Echoes of the Land:

RFID-Powered Interactive Soundscape Inspired by Pre-Colonial Montréal

Primary Documentation Website: https://github.com/jaebrn/cart-360-final

Jennifer Brown
Computation Arts Specialization
Concordia University, Montréal
br_jenni@live.concordia.ca

Katt Lee
Computation Arts Specialization
Concordia University, Montréal
l_kathry@live.concordia.ca

ABSTRACT

This report presents our exploration in creating a tangible interactive soundscape representative of pre-colonial Montréal. We investigated the use of radio-frequency identification (RFID) readers and tags as sensing components indicating the placement of unique objects atop a topological representation of Montréal; each object provoking sound associated with the flora and/or fauna of the island. Through this, we explored methods of enhancing the user experience, considering materiality, form, and audio-visual enhancements.

INTRODUCTION

Designed as a tabletop educational public art display, this project consists of two distinctly categorized elements; the board, housing circuitry and RFID readers, forming a topological representation of the island of Montréal pre-colonization; and the objects, each housing an RFID tag, representative of an element of Montréal's natural flora and/or fauna. Objects, at users' discretion, may be placed within one of several circular indentations within the housing board. Each indentation is located atop an RFID reader. Upon placement, the tag is assessed by the correlating reader, and audio is played corresponding to the tag's unique identifier (UID).

This project's intention is to highlight how our environments have changed throughout the years as a result of colonization and human activity. Echoes of the Land plays on how the surrounding environment is often seen as an object to serve industrialization, and the ways in which this impacts the collective memory of the past. This project reminds us to be conscious of our surroundings while educating newcomers to Montréal of the indigenous wildlife that has survived to the modern day.

Figure 1: Housing Board: RFID reader embedded topological representation of Montréal.

INTERACTION

Our intent was to create a public installation to bring together environmental awareness as well as provide an enriching experience to the user. The user would place the objects onto the board. The board would then react to the object being identified to play the sound depicted in the wire sculpture. Whether that be an animal or plant. When the object would be placed, an led embedded below would glow as a presence was detected. Within the board would house lights that would blink in and out in a way to mimic water patterns.

MATERIALS & DESIGN

Board

Materials were deeply important to the success of this project, both functionally and narratively. RFID signals are likely to be interrupted by the use of certain materials (primarily metals) deemed RFID-opaque *(Payeur, 2019)*. We experienced minimal interruptions in reading through plant based materials such as wood, paper, and cardboard, with tag sensing capabilities reaching distances of approximately two inches through these materials. In considering the themes of environmentalism within this project, synthetic and unsustainable materials were avoided. As such, we opted to construct the housing from wood.

We created a number of vector files for each topological layer, referencing current and historic maps, and research regarding the island's changing landscape *(Figure 3)*. These files were then input via CNC machine to produce the precise shapes contributing to topology *(Figure 1)*.

We looked at old maps of montreal to see what islands were still included, which were renamed, and based the shape of our project off those photos *(Figure 2)*.

When creating the design for the board it was important to somewhat abstract the form of the island. To make sure that it was visually appealing but still thin enough for the readers to read through the wood, small holes were placed throughout the board on different levels. Most of the board was based on the surrounding area of Mont Royal as it had the most topographic variation, and significant diversity in natural wildlife. We thought it would be interesting to reimagine the finer details while leaving the prominent landmarks we still see today. Due to using the CNC machine, many of the edges needed to be adjusted to be cut by its ⅛" cutter without issues.

