Fridge Jam: NFC Powered, Interactive Soundscapes

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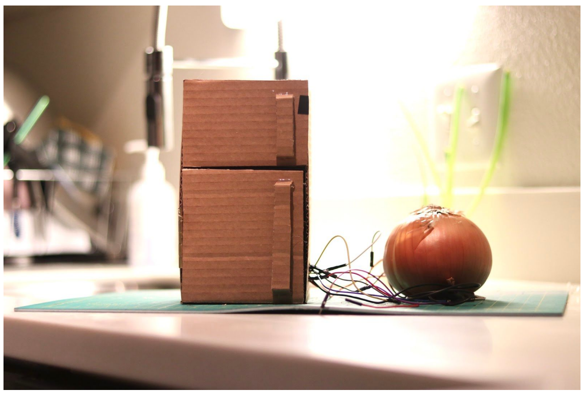

Figure 0. Fridge Jam Build

ABSTRACT

Designed similarly to MIDI devices such as soundboards and launchpads, Fridge Jam utilizes conductive switches and NFC data frames to explore ranges of audio in a closed system soundscape. These soundscapes are defined and dictated by NFC datacards. Where the NFC functionality passports a user to various types of audio libraries. Utilization of conductive switches allows user agency in formatting their unique compositions. Wherein, Fridge Jam promotes autonomy by allowing users to decide their tools to navigate environments of pre-made audio.

Categories and Subject Descriptors

B.4.1: Input/Output Devices: Utilization of Arduino modules such as the MPR121 Capacitive Touch Sensor and the RC522 Radio Frequency Identification aim to function as input devices for data systems. Speakers and computing audio are utilized as forms of output devices.
B.4.3: Interconnections (Subsystems): Fridge Jam is designed as a closed loop system. This loop starts and ends with the power button -- where at start -- users are prompted to utilize NFC UIDs to change various sound libraries within the device. This loop continues through various opportunities of interaction, including utilization of non-switch buttons to play respective audio scales, unique identifiers and audio libraries.
E.2: Data Storage Representations: Data in this device is represented by various forms of Hexadecimal, Binary, and 8 bit information. Hexadecimal and Binary data are handled on the NFC layers. Where 8 bit info has been handled on the audio output layer.
H.5.5: Sound and Music Computing: Conversion of .mp3 files to 8-bit data structures to allow arduino to call on and manipulate audio via a speaker module.

General Terminology

Performance, Design, Experimentation

Keywords

Conductive Interfacing, Soundscapes, Near Field Communication *(NFC)*, 8-bit Audio Conversion, Unique Identifiers, MPR121, RC522

1. INTRODUCTION

Contemporary music devices function on the level of both artist and consumer. This active and passive relationship can further be boiled down to subject matter experts (SME) and music enthusiasts.

The subject matter expert, defines an individual masterful in the traditional interfaces of instrumental devices. These devices range from classical analog instruments, or even the I/O formats of MIDI keyboards. Where the music enthusiast works at a level of appreciation and longing. Appreciation for the sounds and compositions the subject matter expert is able to orchestrate. Yet also a longing, to understand the beauties and complexities analog or MIDI devices. In turn, a longing to orchestrate music as wonderfully as their SME peers. At **the threshold of both relationships are devices that aim to appease the deep subset of skill of the expert and the simplicity of the enthusiast.** This complex yet simple need is what modules such as Fridge Jam aim to fulfill.

In user experience considerations, we put ourselves into the shoes of the lowest knowledgeable subject. In the case of music development, this would be considered the music enthusiast. The enthusiast, upon display of the 66 key electronic keyboard feels overwhelmed by the sheer number of keys available. Or when given the child's recorder, the enthusiast feels unaccustomed to a woodwind's affordance of holes. Those holes, in the enthusiast's mind, apparently must be covered in order to make certain notes. But which notes, and which way must one's hand cover certain holes? To say the least, **musical devices that require forms of multitasking or subset knowledge, create onboarding experiences that drive users away, instead of inviting them in.**

