Isaiah’s Portfolio

Clasp

Encouraging togetherness

While the internet connects us on a level unparalleled throughout history, we can become overly reliant on these digital connections.

A 2018 Pew Research Center study highlighted this, finding that while 45% of teens spend time with their friends “almost daily,” only 24% do so in-person. A 2019 study published by *Child Development* correlates this with rising trends in loneliness and social media usage.

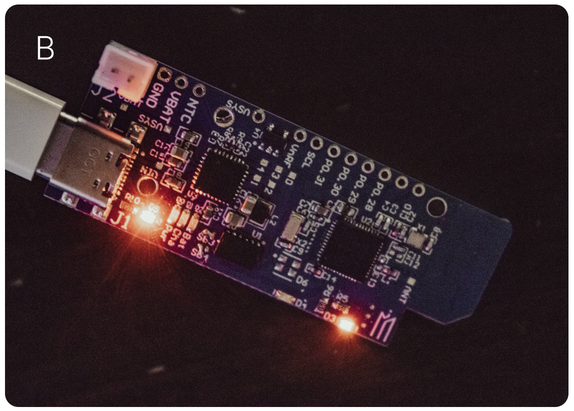
The CLASP (Connection Logging and Social Proximity) device is an attempt to solve this problem of loneliness. Originally designed as a gift for my friends before we head off to college, it encourages users to gather in person by detecting and logging proximity events. When multiple CLASPs are together, users receive rewards and encouragement.

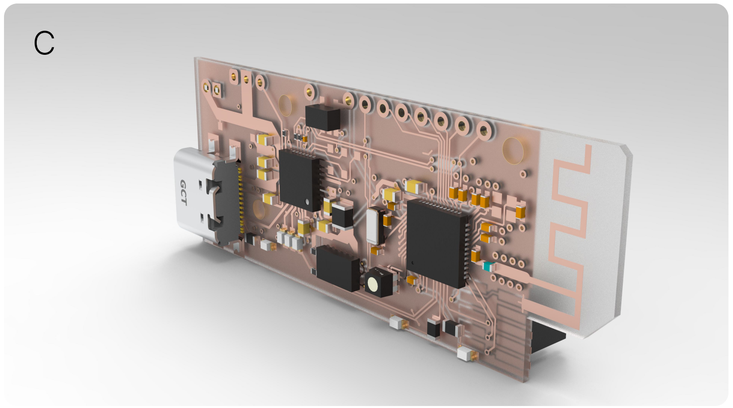
The device’s minimalist design uses two ultra-low-power Nordic chips, the nPM1300 and nRF52382. The 2.4 Ghz RF band is used to advertise its UID, establish connections with the user’s phone, and form mesh connections with nearby CLASPs.

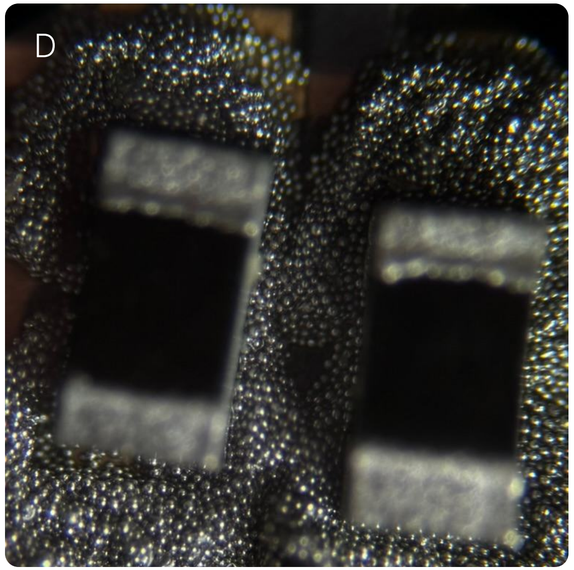
The low power design includes a thermoelectric generator which enables configurations powered by harvested body heat from the user, albeit with reduced detection range and capabilities.

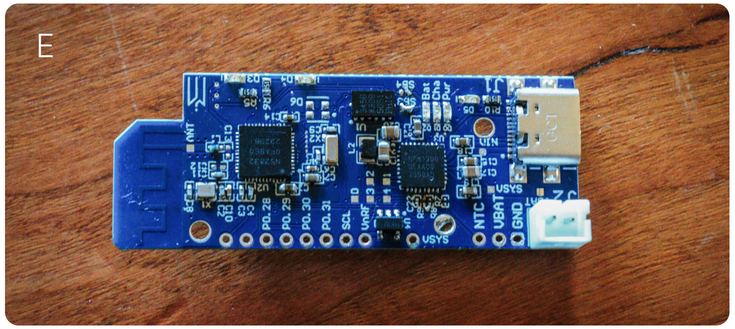
All of this fits in a 1.5×4 cm package, the same size as a stick of gum.

The board design and construction was produced with Altium and PCBWay. The housing consists of machined aluminum, supported by the Artisan’s Asylum or Xometry, and the covers are ceramic plates that can be slip-casted from plaster molds.









A: Showcase of enclosure variants
B: Fabricated PCB (Printed Circuit Board)
C: PCB board showcase
D: Imaging of SCL & SDA resistors
E: Final PCB view

Code Cruiser

Coding without screens

In today's digital era, it is crucial to equip children with essential coding and logic skills. Parents often hand kids a tablet or computer with an educational coding program.

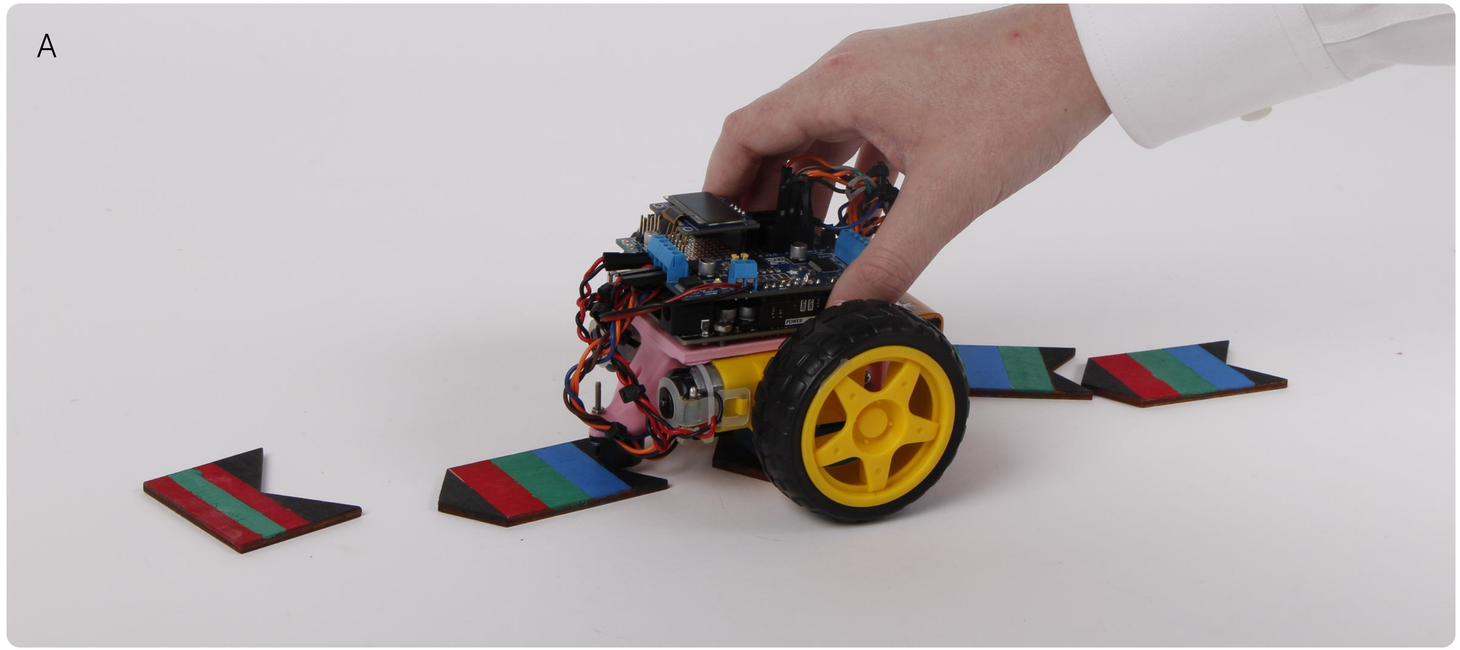
Nice in theory, but often the result is not learning logic and problem-solving skills, but instead wasted hours on a screen. Jumping straight into digital code is often too large and too overwhelming for many young minds, who explore the tablet instead of learning to code.

Piaget's theory of development supports this: direct manipulation of an object supports the development of thought, particularly for young children.

The Code Cruiser project is an educational toy designed to teach children valuable coding and logic skills, with a completely screens-off approach.

I was responsible for the physical design, fabrication, and programming of a robotic car. The car was equipped with a variety of sensors allowing it to be programmed by color sequences painted upon pieces of “track”. Users combine a variety of pieces, similar to Scratch code blocks, into a track. The Code Cruiser then drives along the track, uses computer vision to upload the program into its memory, and then executes the program on a game board.