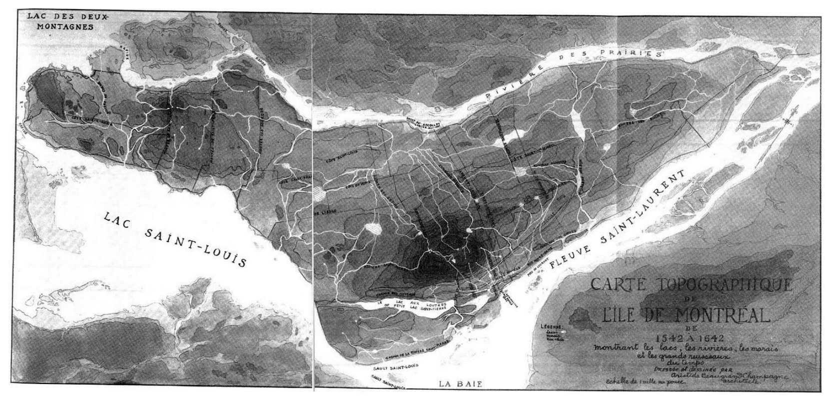


Figure 2: Old map of montreal depicting rivers which for some do not exist currently Credits: [*https://spacing.ca/montreal/2009/10/29/montreals-rivers/*](https://spacing.ca/montreal/2009/10/29/montreals-rivers/)

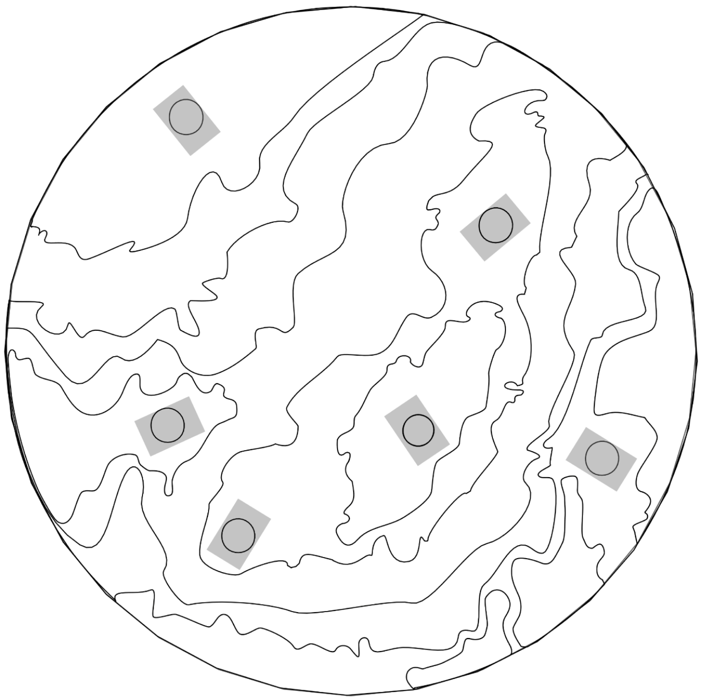


Figure 3: Layered Housing Board vector files, depicting RFID readers and tag indentations for placement.

Objects: Concept

In line with our concept, the objects that were created symbolized different aspects of the wildlife found natively in Montreal. These were made of wire and cardboard. We wanted these objects to convey the industrialisation of the land by incorporating more man made materials into the pieces being physically handled by the audience. The objects create an interaction with the narrative itself, of how we change the landscape we inhabit. *(Figure 4)*

Objects: Animals

To provide a wider range of sounds to the soundscape we created mammals, fish, and plants. These objects were based on animals such as the Red Fox, the Smallmouth bass, an Eastern Cottontail rabbit, and a River Otter as well as plants like the provincial flower The Iris Versicolor. All these animals could be found on the Mont Royal website as well as multiple sources of Quebec wildlife.

Objects: Housing and Tags

Within the bottom of the objects, there was a container created from cardboard which housed the RFID tag. Using the tags provided from the kit, we found that it was too large to fit inside the openings in the board. In the end, we disassembled the tags and twisted the copper wire perimeter to size them down. After testing the tags to verify they were functional they were then glued to the bottom and the wire sculpture was attached to the top of the box. (*Figure 5)*