The design approach of Fridge Jam follows this very ideology. That music devices that work for both an expert and enthusiast are simple aesthetically, but work with complexities on a sub-surface level. This interaction could be achieved with the following development goals:

Primary goals of interaction:

1. Autonomous electroacoustic performances
2. Instrument augmentation through considerations on musical scales & environment sampling
3. Capture users' mental models of buttons to further implement affordances of buttons for capacitive interfaces.
4. Utilize HCI guidelines to reinforce feedback detection and promote user agency

2. BACKGROUND

2.1 Inspiration

Fridge Jam's design follows influence from the interaction flow used in the early 2000s Leapfrog tablets, LeapPad (see Figure 1). These tablets utilized NFC technology to read pages of a book out loud to a child interacting with it. This interaction flow predated the digital screen and tablet stylus. Further, working simply with the affordance a child has with a pen. With this pen, children could infer that it needed to touch something. As not designed like a crayon, where children may consider affordances of coloring or drawing. The pen afforded them to use as a poking device. This poking function combined with the draw of certain highlighted words suggested poking those highlights.

Figure 1. LeapPad Interaction Example

These LeapPad tablets worked in combination with cartridges. These cartridges held binary or boolean forms of data which manifested as the unique books that could be read aloud. And further defined what types of audio would play from the pen's touch. The cartridges were both a passport to various forms of "audiobooks" but also held a whole children's book within its memory. When we think about audio in the context of digital interfaces, we know the familiar .mp3, .wav, or .flac formats. Those formatting files are simply GUI equivalents to complex hexadecimal or boolean datasets. In context for Fridge Jam, we can think of NFC's memory availability as similar to cartridge systems. Where NFC's memory systems may be appropriate for storage and quick recall of audio clips.

Figure 2. Interactive Coffee Table

Similarly, capacitive interaction models have also been built in coffee tables. A group at the Chalmers University of Technology in Sweden designed an Interactive Coffee Table. This table was a musical device that promoted modes of co-creation between strangers in a coffee shop (see Figure 2).

2.3 Room for Improvement

Since the majority of the Coffee Table focused on generative music mechanics, instead of an Arduino sensor, a Microsoft Surface multi-touch table like the PixelSense was used as the "eyes" of the project (Bowden, 7). The PixelSense was a pre-bought device that could detect pressure finger strokes on its display. In this case, the display being converted to function like a table top.

Similar devices also struggle with user affordances. And as discussed in the Coffee Table research, user research caused user pain points. One problem was that users didn't know how to interact with the table when no guide was given. Another was the syncing of audio to button pressing. Herein we have dismissal of user affordances and mental models of interaction.

2.2 Mental Models of MIDI / Keyboarding

Similar devices in the music scene include **MIDI boards and Launchpads.** These devices are often switch powered, and depend on the silicone or plastic button to convert or push audio waves. In consideration of these musical instrument digital interfaces and its familiar users, there are certain contexts and affordances to consider when implementing our own interface.

Oftentimes, MIDI devices are short, and lay flat on surfaces. This design allows users to utilize the device on their own stands or even tabletops. These devices are never angled. As angles may interfere with supplementary surfaces such as music stands, which tilt and angle to a user's preference.

Many MIDI devices utilize auditory or visual feedback when buttons or switches are manipulated. This is not only an aesthetic design decision, but it considers environments where users often use MIDI devices. These environments include clubs, stages, or even the soft LED of the traditional bedroom. In examples of visual feedback, silicone buttons are often transparent and are paired with LEDs. These LEDs are either placed underneath the whole switch, or are utilized as a rim that surrounds edge buttons. **Auditory feedback** in the traditional piano or keyboard manifests as not only the respective scale being pressed, but even the sound of the key being pressed down. This sound is notably those plastic keys being tapped onto metallic keyboard casing, or the weighted ivorite on a grand piano's wood. **These auditory signals are expected within the traditional button interface.** But how does this work in a device where a button does not have switch mechanics? What if a button was actually a grocery store onion? How does a user expect auditory or visual feedback now?