A



B

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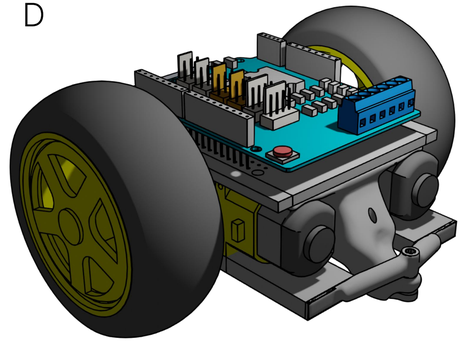


A: Showcase of Code Cruiser
B: Early mockup of track pieces
C: Early prototype of track pieces
D: Early Code Cruiser chassis render

PCB Business Card

Interactive business card

The PCB Business Card is an interactive business card built to showcase PCB design techniques. In particular, the project prioritizes working with low cost, low profile, and low power components. This provided a fun path to learning and growing skills in the realm of embedded circuits.

My goal was to create a number of inexpensive and easy-to-make business cards that wowed recipients with an interactive experience. This included an NFC circuit that would open my portfolio site when tapped, as well as a sand simulation displayed within an 8×8 LED matrix.

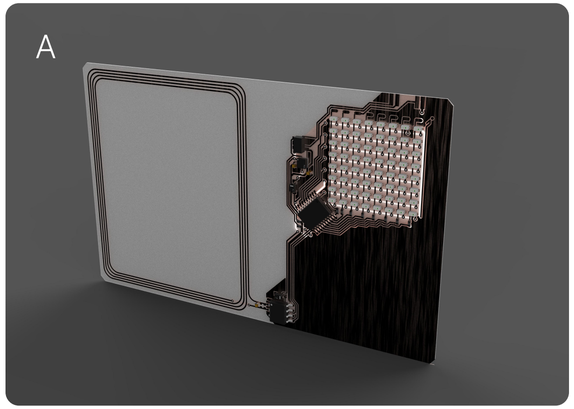
The card uses an open-source RISC-V microcontroller (the CH32V003F4P6 chip), along with three modules: an NFC chip, an LED matrix, and an IMU.

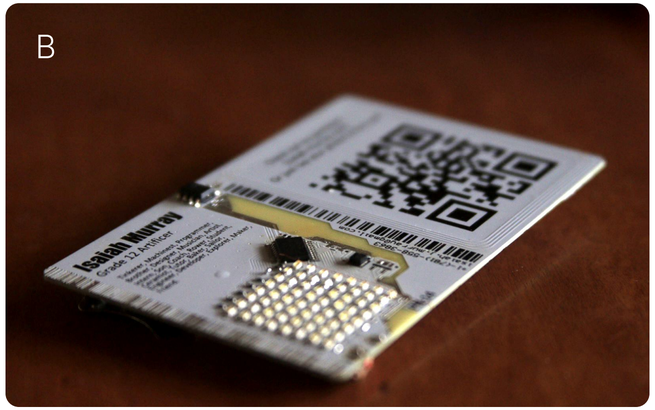
The NFC module opens a website when read by a nearby phone. This occurs by encoding and transmitting the URL for the site via NFC standards. The NFC circuit works passively even if the battery is empty or not installed, enabling rudimentary interactivity at all times. I am using the LSM6DSV16XTR NFC component to accomplish this.

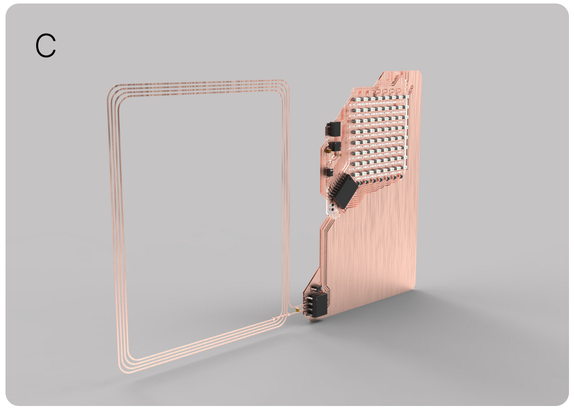
The LED matrix is the primary display module for the card, and was planned to be built using 0201 footprint standard LEDs. The matrix is an 8×8 array of 64 0603 footprint low-current LEDs, in a common cathode matrix.

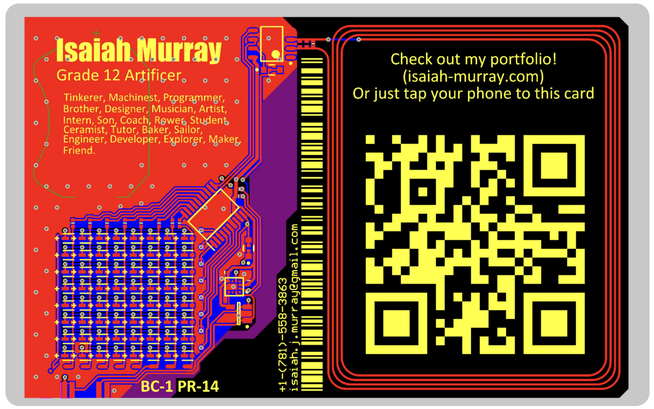
The IMU was the hardest component to source for this project. I researched a number of potential solutions from gyroscopes to tilt sensors to accelerometers, and even considered fully integrated IMUs. Refining the exact parameters required to gauge gravity orientation, I selected the Bosch Sensortech BMA400, a low-cost XYZ accelerometer.

If you meet me, ask for my card!









D

A: Render of the final PCB
B: Perspective view of the completed card
C: Render of the final PCB
D: The card's footprint
E: Top-Down view of the completed card

BRAGI

Spatial computing language learning

BRAGI - Bilingual Reality Augmentation for Global Immersion - an AR/VR application that simulates immersive language education within the scope of a vocabulary memorization system. BRAGI runs on the Meta Quest 3 and Apple Vision Pro augmented reality platforms.

Inspired by Duolingo's learning units, the BRAGI application aims to improve word retention via a novel approach to language education.

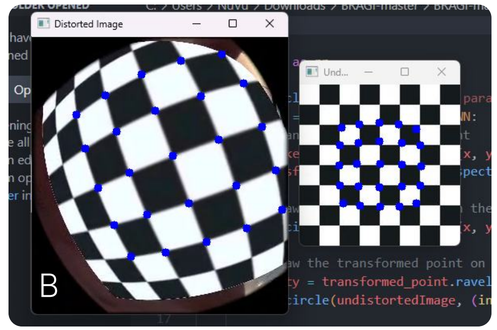
When the BRAGI software runs on a headset it automatically identifies and annotates selected objects in the scene with foreign language flashcards and quizzes. User vocabulary skills improve as they passively navigate the world.

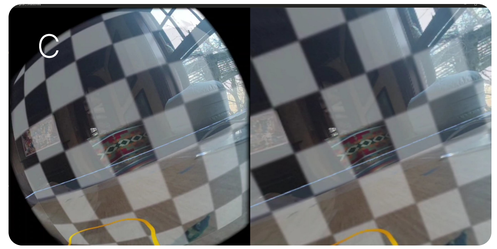
There were a number of significant challenges to implement this project, including:

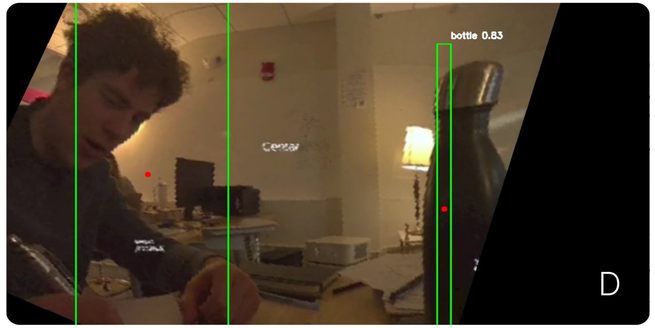
- **Jailbreaking camera output** | Both the Meta Quest 3 and Apple Vision Pro have heavily locked down camera feeds virtually inaccessible to applications. Many heroics, including ADB tools, were required to gain access to the raw camera feed and data.

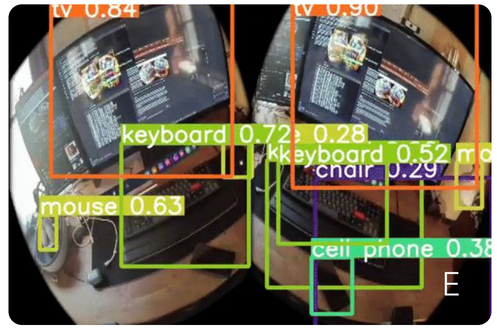
- **Native YOLO model execution** | A custom object recognition model was trained through Python on a desktop computer. Extensive pruning and performance tuning was required to run smoothly on headsets.

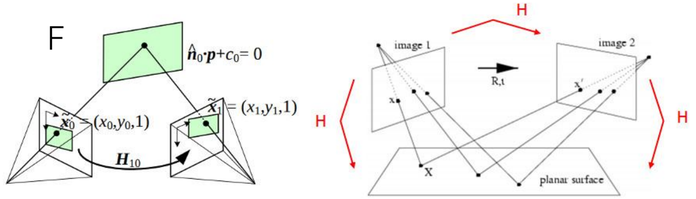
- **Object remapping** | The flashcards needed to be the same distance from the user as the viewed object, enabled by combining eye tracking, lidar, and photogrammetry (requiring a crash course in linear algebra).