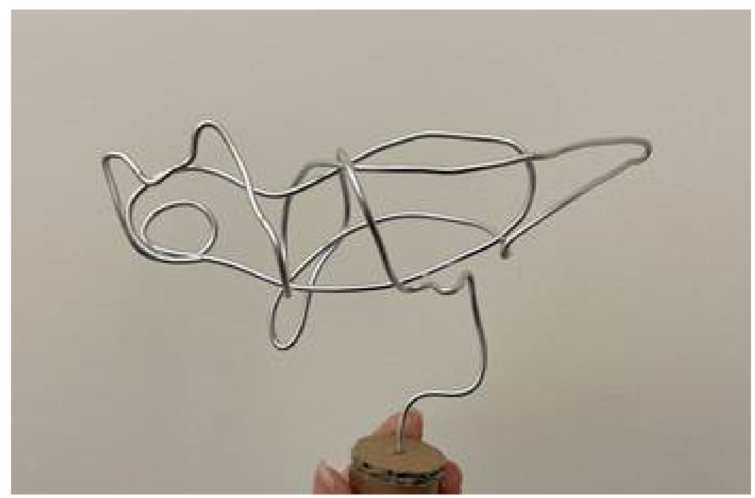


Figure 4: Example of object: pictured River Otter Object

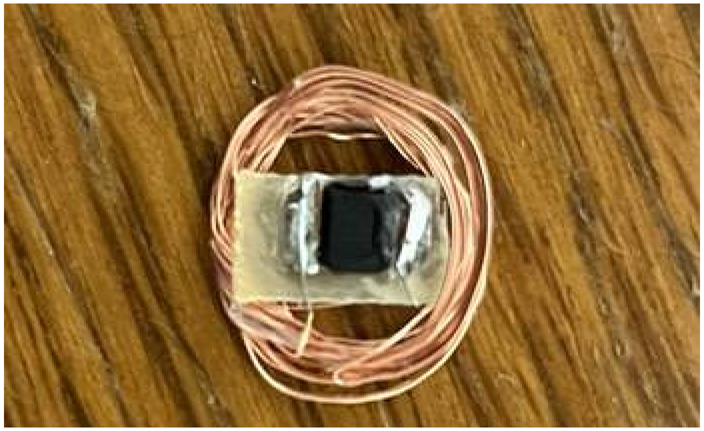


Figure 5. Modified RFID Tag within object housing

HARDWARE

Radio Frequency Identification: Readers

While our final housing unfortunately only contained five readers due to a vector file error, our circuitry functionally supported six RC522 readers operating from a single Arduino Uno. This was accomplished by splitting all but one of the seven pins used by each RC522 reader utilized for power and SPI communications. Several of these pins (such as SCK, MOSI and MISO reader pins) require access to components within the Arduino Uno microcontroller board, accessible only via certain digital input/output pins. As such, to operate multiple readers from a single board, pins such as this must be shared amongst readers *(In-Depth, 2018)*. *(Figure 6)*

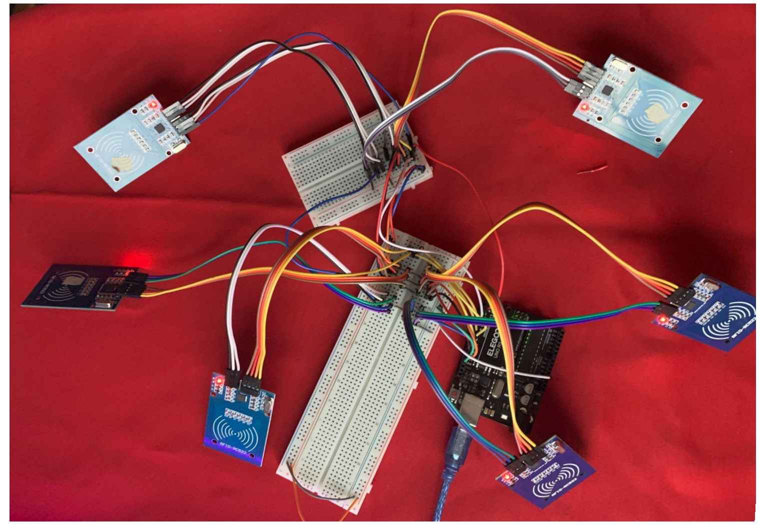


Figure 6: Prototyped RFID reader circuit, supporting six readers.

