INFO 4320 Initial Design: Music Inventory Machine

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ABSTRACT
UPDATED—18 March 2022. This paper describes the Music Inventory Machine project done in the course INFO 4320 at Cornell University. The goal for this project is to develop a machine for storing music in physical IDs with NFC technology, so that users can play the music they want. The machine gives the user the right card by having them interact with a scanner, and the user can then scan the card to play the song.

Author Keywords
Rotators; Motors; Interfaces; Music; Scanner; Arduino; Stepper; NFC; RFID; Spotify: API.

ACM Classification Keywords
•Hardware~Electronic design automation~Physical design (EDA)~Placement

INTRODUCTION
Design Goal
The machine will use NFC cards to store music information in a rotating turntable with a box that also serves as a container. Users can request specific music by scanning the corresponding barcode. Our machine will identify and connect the signal to the correct card and pop it to the user. The user can then scan the music card to play it on this device.

The goal of this project is to provide epic music lovers with physical interaction through a machine that uses the latest technology and yet bonds back through the times of vinyl, cassette and CDs, echoing the wave of new-retro culture in contemporary society.

The make-up of our music inventory machine is like a turntable so that users will immediately associate between the two. It is structured for people to see through the inside that has the main objects - the music cards. The NFC scanner on the top of this machine communicates with the local SD card in the audio shield, and streaming audio services via WiFi. Rotary navigation wheel, buttons and scanners follow a minimalist design approach so that the functionalities around scanning barcodes and operating the machine would be simple for users to understand and creates an effortless workflow.

Description
Our design can be segmented into three distinct parts: the physical storage system, interaction system, and the music decoder / signal amplifier. The interaction system will be how the user interacts with the machine, using the rotary navigation wheel to operate the menu and selecting the song they want on an OLED screen. The physical storage system has two stepper motors, one controls the spinning wheel (turntable) containing NFC cards, which makes the turntable turn to scan NFC cards inside the turntable. The other one pushes up (pop out) the correct card when selected, by using an eccentric sheave with an eccentric rod fitted. When the card has been pushed up, a distance sensor underneath that card will send out a signal to the microcontroller in order to tell the state of that card (popped out/pushed in), then the microcontroller will send the corresponding signal to the motor driver to control turning. The music decoder / signal amplifier will be done on an arduino music shield, it reads the SD card and maintains a list of file names, when the top NFC scanner gets the radio wave and retrieved data from a card, the microcontroller will lookup the song name in local SD card, if the song existed, send commands to the music shield and it will automatically play the song and do signal amplify for us via two 8 ohms speaker connect to the music shield. If the song does not exist, the controller will use the Spotify API to retrieve data and play the song over-the-air via WiFi connections.

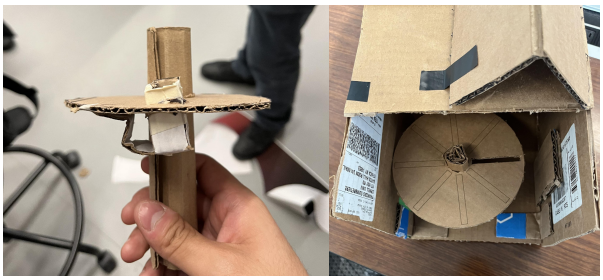
INITIAL PROTOTYPE


Figure 1&2. Motor / wheel storage system design.

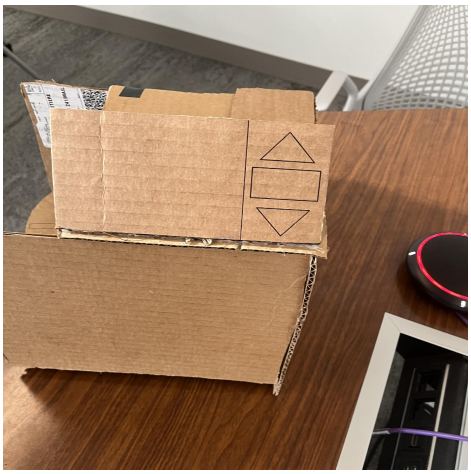


Figure 3. User Interaction Interface.

Figure 4. Overall Structure.

For the initial prototype, we were unsure on how to push the card structure up. Figure 1 shows the motor / wheel storage system design. There will be a central axle, and a wheel with slots with a card holder in it. These card holders will hold the NFC cards. We will likely use a stepper motor to ensure precise movements, since the card holders need to be in exact positions to push the card up through the top of the machine. We decided that the cards will be pushed by one piston that pushed the entire holder up. The NFC reader is shown in the second picture as the cardboard piece on the right perpendicular to the card holder. Figure 3 shows the design for the user interaction interface. It will have buttons for up and down and select. The up and down buttons are to move between songs, and when the user finds a song they like, they will select it. Then, the storage system will find the right card and retrieve it for them. The physical interface will use an OLED screen. Figure 3 also shows the NFC music player in the back. It's a simple flat surface which the user will tap the card on.

FINAL PROTOTYPE

Figure 5. Modified design for pushing the card up through the slot.