A: User perspective
B: Camera mapping calibration network
C: Camera mapping calibration image
D: Object detection pre-affine
E: Object detection after remapped
F: Object mapping algorithm

Pysankyбот

Automating egg decorating

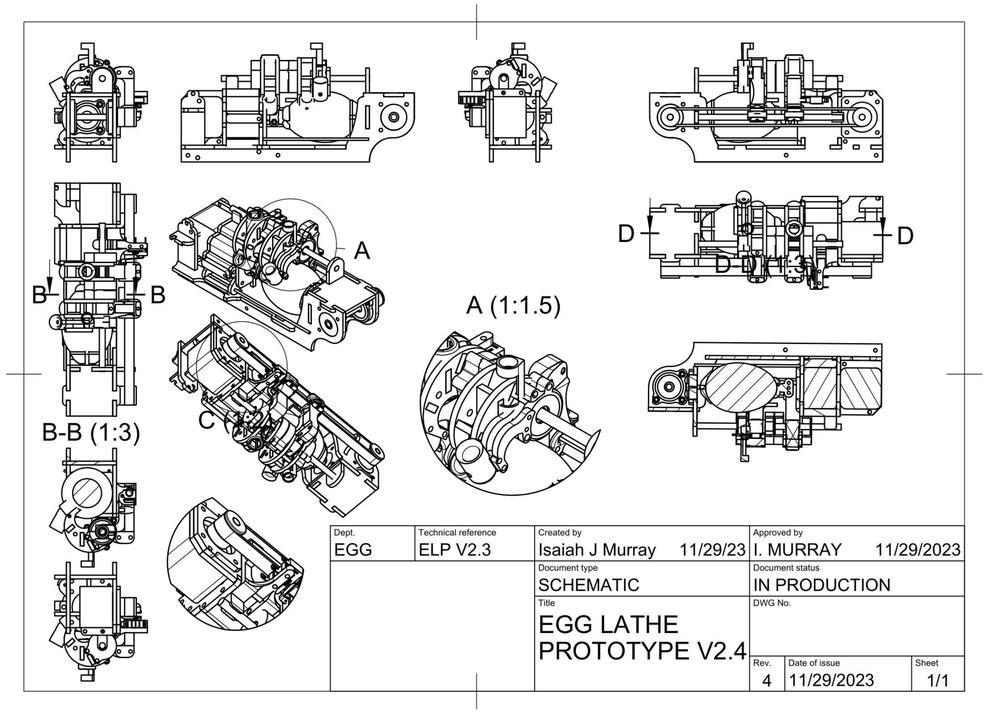
Originally started as a party trick at one of my family gatherings, Pysankyбот, also known as Egg Lathe, automates traditional Ukrainian egg dying techniques.

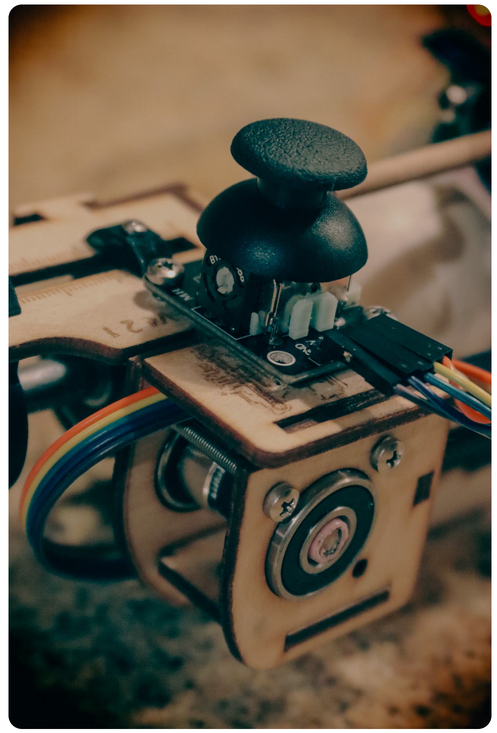
This project investigates the artistic side of engineering, combining the software and methods of an automated lathe with precision manufactured components to accurately deposit pigments and wax on the surface of an egg in accordance to input paths.

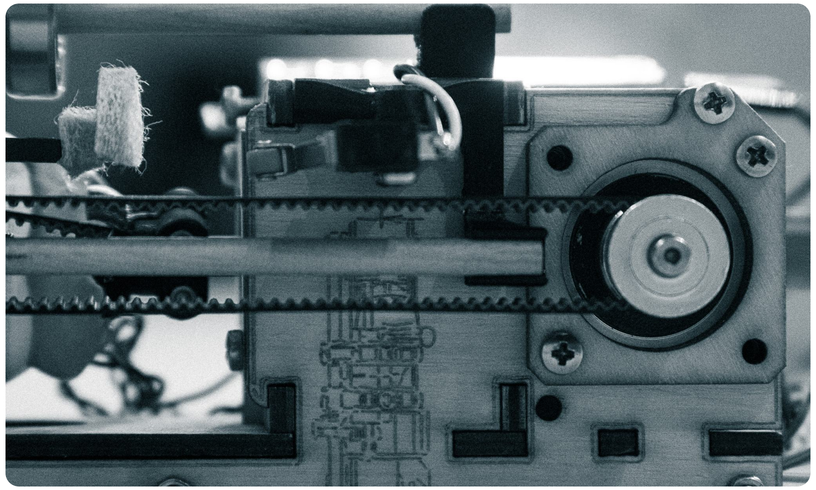
I thought this would be quick and easy, and designed a simple prototype. Unsurprisingly, even simple tasks were incredibly complex. It required three massive rebuilds to move from version zero to a functional prototype.

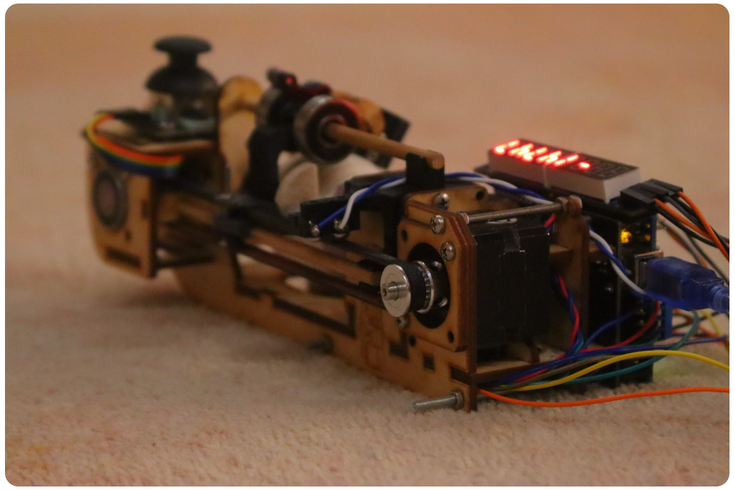
I used a series of timing belts and compliant mechanisms to obtain a strong frame, added a process delay to allow part stabilization, and attained 5×1 mils precision for egg marking.

This project is a testament to the beauty, frustration, and complexity that is uncovered when diving into a solution for a seemingly simple problem.









Thermal Resonator Phase Control Material Efficiency Refinement

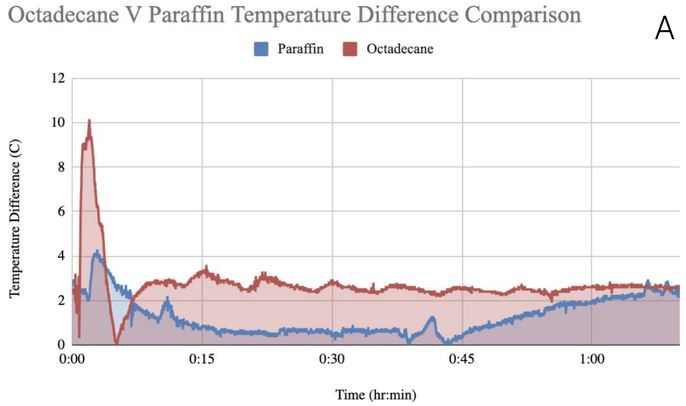
MIT HIP-SAT lab research

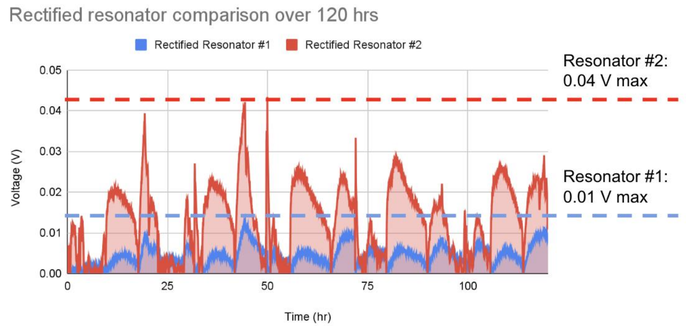
This research project focused on the design of thermal resonators, devices that generate electricity from entropy as a member of Professor Strano's Research Group at MIT, during my HIP-SAT internship.