Radio Frequency Identification: Tags

The RC522 modules utilized within this project are accompanied by a 13.56MHz tag *(Figures 7, 8).* To house them, we removed the outer plastic and embedded solely the coil and inner tag within our identifiable objects. *(Figure 5)* While the separated inner tag was easily read by the reader, we experienced interference when attempting to read the inner tag housed within the object's themselves.

Figures 7,8: RC522 RFID Reader Module & 13.56MHz RFID Tag
Image credits: Last Minute Engineers

Audio-Visual Components

Accompanying the RFID system, our circuitry supports a number of LEDs, designed to be embedded within the housing board indentations, illuminating upon the placement of a recognized RFID tag. We initially hoped to include internal components and circuitry to support audio production. Ultimately, we maintained connection between the Arduino Uno and an external PC, playing audio from the PC's disk, over its speakers.

Housing & Wiring

The housing design was created in Blender, a 3D modeling software, using vertex points converted into grease pencil. Blender was used after multiple attempts in Adobe Illustrator to turn sketches created with another drawing program into vector layers. It was challenging to estimate scale and anticipate what would be needed and what could be done with the CNC machine.

SOFTWARE

Our artifact operated using two software platforms; Arduino IDE, and Max 8. Arduino was used for the internal circuitry; lighting, reader operations, and logic regarding object placement. Max was used solely for audio output from an attached PC, with output correlating to Arduino IDE's RFID readings.

Standard communications using the RC522 was accomplished with the use of two libraries; MFRC522 (for operations utilizing the reader's MFRC522 chip) and SPI (for communications between readers and the Arduino Uno microcontroller) *(Balboa, 2012) (SPI - Arduino Reference, n.d.)*. Our initial code was heavily inspired by Github user Annaane's multi RFID setup, also utilizing the RC522 module *(Annaane, 2019)*.

A majority of the logic concerning object and reader identification was developed using arrays. There are several arrays within the code, containing the readers, the recognized UIDs, and integers reflecting the state (on/off) of each object associated with a recognized UID. Though unused in this context, the program also recognizes the location of objects amongst the readers, should audio be implemented with multiple sources.

The program assesses each RFID reader within an offset loop, as our use of pin splitting prevents readers from being assessed simultaneously. When a recognized UID is received by an RFID reader, an integer numbering 1-5 (associated with each of the five tagged objects) is written to the serial output. When a recognized UID previously received by a reader is no longer present upon that reader, a corresponding integer numbering 6-10 is subsequently written to serial.

Within Max, the same serial is read. Upon an incoming integer 1-5, the associated audio channel is activated; upon incoming integer 6-10, that same associated channel is deactivated, producing a responsive audio output. Similar logic is utilized within Arduino IDE to produce LED illumination at the reader receiving a recognized UID.

DIVISION OF LABOUR

Jennifer

My work consisted of three primary areas throughout this project: woodworking, circuitry, and code. My initial focus was on developing a circuit configuration to support six RFID readers. Alongside this, I developed the circuitry to support RFID reading correlating lighting, handled internally by the Arduino Uno.

I continued developing code to support our function of reading multiple RFID outputs and identifying various tag UIDs. To this effect, I created a loop which determines the state of each reader at offset intervals. Readers are unable to be read simultaneously due to their pin splitting. With this, I created a function to produce an integer correlating to the initial placement and removal of the identified UID, to be utilized by Max to produce a corresponding audio output.

I additionally produced the wooden components of the housing; using a CNC machine to create precisely cut wooden pieces via Katt's vector files. I then sanded the pieces, removing the connective layers of wood. Due to vector sizing errors and a missing vector file, I returned to the woodshop to remove some additional pieces of the housing layers to make room for the circuitry and components.