2.3 Considering Mental Models to Implement Affordances in Conductive Interfaces

Upon understanding a user's mental model of the traditional, musical button system, we can further infer how users expect our own "buttons" to work. Buttons, in-quoted, as our buttons can be defined as anything a user pleases. **Through Fridge Jam's**

utilization of conductive technology, users are able to pick and choose which items they want as a button. Be it an onion or even a spoon, conductive modules such as the MPR121 allows a button to detect changes in capacitance. So instead of that traditional, push-down-until-detected mechanic, **our device's buttons work as tap-lightly-until-there-is-a-change-in-an-object's -capacitance.**

2.4 Improving User Interaction

Since an onion cannot exactly give auditory feedback beyond the respective audio being triggered by the device, we can instead look into visual feedback. Visual feedback, as implemented in Fridge Jam, might manifest with use of an LED module. When a user presses their chosen button, a respective LED will light up. This LED will stay on for the amount of time a user holds their finger on it. Considerations of a user's mental model in traditional devices defines informed design decisions in Fridge Jam's development.

2.5 Exploring and Designing for Mental Models of NFC

Subliminal usage of Near Field Communication in a user's everyday life includes interactions such as scanning transit passes, locking shopping carts, and ID cards/Passports. **Near Field Communication** has dominated mechanics such as unlocking, verification, and scanning. In the field of play, contemporary video games have also included use of NFC to unlock characters or levels, similar to Nintendo's Amiibos. The mental model of NFC comes from domestic habituals and even one of play.

To further incorporate NFC within Fridge Jam. We had to explore the capabilities of Near Field Communication devices. In a range of byte-based systems, NFC has the ability to hold Hexadecimal data which translates to device or game specific information. Depending on the size of that data, NFC has the ability to hold up to 8,192 bytes. In the case of the cards available at hand, the MIFARE Ultralight series holds up to 512 bits of memory (NXP B.V, 12). This memory ability of the NFC cards allow the device to hold short audio files. Which in the case of Fridge Jam, exist as 8-bit datafiles of .mp3 sounds. **As not fully incorporated in the minimum viable version of the project, NFC was chosen due to its ability to quickly read and hold data of audio files.**

4. SYSTEM OVERVIEW

Fridge Jam consists of two input devices, and one output device. The input is handled by an RC522 NFC/RFID reader and a MPR121 capacitive touch module. On a complex addition, a LCD 16x02 screen may also be included. Pending time constraints, consideration of this module can be utilized flexibly.

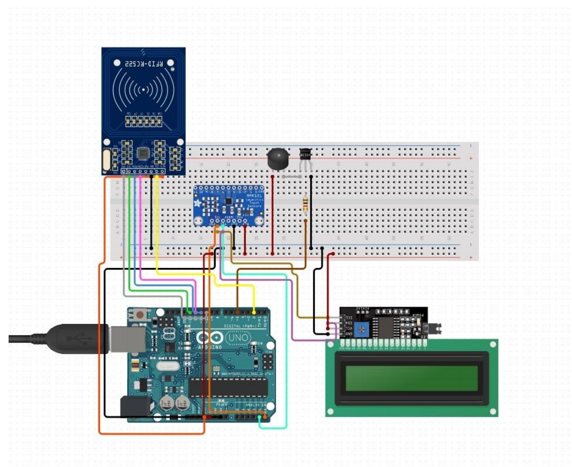

Figure 3. Fridge Jam Schematic

3.1 Input Analysis: RC522

The RC522 functions as the NFC reader in this schematic. The RC522 allows reading of hexadecimal data that can then be compared to a written c++ library. This library would further contain data for audio PCM files.

```
if (mfrc522.uid.uidByte[0] == 0x04 &&
    mfrc522.uid.uidByte[1] == 0x4a &&
    mfrc522.uid.uidByte[2] == 0x88 &&
    mfrc522.uid.uidByte[3] == 0xd2 &&
    mfrc522.uid.uidByte[4] == 0xe8 &&
    mfrc522.uid.uidByte[5] == 0x6b &&
    mfrc522.uid.uidByte[6] == 0x80) {
    Serial.println("piano card detected");}
}
```