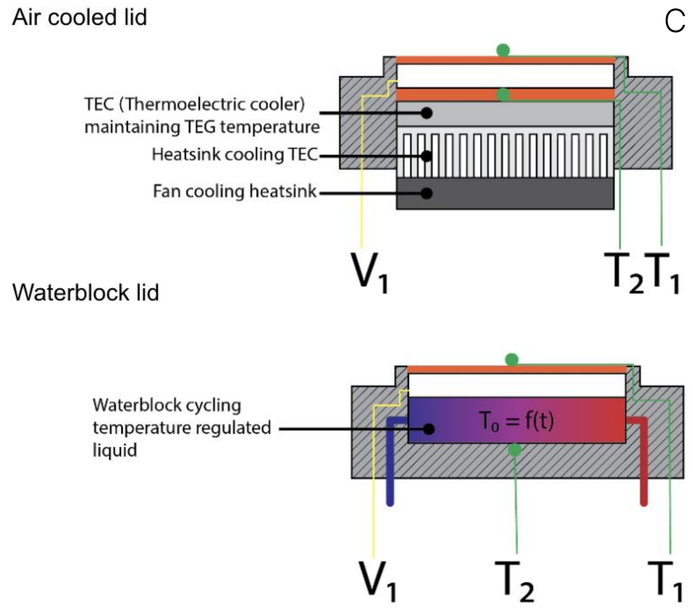
More details at: Ultra-high thermal effusivity materials for resonant ambient thermal energy harvesting

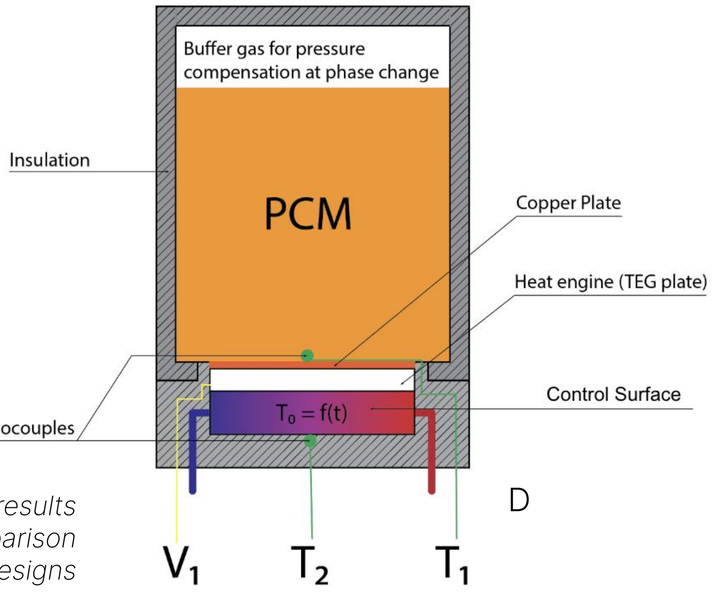
I studied and refined the Phase Change Material (PCM) composition of thermal resonators. I also constructed a test setup to systematically record the electrical potential of the device.

The test setup comprised a vacuum insulated containment canister sealed with a thermally controlled lid equipped with a thermocouple sensor shroud. A controllable heating and cooling loop was used to simulate entropy in the test environment while a high-precision voltage reader recorded the electrical spikes from a thermoelectric generator plate sandwiched between the thermal control surface and the PCM. The thermal control surface's temperature was oscillated in accordance to weather data from a desert and the integral of the output voltage was averaged over time. This process was performed multiple times for each PCM and averaged out to obtain a final, single-dimensional, result quantifying the performance of each PCM. This resulted in discovering octadecane's superiority against paraffin as a phase change material.









A: Temperature gradient results
B: Rectified voltage comparison
C: Test setup proposed designs
D: Test setup canister assembly

Pinhole Cameras

Physics and photography

In this captivating project, I embarked on a creative journey that seamlessly blended the realms of art and physics. Our project team set out to construct a series of pinhole cameras, diving headfirst into the world of analog photography.

This project allowed us to bridge the gap between art and science, showcasing how they intertwine to create a captivating and educational experience. Through pinhole photography, we discovered the beauty in simplicity, the magic of light, and the endless possibilities for artistic expression.

My contributions

Pinhole Camera Expertise: I led the construction and refinement of various pinhole cameras, optimizing image detail through design experimentation.

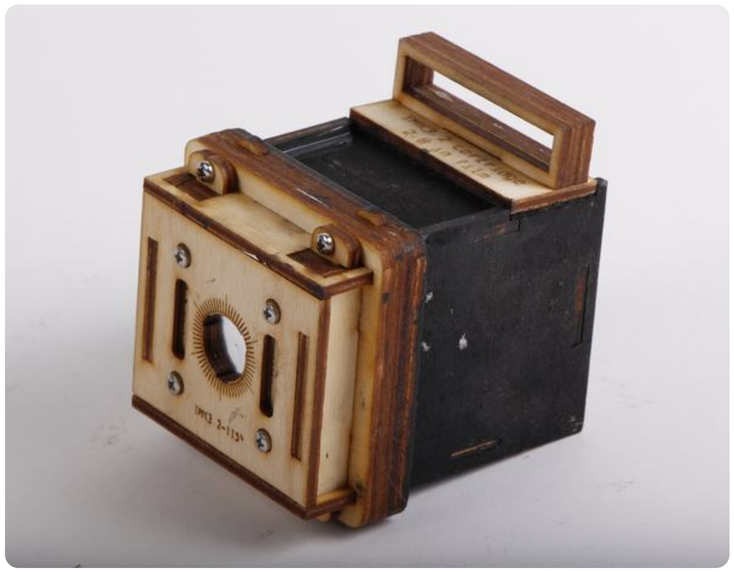
Independent Physics Study: I explored the physics of light and film paper independently, enhancing my understanding of their role in pinhole photography.

Photo Development Skills: I acquired and applied photo development skills in our darkroom, from exposure to final prints.

Darkroom Setup: I played a crucial role in establishing our darkroom, ensuring it met the necessary standards for photo development.

Throughout this project, many pinhole cameras were designed and fabricated. Alongside my fellow students, we captured a number of images on photographic film, which we then developed and presented.

This project had the interesting aspect of merging engineering with art, noting the artistic and elegant aspects of both the photos taken and the camera itself.



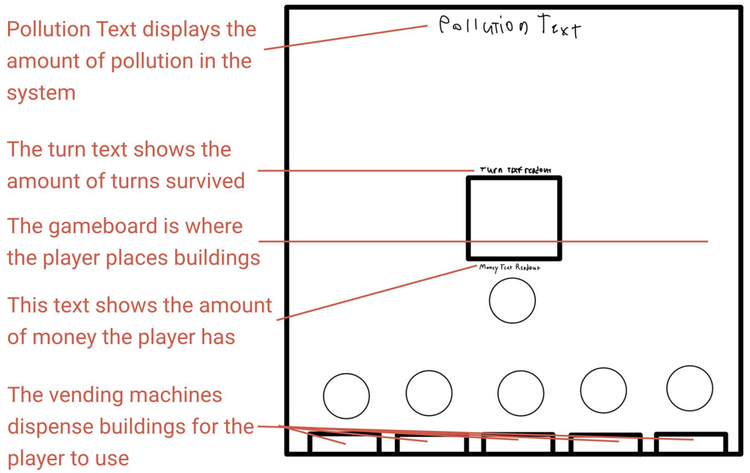
Sustainable Survival

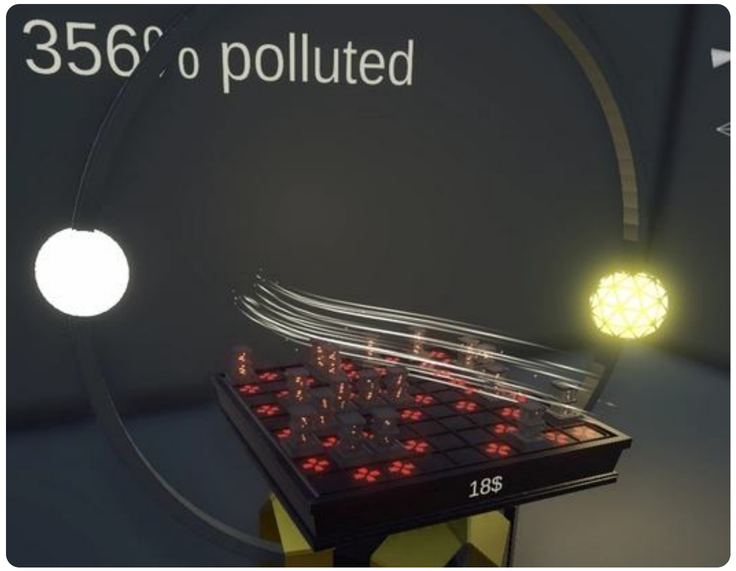
Powering pollution reduction

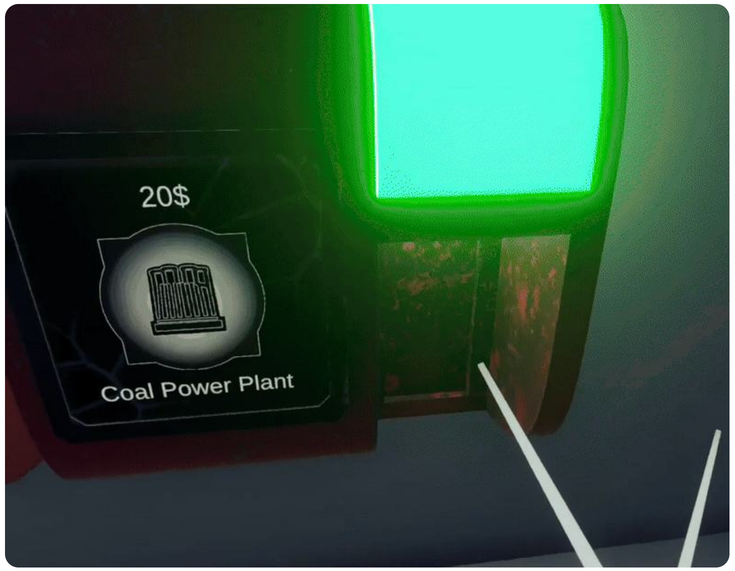
Sustainable Survival is a VR experience where the user simulates the planning and maintenance of a power grid while generating income and fending off pollution-based enemies.