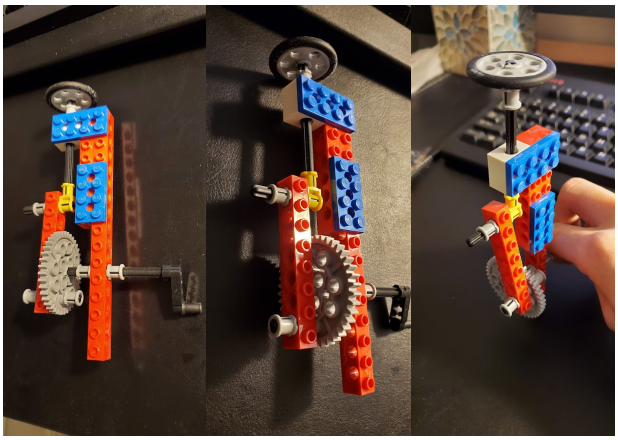


Figure 6&7&8. Details of Lego piston mechanism structure.

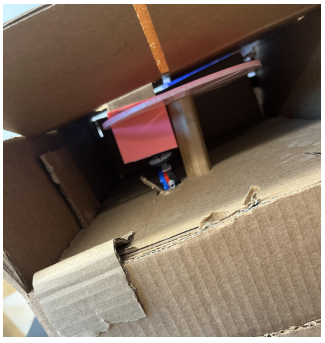


Figure 9. Lego piston pushes up the card holder.

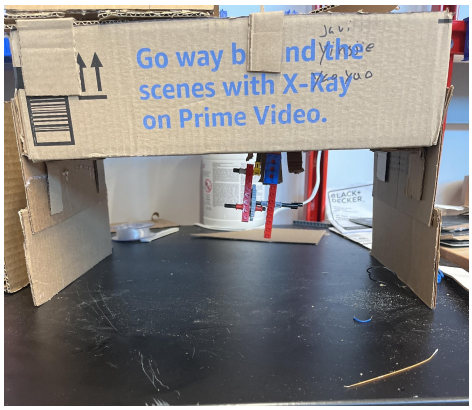


Figure 10&11. Front view with Lego piston structure installed inside.

Figure 12. Top view of the whole machine.

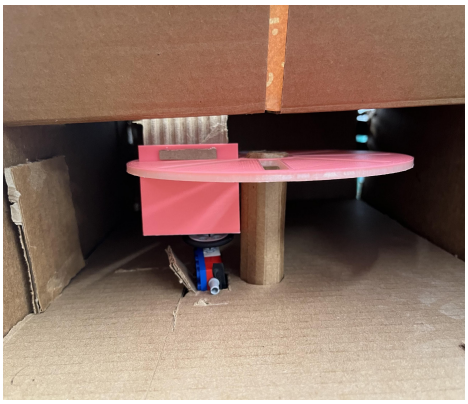


Figure 13. Side view of the turntable and card holder with Lego piston push-up mechanism.

Figure 5 shows a full image of our final prototype. It's a simple box with the physical interface and scanner on the outside, but the storage system on the inside. There will be one opening in the box to let the selected card through.

Figure 9 shows our modified design for pushing the card up through the slot. The wheel storage will have card holders, and a piston, modeled by the Lego structure shown in figure 6&7&8. It will push the card up for the user to grab and use. Another view of the Lego structure is available in figures 10&11, 12, and 13.

The physical system is similar to the initial prototype, and so is the scanner.

FUNCTIONAL UNITS

After receiving TA and peer feedback, our final design will still fall into three major components.

Storage System

The most challenging component is still the storage system. To maximize the stepper motor's utility, the wheel storage will have to store several cards divisible by 200, the number of steps in a stepper motor. We have not decided on a number, but 10-20 is ideal. Additionally, scanning the cards will prove to be challenging, but we are hoping to use cards of at least 6 mm diameter so the scanner can be perpendicular to the card holders for motion simplicity. We are happy with the piston/upward pushing structure driven by a stepper motor, but are still considering one alternative. We are considering putting springs in the card holder, which are released when the right card is identified, pushing the card up to the user. This could prove to be challenging, and so we may stick with the existing design.

Physical Interface

The physical interface should be straightforward, but some challenges exist. First, our team's original plan for the interface was to have the user select their song first, and the storage system would scan every card until the desired one was found. Now, we are considering having the up/down buttons correspond to stepper motor movements, and the

scanner scans the card with every new rotation. When the user finds a song they like, they press the select button, and the piston pushes that card up. We are leaning toward this because it improves the user experience. It would not be more difficult than our original design, just change how we set up the code and buttons.

Scanner

The scanner presents one major challenge and depends on how much time we have and how complex we want our system to be. Since we plan on using a Spotify API to play music if the song is not in the SD card, the nfc cards will simply refer to the API, and the API will handle playing the music through the wifi feature on the motherboard. Extending from this, we can either connect through Bluetooth or an audio jack. Time permitting, we will do whatever results in the best user experience.