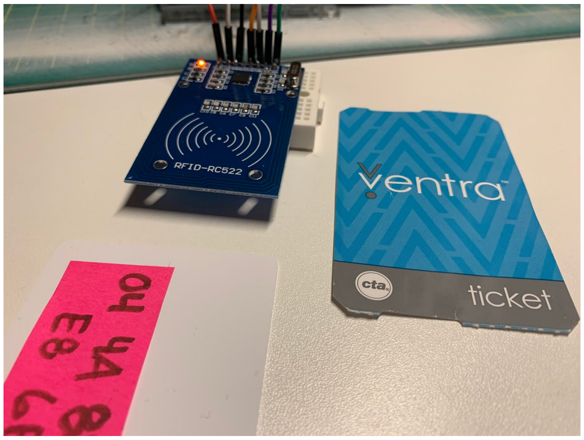

Figure 4. Upcycled NFC Cards

3.3 Input Analysis: MPR121
The MPR121 has been included to allow users to define unique types of buttons within their space. (See paragraph 2.3 for more technical info about the MPR121 module).

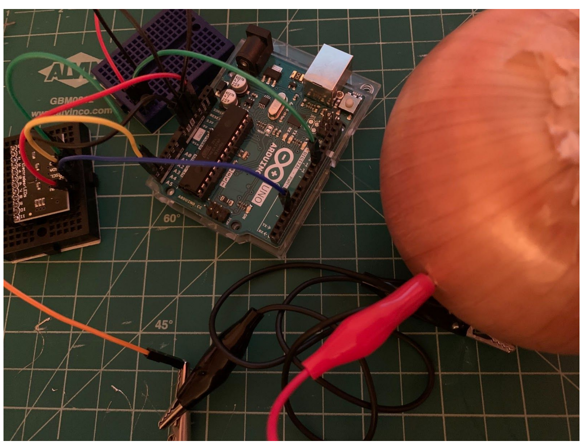

Figure 4. MPR121 & Onion

3.4 Design and Iteration
The first design featured a flat tabletop build. In which all modules would be placed on the top portion of the container. This build considered user needs such as incorporation with their own tabletops or music stands. Yet, this build lacked the visual joy of experimental designs.