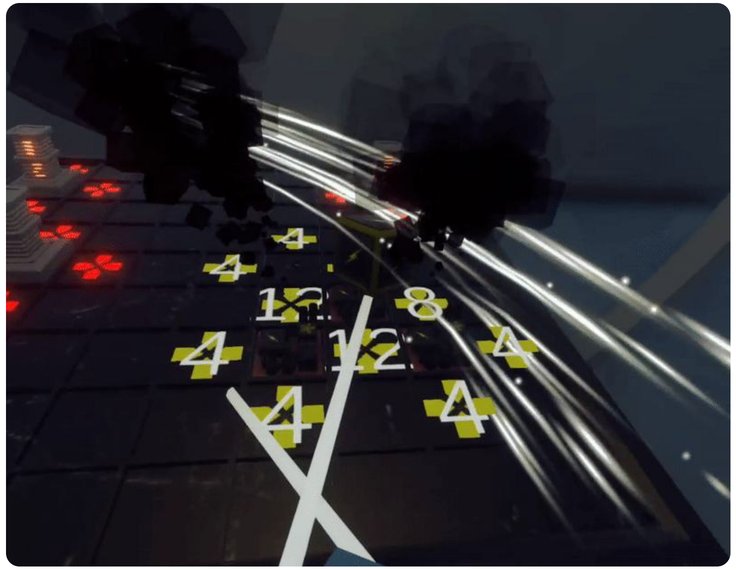
The game consists of a player purchasing buildings, which they can then place on a game board. The experience then simulates a turn-based system, where generators provide power to a variety of buildings which can either defend against enemies or generate income.

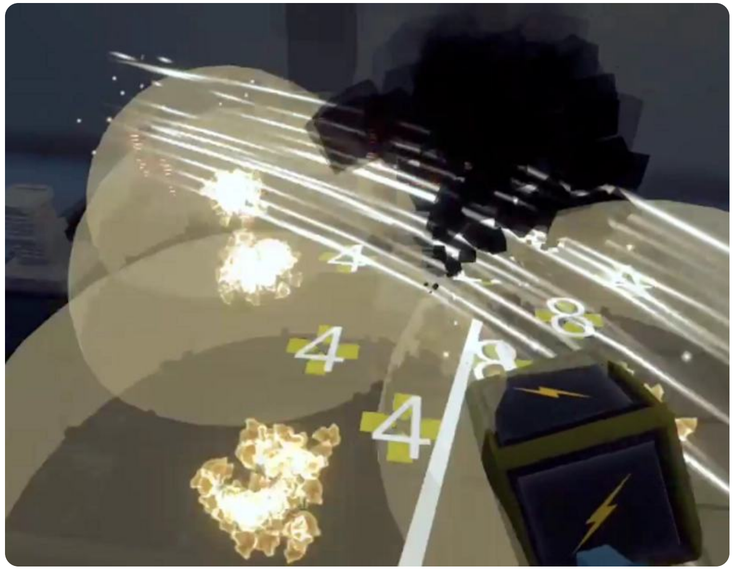
Game Room Layout











Vibes Button

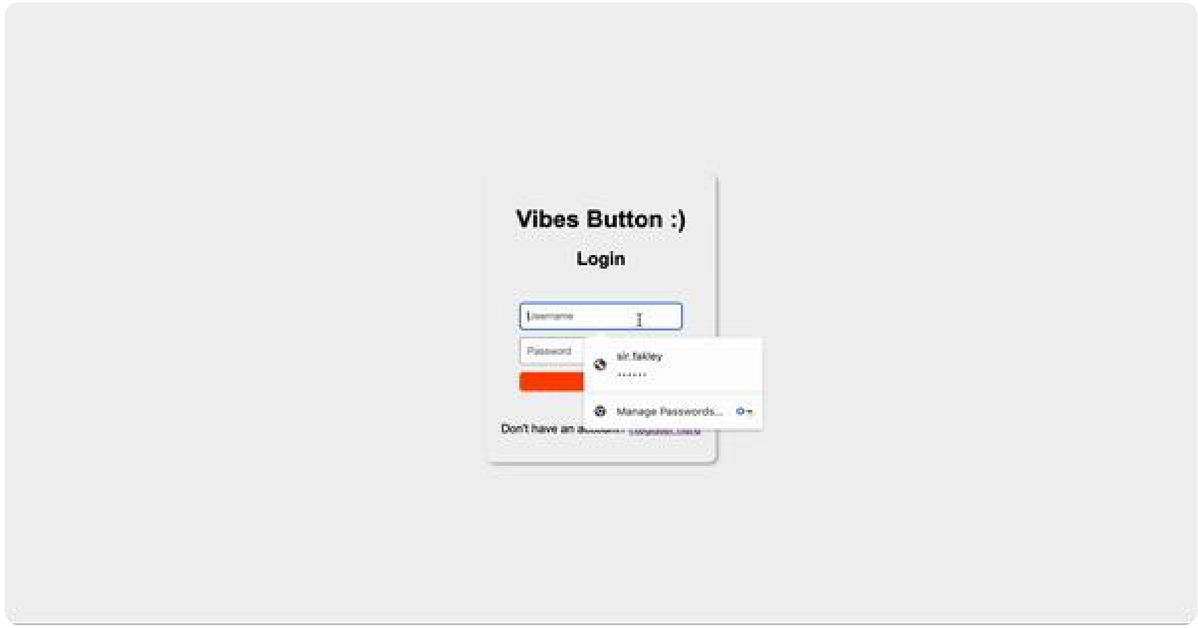
Injecting optimism through LLMs

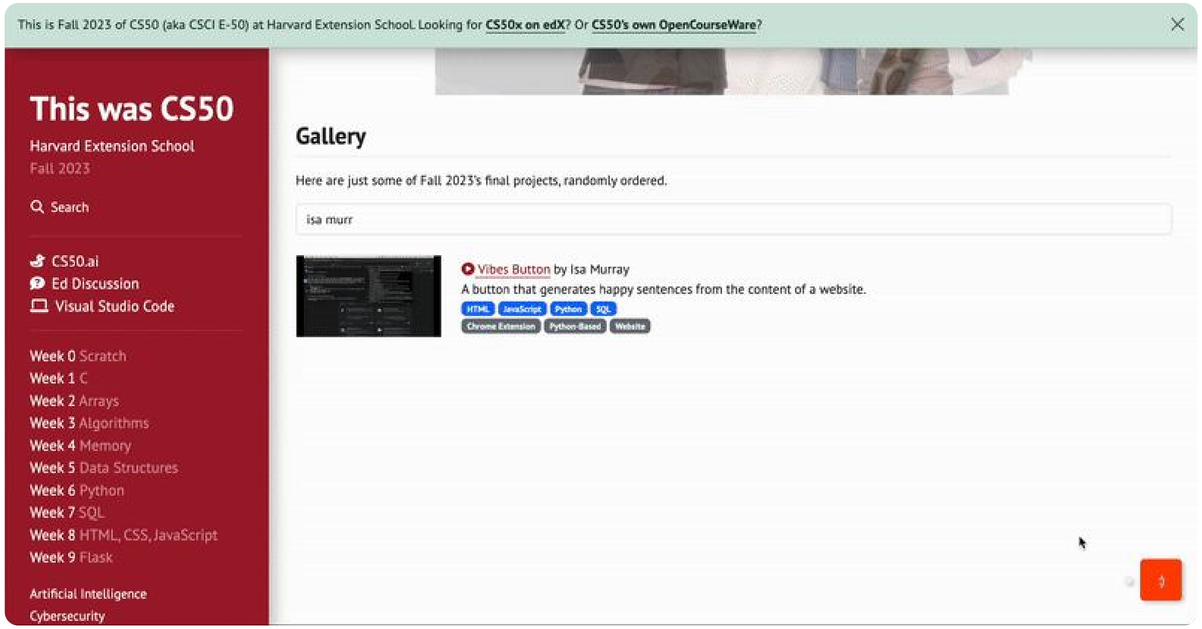
Vibes Button was my final project submitted for Harvard Extension School's CS50 course. The goal of this project was to develop a tool to inject optimism into the internet, where doom scrolling is so prevalent. The project consists of a chrome extension and a server-side website.

