Revolve.

Physical Computing Gizmo (2024-25)

Group 38 - Devansh Goel & Lara Merican

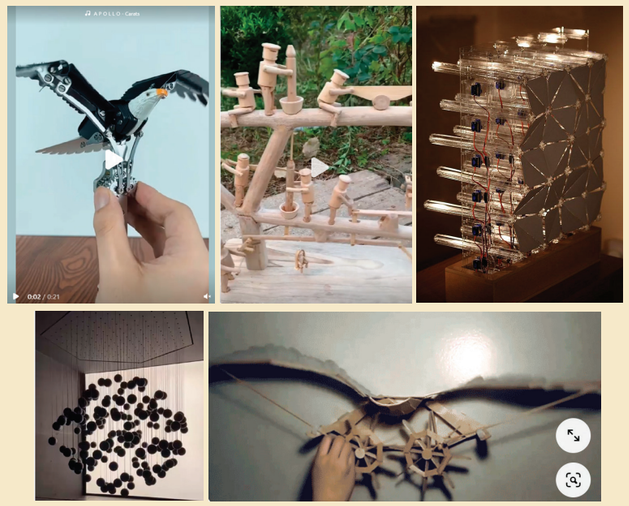
Brief and Introduction

After moving into a new house, there are many items that would typically be discarded from cardboard packaging boxes to old, unwanted kitchen utensils. With this project, we aimed to explore the hidden beauty and value in these unwanted items to fully embrace the common saying, “one man’s trash is another man’s treasure”. Ultimately, our goal is to not only make an interactive structure, but also to create a piece of art which hopefully raises awareness of sustainability and resourcefulness. By re-purposing these unwanted items, we hope to inspire a way to reimagine waste, which aligns with this year’s theme of “Upcycled Gizmo”.

“The UK generates approximately 2.5 million tonnes of packaging waste annually, with only around 44% being recycled”

Simply adding plants to the office can increase well-being by 47%, creativity by 45%, and workplace productivity by “38%.”

Exploring possibilities of ‘upcycling’



Exploring ‘physical mechanisms’

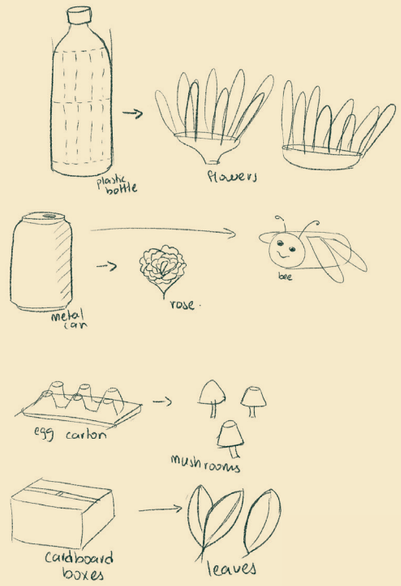
Initial Ideation

We began by ideating movement mechanisms for all components, considering options like rail-and-pinion systems, pulley systems, etc. to achieve dynamic, lifelike interactions. We also explored various user-interaction sensors, from infrared to trill, to facilitate interactive engagement. During this phase, we focused on transforming discarded materials into an installation that was both functional and symbolic. By integrating upcycled materials with technology, we aimed to create a cohesive narrative about the hidden potential of waste, blending artistic expression with sustainability-driven engineering.

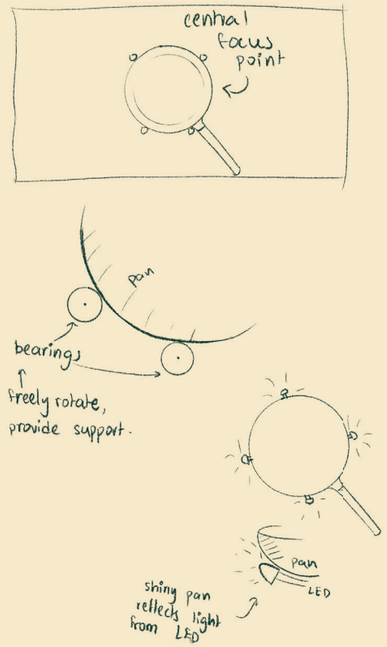
How Might We Question:

HMW design an interactive system using upcycled materials that inspires users to rethink their relationship with waste and recycling while remaining visually appealing?