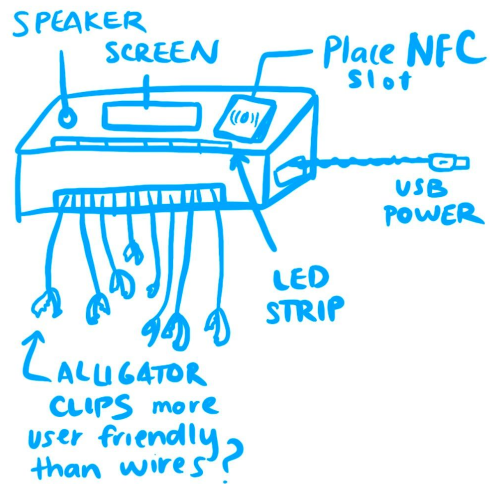

Figure 5. Iteration 1 - Flat Tabletop Module

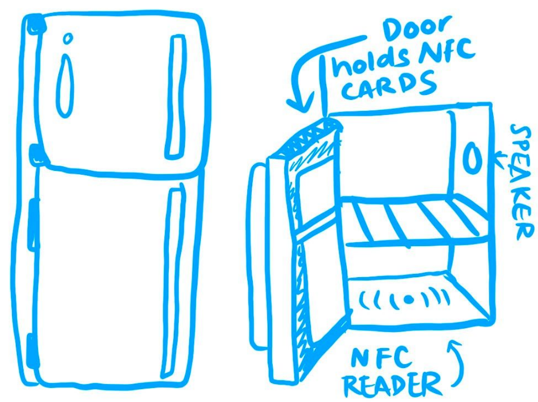

Figure 6. Experimental Mini Fridge Container

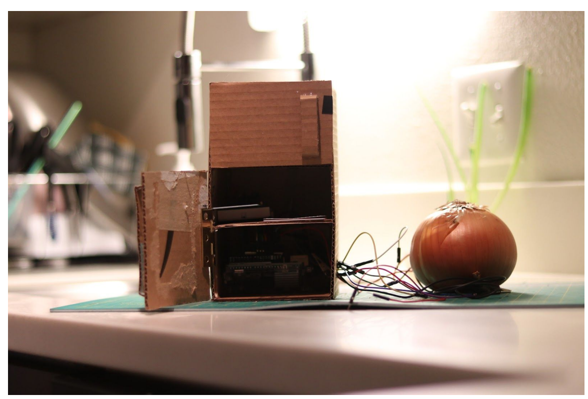

Figure 7. Ideation Realized

3.5 Design and Iteration

Post prototyping phase, the fridge container was designed. In which users could store NFC cards, and interact with the module in a small scale component. In user testing analysis, users were discovered to be more curious and hands on with the fridge device. Often opening and closing the doors to see what was available within. This design promoted interactivity and curiosity.

3.6 Full Build: Usage Analysis

As mentioned and bolded in earlier paragraphs, the following mechanics would be implemented to improve user experience:

1. NFC to hold audio bit data
2. LEDs to light up when buttons are pressed
3. LCD screen to display to a user which NFC card is currently being read

4. CONCLUDING THOUGHTS & FUTURE DESIGN

Fridge Jam works for both musical experts and casual users. On a domestic level, Fridge Jam is a device that can be utilized in a bedroom or household environment. As buttons can be whatever a user choses, the reliability of the build is as the user defines. Buttons can be as large or as small as desired. As such, this customizability allows this device to work for a wide age range. As smaller buttons may hold ingestion or breakability dangers when used by younger children. Buttons can be replaced by plush toys or even food items. Inviting interactivity or teaching tactility and response to developing toddlers.

On a larger scale, **this conductivity capacitance can be utilized in a guerilla context**. When Fridge Jam is connected to commonly touched surfaces such as buttons in an elevator, trash can handles, car doors, or even bus seats -- the mundane gets transformed into public, interactive soundscapes. Wherein, there is opportunity for surprise. Users of those mundane interactions don't experience auditory feedback. That unexpected element promotes a sense of community, as many individuals are seemingly experiencing the same out of the ordinary phenomenon of musical bus seats. **Fridge Jam affords opportunities for musical co-creation in the public domain.**

5. REFERENCES

Bowden, Zac. Retro review: Microsoft's 2008 Surface 'coffee table' in 2017. Windows Central. 15 February 2017. Web. Date accessed 11 December 2020.

Museum of Obsolete Media. *LeapPad (1999-2008).* N.d. Date accessed 11 December 2020.

NXP B.V. MFRC522: Standard performance MIFARE and NTAG frontend. 27 April 2016. Datasheet. Date accessed 11 December 2020.

NXP B.V. MIFARE Classic EV1 1K - Mainstream contactless smart card IC for fast and easy solution development. 23 May 2018. Datasheet. Date accessed 11 December 2020.

Paragon ID. *Do you have a hole in your business model that could be filled by Radio frequency identification (RFID) technology?* N.d. Date accessed 11 December 2020.

Robert Fohlin, Peter Kun, Laura Rebolo, Markus Jansson, Niels Swinkels. "Music co-creation in public spaces via interactive coffee tables." Department of Applied IT Chalmers University of Technology, Sweden. N.d. Scientific Journal. Date accessed 11 December 2020.

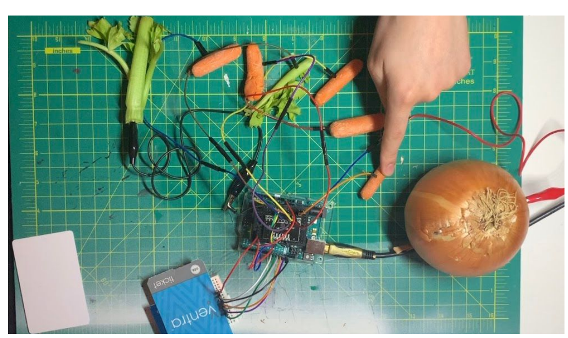

Figure 8. Raw Interaction