The extension works such that when users press the "Vibes" button, website content and URL information is scraped. This is fed into a tuned LLM which generates an optimistic saying based on the input. Concurrently, the chrome extension makes calls to the server-side website, logging responses and API usage, allowing the service to collect training data through ongoing usage.

An installation tutorial can be found here:
https://www.youtube.com/embed/1nJ2gvhv4Ag?autoplay=1&rel=0

The GitHub repository is available at:
https://github.com/LoveAsAConstruct/Vibes-Button





A fun vibe!

Showcasing new skills and talents, we welcome conversations around diversity and innovation. We explore the depth of potential we each possess, bringing us together to create a more diverse and unified world.

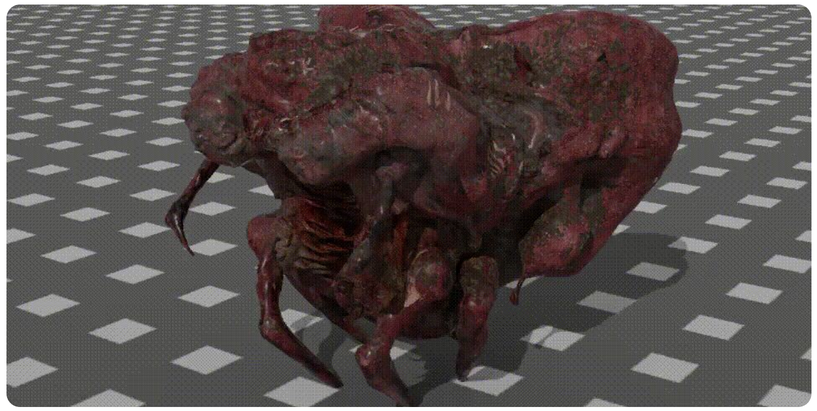
Vibes Button!

:)

Digital Artistry

“Make good art”

I have accrued deep experience creating digital art with programs such as Blender and Houdini. This is a selection of individual works created with these programs.



The Ascent

A tree climbing simulation

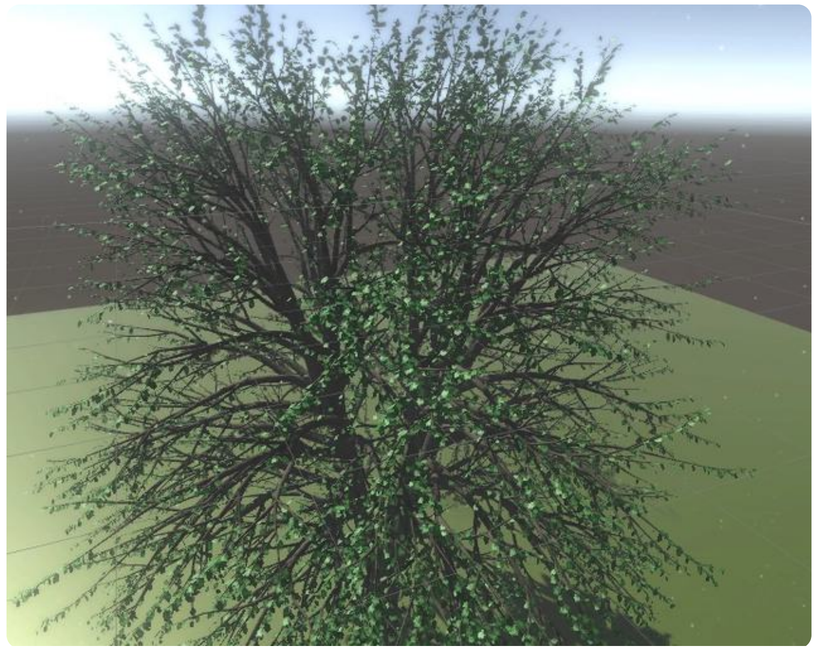
The Ascent is a virtual reality game simulating the experience of an arborist climbing a tree to in order to retrieve its seeds.

Players use naturally occurring handholds or manually placed adhesive climbing nails to propel themselves up the tree. Playing as an arborist, you must use these mechanics to collect seeds.

Virtual reality hand controllers are used to physically propel one's body. However, the player's hands have stamina that depletes if the grips are grasped with excessive or insufficient force. The stamina meter requires the player to regulate their grip force as do professional climbers.

The simulated tree is procedurally generated using a configured T-system with an expanded spline. To reduce processing power while providing realism, the bark texture is also procedurally generated prior to gameplay, and then baked into a low-resolution tileable material.

This project was partly inspired by my experiences at our NuVu student climbing club.



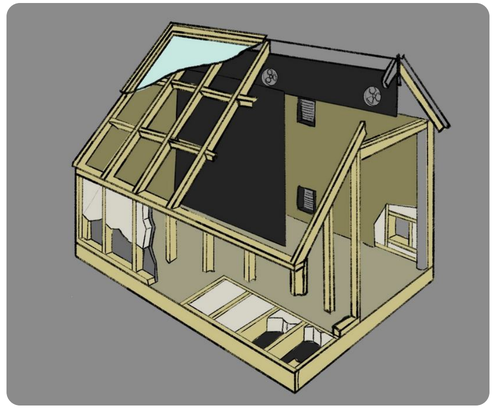
Kroka Collaboration

Sustainable survival mechanics

The Kroka Collaboration was a project focusing on the creation and design of installations for the Kroka Explorations organization, a wilderness survival school 100 miles north of NuVu. Installations included solar kilns to dry firewood, rocket stoves, and boat lifting systems.

Our team made a series of multi-day excursions to install our prototypes on the Kroka campus over the course of a three week period.

We installed a 7:1 pulley system that vastly increased the efficiency of their boat storage and lifting system, a rocket stove capable of boiling water on multiple burners, and reviewed schematics for a solar kiln capable of drying 24-cords of wood.



Revitalized Housing

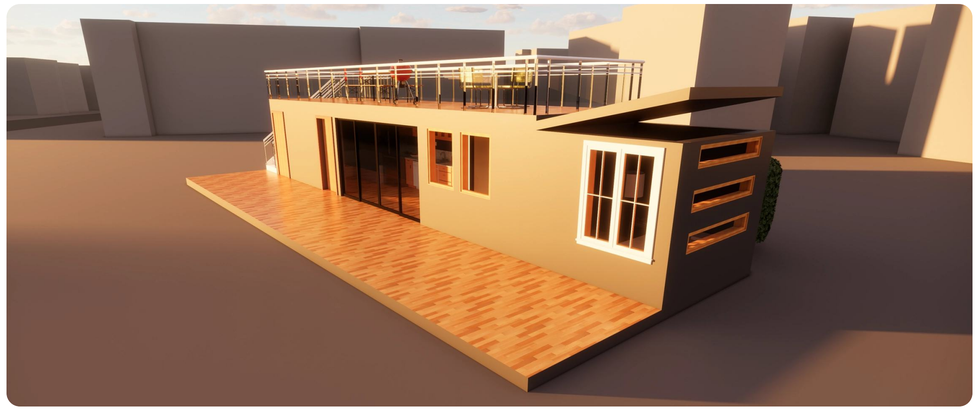
Housing for previously incarcerated

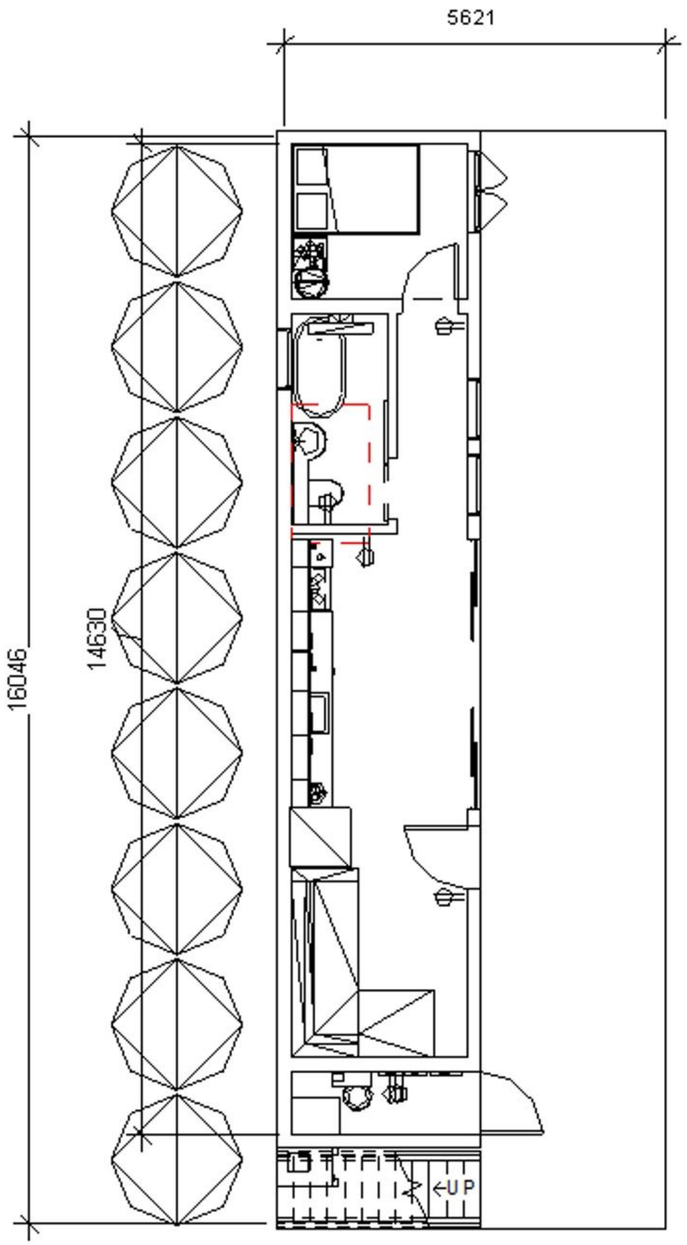
Tiny Houses is an architectural organization focused on the development of a site in Oakland, California, designed to be a community area to house and aid the previously incarcerated.