Ideated the working principle and physical forms of different mechanical components made from upcycled material which rotate and move on a surface, following the motion of a hand that waves in front of the surface.



Looked at different upcycled products related to nature made from household waste items. Grouped together different items to create themes.

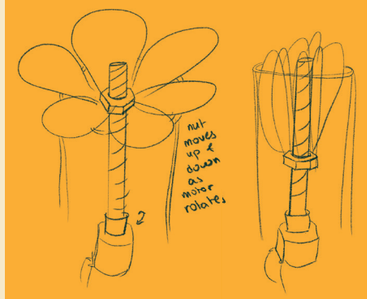


A large item we had was a pan which could no longer be used. We wanted to make this the central focal point of the installation, almost resembling a sun.
We explored possibilities of the pan rotating. However the pan would need to be supported by a large and powerful motor which is expensive (going against the theme of recycling) and needs high amount of power.

Components and Mechanisms

1. Flowers:
The flowers, made from recycled plastic bottles, bloom and unbloom using a string-pulley system. Strings connected to the petals are pulled using a DC motor to close the flower, and released to open it.

Mechanism 1: Rotating nut and bolt



Rotating the bolt gradually spreads the petals apart, mimicking the blooming action

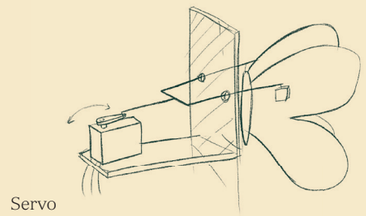
Mechanism 2: String and pulley system

A string and pulley system can control the petal movements by pulling the strings attached to the petals

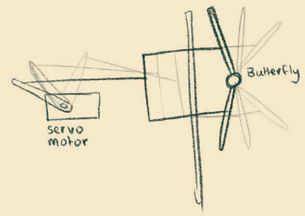
This system was chosen as it is easily scalable, flexible in arrangement and easy to maintain

2. Owl:
The owl is made of recycled containers and moves its head and hoots as you pet it. A servo motor controls the movement of the owl's head. Copper tape placed around the body of the owl detects touch. A wire attached the copper tape behind the body connects it to the trill sensor.

3. Butterflies:
Butterflies made of cardboard flap as the user interacts with the board. This system uses a push-pull actuation mechanism. A servo motor is used which rotates 180*. An aluminium wire goes through a hole in the board and connects the servo to the butterfly's wings. The semi-circular motion of the servo is converted to translational motion which causes the wings to flap.



Butterfly



4. LEDs:
The LEDs, placed across the board, change colours as the temperature changes. From blue at room temperature, it changes to red when body heat is transmitted to the temperature sensor.

5. Bowls:
The pasta bowls at the bottom of the board are used as sound-tiles to create a more engaging interaction for users. The pasta bowls have a circumference of copper tape which relays the touch sensing to the Trill.

The board is excess material that came as part of packaging for a table.

The leaves are made from thin cardboard boxes such as e-commerce deliveries, cereal boxes etc.

The stands are made from off-cut wood pieces from other people's projects

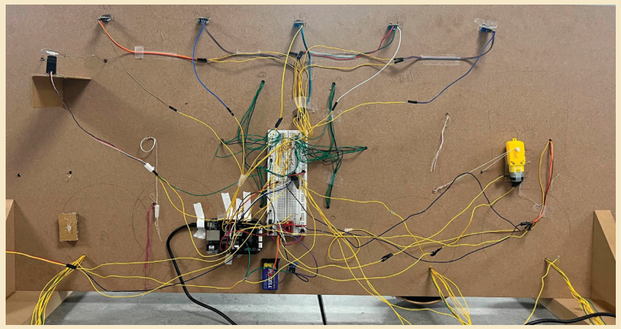
Electronics and Workflow

Bela, a real-time embedded platform designed for low-latency audio processing and interactive applications, is used to control the interaction and actuation system.

