch could improve the discreteness of the system.
Recommendation:
The simplest alternative would be to use either less tactile push buttons, or to use membrane keys as the sensors. This would allow for the firmware to be left relatively untouched, besides some possible changes to the timing for gestures, while significantly changing the experience of the user. Other sensor solutions that were explored included force sensing linear potentiometers, or force sensing resistors. These are essentially strips that allow the force and the position along a single axis to be measured using the resistance of the sensor. The issue

with these is that they were expensive and drove the cost of the system up too much.

5.8 Come up with a more modular design

The current design should be able to fit most CD storage systems that use a standard slot system. The PCBs are designed to have the sensors spaced so that each sensor is positioned in the center of one of the slots. This works great for storage systems that use this slot system, but if a user wanted to use this system on a bookcase, or possibly for different types of media, such as cassettes, movies, etc. , a more adjustable design could be implemented.

Recommendation

Some ideas that got floated for this included a proprietary sensing strip, which could be very cool, but also would probably cost a lot to design and manufacture. Other options were having individual PCBs for each switch, and designing a sliding rail system that each of the switches can be adjusted on.

6.0 References

[1] “How Coronavirus Spreads,” *Centers for Disease Control and Prevention*, 08-Oct-2020. [Online]. Available: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html . [Accessed: 16-Apr-2021].

[2] A. Katwala, “The spiralling environmental cost of our lithium battery addiction,” *WIRED UK*, 03-Aug-2018. [Online]. Available: https://www.wired.co.uk/article/lithium-batteries-environment-impact. [Accessed: 16-Apr-2021].

[3] [J. K. Park, L. Hoerning, S. Watry, T. Burgett, and S. Matthias, “Effects of electronic waste on developing countries.” Advances in Recycling & Waste Management, 2017. Available: https://www.hilarispublisher.com/open-access/effects-of-electronic-waste-on-developing-countries-2475-7675-1000128.pdf [Accessed 16-Apr-2021]

[4] “Cleaning Up Electronic Waste (E-Waste),” *EPA*, 04-Jan-2021. [Online]. Available: https://www.epa.gov/international-cooperation/cleaning-electronic-waste-e-waste. [Accessed: 16-Apr-2021].

[5] “Cleaning Up Electronic Waste (E-Waste),” *EPA*, 04-Jan-2021. [Online]. Available: https://www.epa.gov/international-cooperation/cleaning-electronic-waste-e-waste. [Accessed: 16-Apr-2021].

[6] “The MIT License,” *The MIT License* | *Open Source Initiative*. [Online]. Available: https://opensource.org/licenses/MIT. [Accessed: 16-Apr-2021].