A major part of the design is tiny houses, mobile housing facilities that are designed to house previously incarcerated people while they work to get back on their feet.

The project uses architecture methods and the study of neuroarchitecture to design the environment to be comfortable and relaxing for its occupants. Elements such as natural light were used to create a dynamic environment while variable space maximized the storage and living space within an area.

Integrating nature is important for the people's mental well-being as well as keeping the space alive and comfortable.





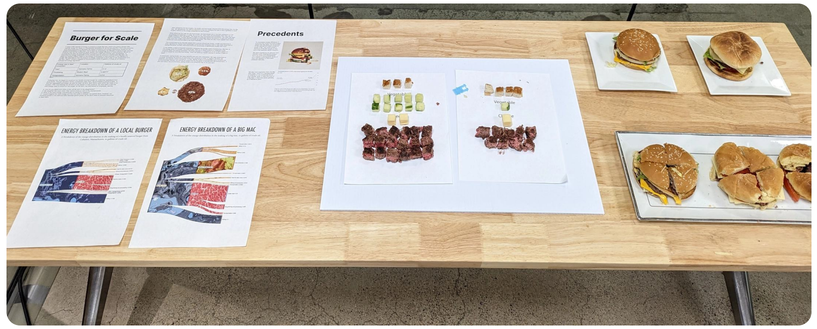
Burger for Scale

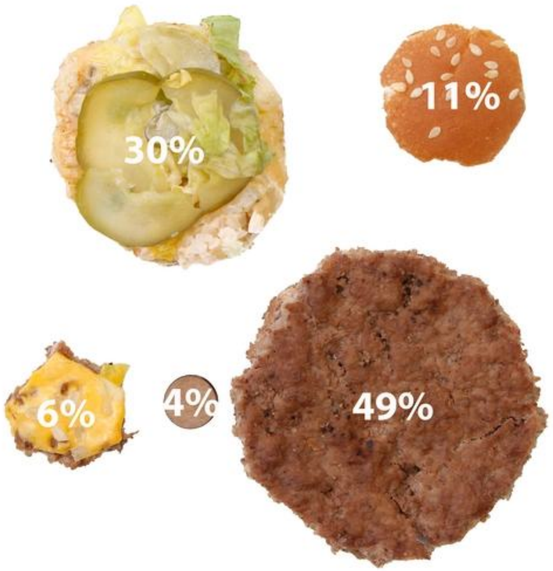
Visualizing a burger footprint

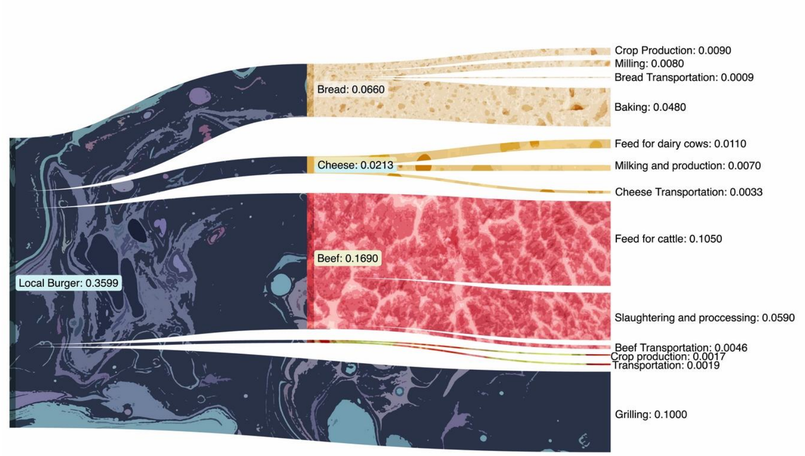
Do you know how much energy it takes to make a burger? Our project uses a McDonald's Big Mac to promote eating local foods in order to eat more healthily while helping the environment.

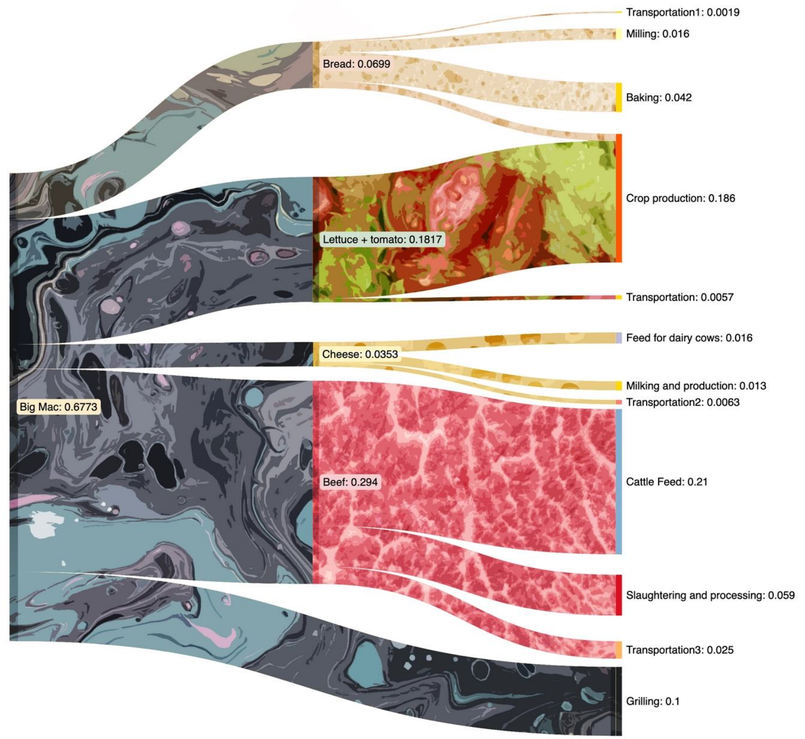
A Big Mac has an extreme energy deficit due to the processing of its meat, vegetables, and cheese. In contrast, local produce is more energy efficient as it uses fresh produce, is not shipped long distance, and allows for naturally grazed livestock.

This project is an installation consisting of a series of visualizations that raise awareness regarding the inefficiencies of commercially produced meat. We show that energy requirements for commercial cow management results in higher greenhouse gas emission and lower energy savings while reducing the nutritional value of the beef.