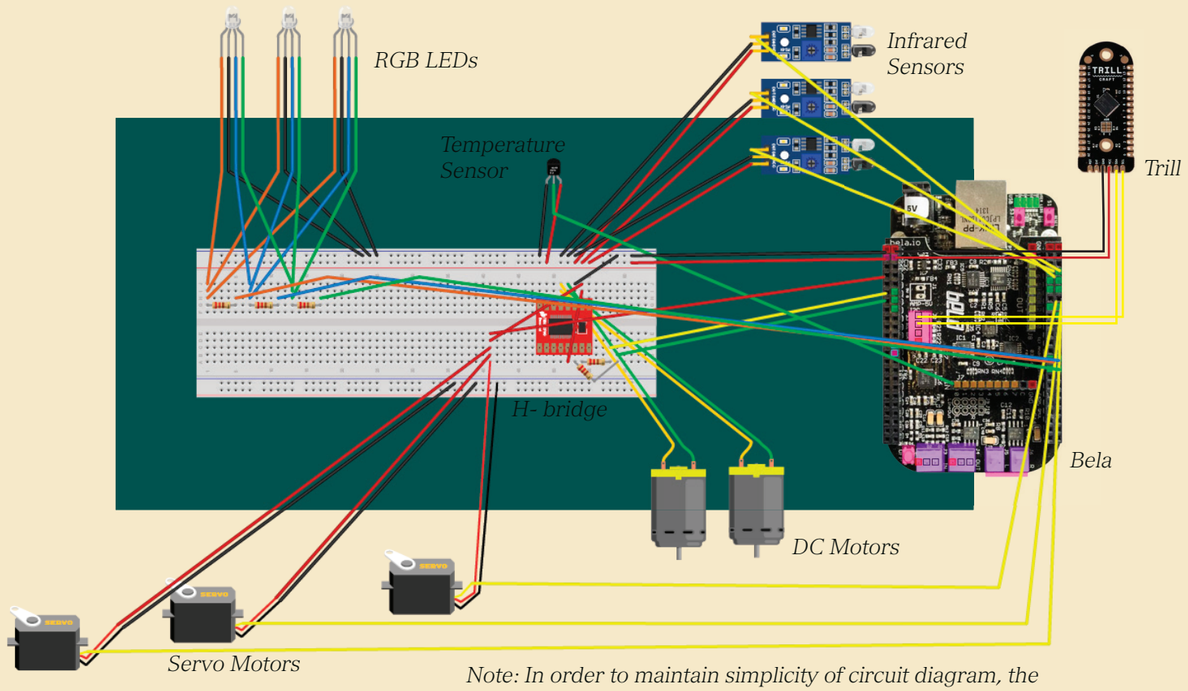
Sensors*: Infrared Sensors, Temperature Sensor, Trill.*
Actuators*: RGB LEDs, DC Motors, Servo Motors, Speaker*
Trill Sensor offers high resolution touch sensing and has scope for large surfaces.
Infrared sensors efficiently detect hand movements and are compact, non-intrusive.
RGB LEDs allow for dynamic colour changes and aesthetic flexibility.
DC motors are used where rotational motion is required and Servo motors are used where precise movement in terms of angles is preferred.

The components are connected using jumper wires and a breadboard. The infrared and temperature sensors, along with the Trill sensor, share a common GND and 3.3V power source. The RGB LEDs have a common cathode, and their R, G, and B pins are connected to digital pins via 220-ohm resistors.