Katt

My work was mainly focused on the objects, code for a wave pattern with RGB string lights, the creation of the housing design and constructing it together within the housing.
The vector files used consisted of multiple layers that had to be individually made from a sketch I had done previously. Scale was an issue as I am not familiar with how to create images for the CNC machine. I tried my best to approximate scale and provide a reference image. However there were still issues during cutting that I had no time to redo.

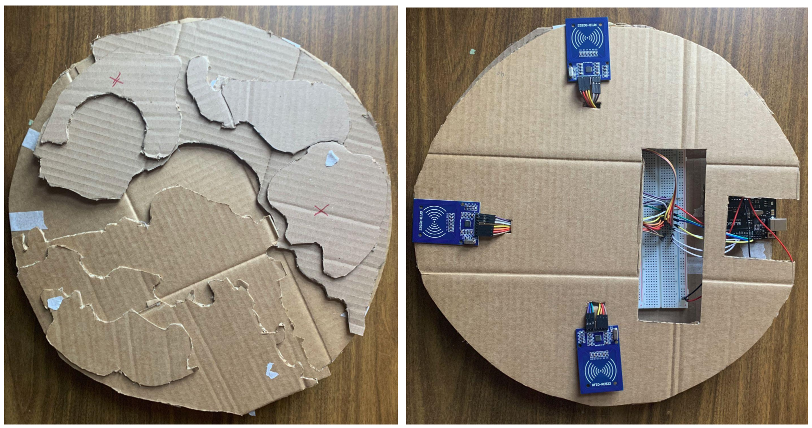
The wire objects were hand bent and assembled with the hopes of 3D printing a more secure housing on the bottom. Since the cutouts for the objects on the board were varying sizes, cardboard was used instead. As well, I learned the FASTLED library to create patterns with LEDs.

Afterwards when I had finished making the objects, the code, I was tasked with assembling it together. My original plan was to solder the wires together, splitting the shared wires into 6 ways each as well as having separate wires for the SDA pins. Without extra readers and limited time soldering was not a viable option at the time. Instead I attached the readers with extra jumper cables to extend their reach, as well as creating space within the housing to account for the breadboard's height with cardboard spacers.

PROTOTYPING

Board

During our prototyping phase many considerations were made with the layout and interaction design. The board was constructed out of cardboard, allowing us to cut holes as needed without difficulty. In the end more space was required for the components and layers were added to accommodate the size *(Figures 9, 10)*.



Figures 9, 10: Cardboard prototype, upper layer (left) and internal housing (right).

Objects

During this time object prototypes were made of varying materials, such as EVA foam and paper. With both materials while the objects looked sleek and clean there were concerns about structural integrity and durability. The initial idea was to have hollow objects that could be lit with LEDS from the inside. We had concerns whether the extra LEDS within the objects would create interference. foam/paper models were not viable for the final artifact. With the fragility and limitations with lighting, the material was changed.

ARTIFACT

The final artifact contained within, 4 functional readers, and 5 separate objects that could be detected. While not everything had been completed fully compared to the goals set out for the project, the main components were present which effectively portrayed the intent.

OBSERVATIONS

There were plans to have everything to power and create sound in the board with no external connections, with the power requirements of the board we found it less feasible for it to all be housed inside. Plans were made to have lighting connected to a separate arduino which would control the ambient lighting to mimic water underneath a layer of cloth.

Unfortunately due to time constraints, these goals were not fully realized. On the day of the presentation we received many connection issues due to poor connectors. Many of our objects were detected by select readers as opposed to all of them. With time we hope these bugs could be fixed. The lighting for the water was also not present during the final presentation. With time we hope to add it later to the board.

FUTURE DIRECTIONS

In continuing this project, several elements require further attention or reworking. Primarily, it would be a significant improvement should the artifact operate unattached to an external PC. For this, the use of an additional Arduino audio module is required, as well as the use of external speakers. Furthermore, an internal power source would be required.