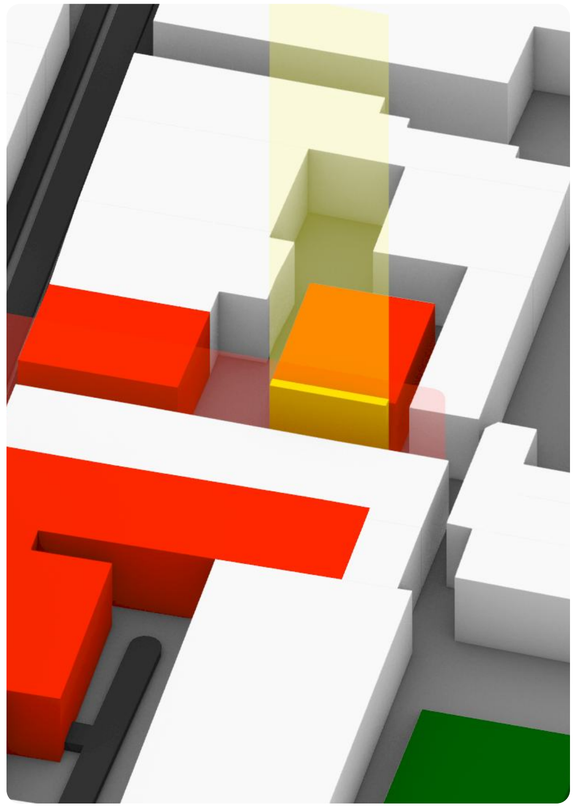
Fair Flair of Facades

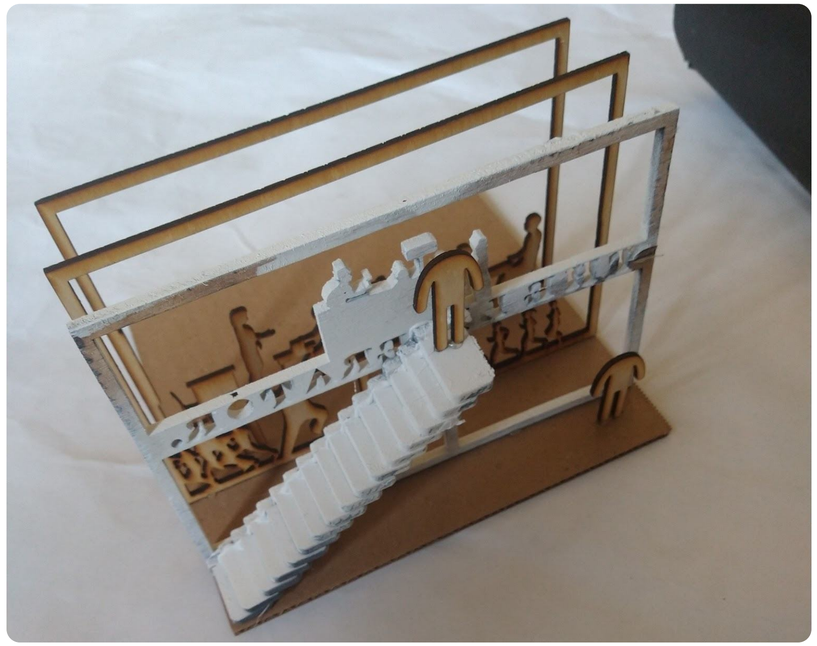
Black Heritage Trail installation

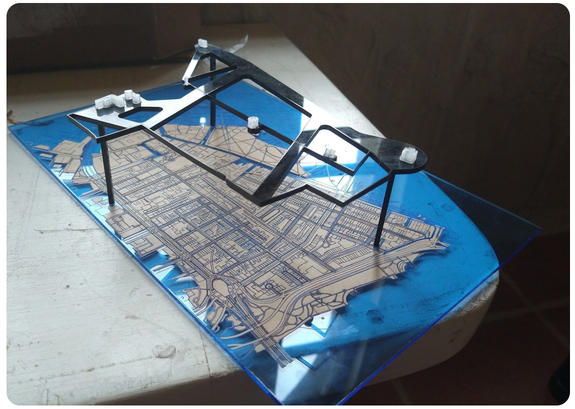
This project emphasizes the history of the Black Heritage Trail in the historic Beacon Hill neighborhood of Boston through interactive facade installations that protrude out of the front of the Museum of African American History illustrating the major events that occurred on the trail.

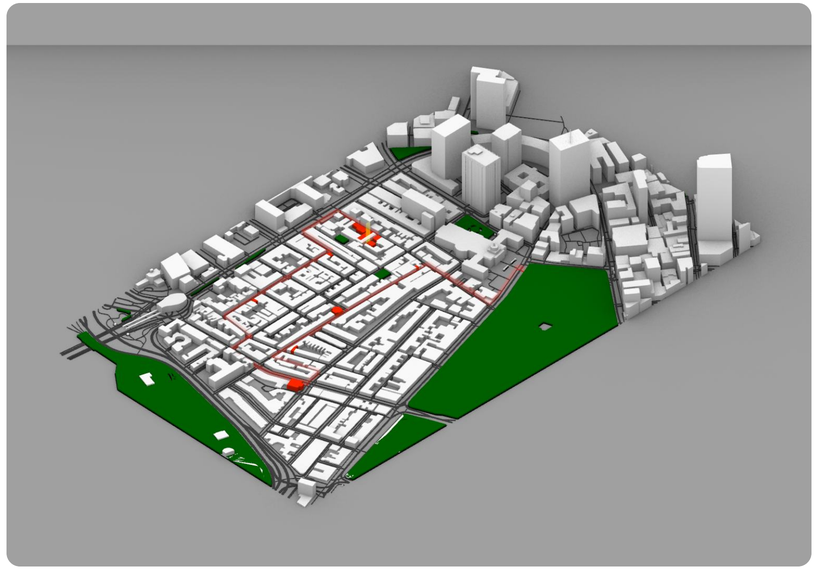
The facades draw attention to the historical layering within each facade of the site and help visitors engage in the visualization of the history.

The facades were inspired by Charles Gaines, a contemporary artist. Gaines studied at the Rochester Institute of Technology School of Art and Design, and now resides in Los Angeles. His works include photographs, mosaics, and most predominantly, numbers.









Boxed Memories

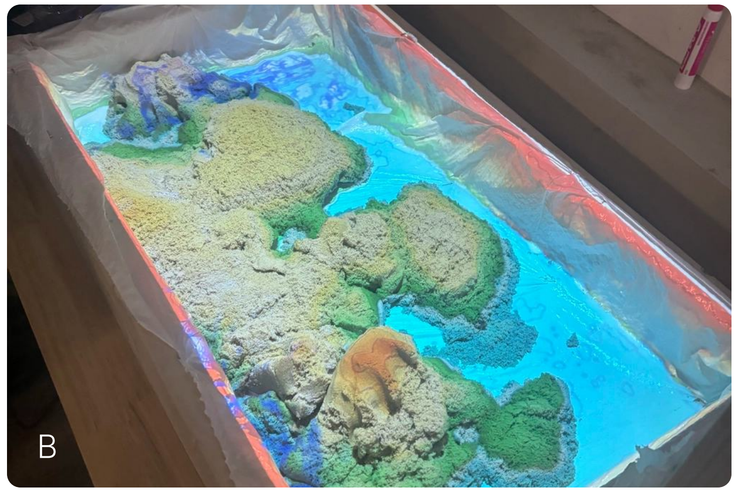
Escape from the sandbox!

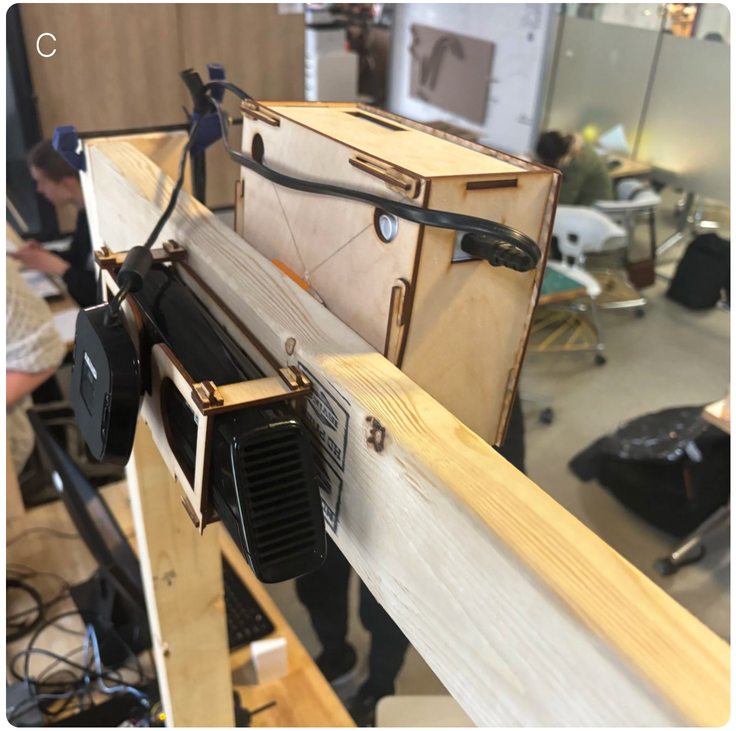
This project was developed by request for the Cambridge-based Red Fox Escape room business.

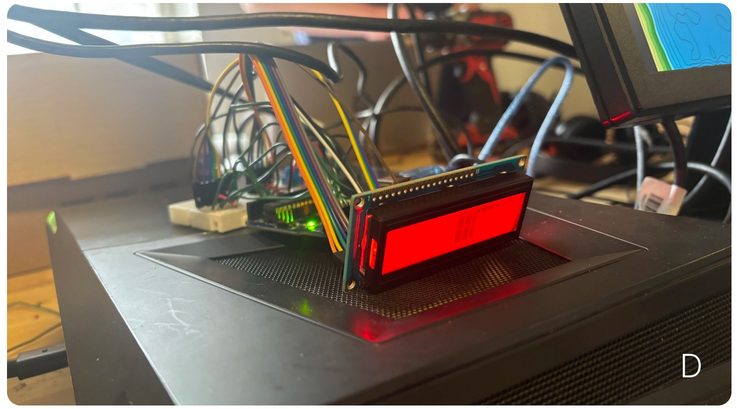
The client requested a puzzle involving a “magical” effect involving cartography. I developed Boxed Memories in response.

Inspired by open-source AR sandboxes, Boxed Memories is comprised of a projector and depth camera contained within a wooden frame at a distance from a sandbox. The sandbox may hold any non-reflective material. A nearby screen displays a combination for a lock once players solve the puzzle by mimicking the geography of a nearby map in the sandbox material.

The depth camera is a Kinect 360, using scattered infrared dots to estimate the depth of a scene. This depthmap is processed through a mapping function calibrated to the layout of the sandbox. The processed depthmap, now a heightmap, is run through a color ramp, and converted into a multi-color geographical map. Final post-processing adds water simulation, and simulates rainfall when players hold their hands over the box.







A: Sandbox in-use
B: Sandbox in-use
C: Mounted projector and Kinect 360
D: LCD responsible for final combination display