Servo motors and the H-bridge motor driver require 5V to operate. To avoid voltage overload when all components are connected, the servo motors are powered by the Bela 5V, while the H-bridge is powered by a 9V battery.



The connections were made neat to help easily spot wiring mistakes, when required



Note: In order to maintain simplicity of circuit diagram, the quantities of some components were reduced in this representation.

The script for Bela for this project was written in Arduino-style C++ coding language. The Trill library was utilized to enable touch sensing using the Trill sensor and copper tape. When the tape is touched, the pitch of a certain trill pin crosses the threshold value. Puredata was used to load and play sounds. The code attempts to use as few delay statements as possible, and instead replacing them with millis(), which measures the time instead of holding off the entire code for a certain amount of time.

Flow Diagram

While this feature was not implemented in the initial prototype due to time and resource constraints, it remains a viable future addition.

User approaches the wall
(*Ultrasonic sensor* detects when something is within 2m)
→ The wall lights up slowly
(RGB LEDs slowly increase intensity using duty cycle of PWM signal)

User holds the temperature sensor to provide body heat or brings a hot item near it
(Temperature sensor measures temperature and returns analog
→ The lights on the board change colour from blue to yellow-green to red
(Using PWM signals from the digital pins, the intensity of the red, green and blue pins of the LED is controlled)

User pets the owl's body
(Copper tape connected to a Trill sensor detects touch)
→ The owl hoots and rotates its head side-to-side
(Owl hooting sound is loaded and played using Puredata. A servo motor rotates the head of the owl using PWM signals with the duty-cycle controlling the angle)

User waves hands in front of the board
(Many infrared sensors placed in a row detect the direction of motion of the hand by checking which sensor was activated after the first)

- Moves hands from left to right → Flowers un-bloom
(A DC Motor rotates in one direction to wind up string which closes the flower petals)
- Moves hands from right to left → Flowers bloom and butterflies flap their wings
(DC Motor rotates in the other direction to open the flower. A Servo Motor repeatedly moves 180* to make the wings flap)

User touches the circular bowls
(Copper tape connected to Trill sensor detects touch)
→ Different boxes play different sounds, allowing the user to create beats and music
(Puredata is used to load and play the sound files when a touch is detected)

Evaluation

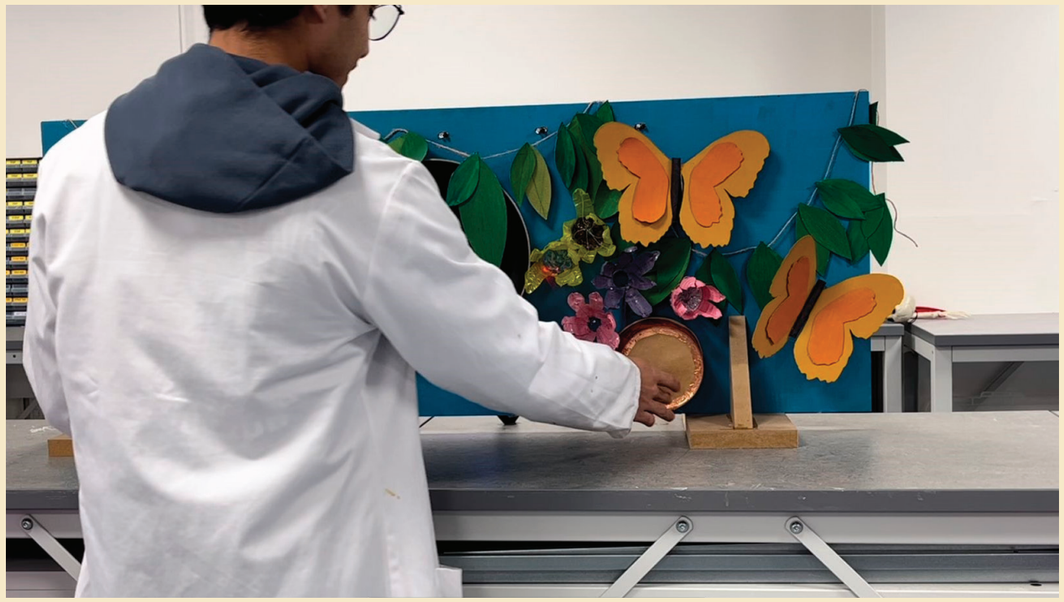
The project was evaluated based on its ability to engage users and effectively convey the theme of upcycling. User feedback sessions were conducted during prototype testing, where participants interacted with the blooming flower mechanism and commented on its intuitive design and symbolic representation of renewal. The feedback was distributed into four categories.