Though our code supports dynamic RFID-triggered lighting, further structure is required within the housing to best support these components. Similar alterations to the housing would improve the fidelity of the resulting artifact, such as an impermanent (yet stable) method of layer assembly, (providing access to the circuitry for troubleshooting if required) and a reconfiguration of the internal circuit housing to properly fit the size of our components. Further emphasis could be applied upon the visuals of the housing, such as adding a stain or varnish to the wood, or using a more thematically relevant species of wood (i.e. wood from trees naturally occurring within Montréal. Reconfiguration of the reader location, soldered internal wiring (as opposed to stringed jumper wires) and higher fidelity RFID tag housing are also needed to further the consistency of the artifact's functionality.

Narratively, our artifact is designed as an informative public art display, representing a non-colonial perspective on the wildlife of Montréal. To this effect, additional information could be supplied to users (for example, an LCD screen within the board communicating information regarding the flora/fauna represented by the objects, and the representative locations within the board: e.g., "Red fox to the North…").

It is imperative to note that neither author identifies as Indigenous. Regarding the themes and narratives, the inclusion of Indigenous perspectives is crucial in the continuation of this project. While we make significant effort to remain accurate in our depiction of a pre-colonial Montréal, increased communication and representation of the communities historically centered upon this land is invaluable.

REFERENCES

Annaane. (2019, January 19). MultiRfid. GitHub. https://github.com/Annaane/MultiRfid

Balboa, M. (2012, January). Arduino RFID Library for MFRC522. GitHub. https://github.com/miguelbalboa/rfid

Eiche, A. (2010, June 29). A Beginner's guide to Making an Arduino Shield PCB. AaronEiche.Com. https://aaroneiche.com/2010/06/24/a-beginners-guide-to-making-an-arduino-shield-pcb/

In-Depth: What is RFID? How It Works? Interface RC522 with Arduino. (2018, July 30). Last Minute Engineers. https://lastminuteengineers.com/how-rfid-works-rc522-arduino-tutorial/

Ishii, H., Mazalek, A., & Lee, J. (1999). Bottles as a Minimal Interface
to Access Digital Information. MIT Media Laboratory. https://trackr-media.tangiblemedia.org/publishedmedia/Papers/466-Bottles%20as%20a%20minimal/Published/PDF

Ishii, H., Mazalek, A., Lee, J., Fletcher, R., & Paradiso, J. (1999). musicBottles. https://tangible.media.mit.edu/project/musicbottles

Joon Moon 문준용 portfolio. (n.d.). Retrieved November 4, 2023, from https://www.joonmoon.net/

Joseph, J. (2022, May). Interfacing RFID Reader With Arduino. Circuit Digest. https://circuitdigest.com/microcontroller-projects/interfacing-rfid-reader-module-with-arduino

Lewin, J. (2012). Chandelier Harp. https://www.jenlewinstudio.com/portfolio/chandelier-harp/

MFRC522
Standard performance MIFARE and NTAG frontend. (2016). NXP Semiconductors. https://www.nxp.com/docs/en/data-sheet/MFRC522.pdf

Miranda, E. R. (2008). Emergent songs by social robots. Journal of Experimental & Theoretical Artificial Intelligence, 20(4), 319–334. https://doi.org/10.1080/09528130701664640

Moto Waganari – artist. (n.d.). Retrieved November 4, 2023, from https://motowaganari.wordpress.com/

Nature on Mont royal (2023), https://www.lemontroyal.qc.ca/en/nature-on-mount-royal

Montreals rivers (2009), Spacing.ca https://spacing.ca/montreal/2009/10/29/montreals-rivers/

Payeur, C. (2019, August 22). RF-Lucent vs. RF-Opaque: Component Materials in RFID Systems. Computype. https://www.computype.com/blog/the-importance-of-component-materials-when-constructing-rfid-systems/

Smart Lock for an Escape Room: Multi RFID Readers System. (2018, April 23). https://www.youtube.com/watch?v=ahc8Yai_sWI

SPI - Arduino Reference. (n.d.). Retrieved December 3, 2023, from https://www.arduino.cc/reference/en/language/functions/communication/spi/

Tangible, & Wu, J. (2011). jelly swarm.