1. Functionality: Users appreciated the responsive movement of the flower mechanism but suggested improving smoothness and durability for prolonged use. The owl and butterfly were said to have worked “with no problems”. Users mentioned that the copper tape on the bowls can be increased by a few rounds of the tape to add to comfort while working alone.

2. Aesthetics: The use of upcycled materials was praised for its visual appeal and symbolic connection to sustainability. Users gave positive feedback for the visuals of the projects. However, suggestions included integrating additional subtle lighting to further enhance the immersive effect.

3. Interactions: The hand-tracking interaction was described as intuitive, but users noted occasional lag. Also, for tracking movement using IR sensors, the hands need to be very close to the sensor which is not ideal. Fine-tuning the sensor calibration will address these issues.

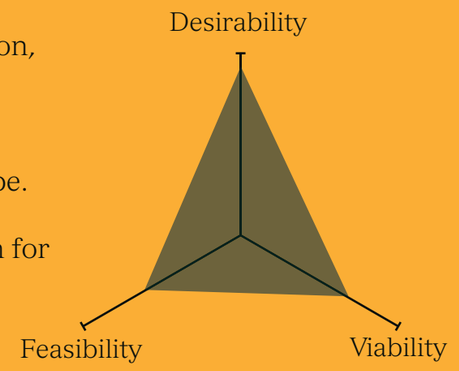
4. Experience: Overall, participants found the installation engaging and meaningful, making them feel closer to nature and technology at the same time.



Suryansha Sheth DE1, User Validation

How might we design an interactive system using upcycled materials that inspires users to rethink their relationship with waste and recycling while remaining visually appealing?
This project addresses the HMW question by leveraging upcycled materials to create an interactive system that embodies the process of renewal and transformation.

Desirability: The project resonates with users through its aesthetic appeal and engaging interaction, making sustainability relatable and inspiring.
Feasibility: The system relies on accessible technologies, such as IR sensors, string-and-pulley mechanisms, which are straightforward to prototype.
Viability: The project uses low-cost upcycled materials, making it an economically viable solution for small-scale or educational installations.



Future Possibilities

Looking ahead, there are many opportunities to enhance and expand this project.

1. Personalisation and modularity:
Future iterations could allow users to customize the arrangement of components, such as placing the components in any arrangement or even replacing components. Modular attachments could expand the system’s scalability, enabling it to fit various spaces and themes. This will give the users an even more personal touch with nature and sustainability.

2. Advanced sensors and internet integration:
Revisit the idea of adding ultrasonic (US) sensors to detect user presence and light up LEDs gradually, creating an inviting interaction. Advanced sensors could be used to create more enhanced interactions such as sound sensor, environmental sensor, etc. Integrating IoT technology will also offer more features to the product. The system could respond to real-time data such as weather conditions and seasons.

Opportunities for improvement and upgrades:

1. Fixing mechanisms: Use gear systems instead of string-and-pulley system to make the movements more smoother and more comfortable
2. Increase sensitivity of the IR sensors.
3. Make the components modular so the placement arrangements are customizable.
4. Use Wi-Fi or Bluetooth to connect the installation to a smartphone app, allowing remote control or customization.
5. Add a layer of interactivity to teach concepts like upcycling or environmental awareness.