Weather Stage

2023 Physical Computing Portfolio

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Interactivity Demonstration

Normal Weather

When user is inactive, the 8 white LEDs inside the cloud continuously emit light, simulating natural illumination. Simultaneously, the motor consistently propels the character to walk along the track.

Sunny Day

When user brings a flame close to the flame sensor, it initiates a heatwave period. During this time, the red, orange, and yellow LEDs illuminate continuously while playing a sound effect of ocean waves. This signifies the heightened intensity of the sun's rays. If the character moves under the beach umbrella, he will take a break in the shade.

Snowy Day

When user holds the Christmas tree (equipped with a magnet) close to the hall sensor, the Christmas sound effect plays, and the character stops to play in the snow near the snowman.

Rainy Day

Starting to rain

Character is hiding inside the house

When user presses and holds the button continuously, the 8 white LEDs inside the cloud turn off. Meanwhile, the 8 blue LEDs continue to illuminate, accompanied by a rain sound effect. This setup symbolizes a cloudy sky with the onset of rain. In response, the character retreats inside the house to seek shelter from the rain.

Thunderstorm

Clouds are pulled down
Starting to thunder

Character is hiding inside the house

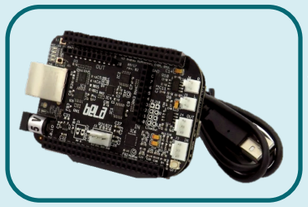
When user blows into the microphone sensor, a simulated thunderstorm ensues for a duration. The blue and white LEDs blink, the servo moves the cloud back and forth, and the sound of thunder plays. This sequence symbolizes the onset of strong winds and flashing lightning. In response, the character promptly runs back inside the house.

Bill of Materials

Material Sourcing for Appearance Components

Component	Material	Where to get	Reason for selection
Shell	4mm Plywood Sheet	ACEX Workshop	Strong enough, drilling won't be compromised with high efficiency
Gear & Chains	ABS	Online	Time-saving and precise enough to be easy to use
Magnetic Strip	Magnet	Online	Easily removable and sufficient to secure the front board
Model Tree & Grass	Foliage Wire Flocking	Model Shop	Used to hide wires and for decoration
Stone	Stone	Model Shop	Decoration
Clouds	Cotton Balls	Pharmacy	Used to hide LED strips and decoration
Beach & Snow	Sand	Model Shop	Decoration
Paint	Pigments	Model Shop	Decoration
Nail Polish	Nitrocellulose & Resins	Pharmacy	Decoration
House Character Snowman	3D Pringting PLA	ACEX Workshop	Decoration
Supports	3D Pringting PLA	ACEX Workshop	Support

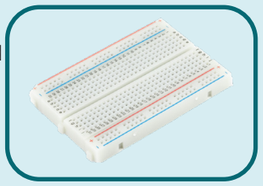
Electronic Components



Bela

Embedded computer designed for creating rich interactions

As Processor and Controller



Breadboard

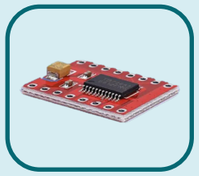
Rectangular board with numerous interconnected holes

A platform for building and testing electronic circuits without soldering

Jumper Wires

Jumper wires are flexible wires with connectors at both ends

Simple and convenient way to establish connections between different points



H-Bridge

Commonly used to control the direction and speed of a motor

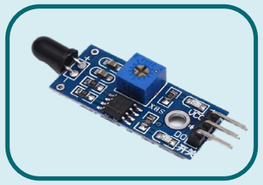
Keep circuits safe in our project

Inputs

Button

Make or break the electrical connection only while it is being physically pressed.

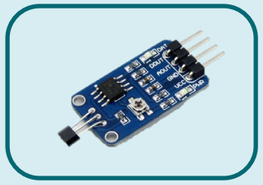
Determine its high and low levels to control rainy days



Flame Sensor

Alert or initiate a response when it detects the characteristic optical radiation emitted by flames.

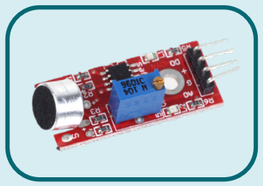
Determine its high and low levels to control sunny days



Hall Sensor

A transducer that detects the presence of a magnetic field. It operates based on the Hall effect.

Determine its high and low levels to control snowy days

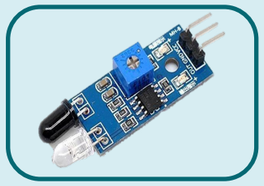


Microphone Sensor

It converts variations in air pressure caused by sound waves into electrical signals.

Determine its high and low levels to control thunderstorm

3 x

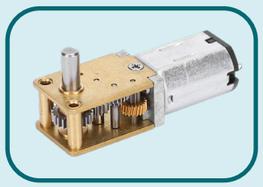


Infrared Sensor

Detect the presence or absence of infrared radiation emitted by objects or sources in their vicinity.

Determine if the character reaches the house, the beach and the snow.

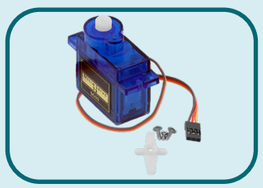
Outputs



Gear Motor

Combination of an electric motor and a gearbox integrated into a single unit.

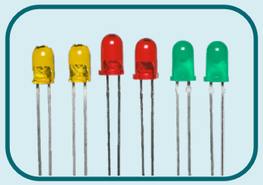
The motor is used to rotate 4 under stage gears to move the track.



Servo Motor

Motor that is designed to provide precise control of its angular position, velocity, and acceleration.

Sweep to pull the clouds back and forth.



LEDs

Semiconductor devices that emit light when an electric current passes through them.

8 blue lights, 8 white lights, and red, orange, and yellow to simulate 5 types of weather.

Speaker

An electroacoustic transducer that converts electrical signals into sound waves

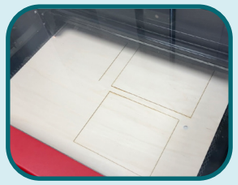
Play the sounds of raindrops, lightning, waves and Christmas bells.

Production Process

3D Printing & Laser Cutting

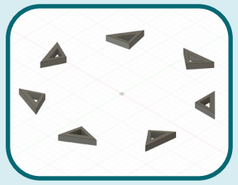
Shell

1



We opted for laser-cut wood sheets for the shell instead of 3D printing for a few reasons. First, our box has a straightforward shape. Second, we can assemble a portion of the shell initially to measure and position it accurately, allowing for the placement of electronic parts, drilling holes, and other tasks. Lastly, laser cutting proves to be a quick and highly efficient process for our shell.

2



To enhance structural stability, we utilized 3D printing to create right-angled triangular brackets attached to each corner. These brackets provide support to the shell and prevent deformation.

3D Printing Objects ---- Requires a smaller size and higher accuracy.

Character

A groove has been crafted beneath the character, aligning with the chain's thickness (7.66mm). This design ensures a secure attachment of the character to the chain without the need for glue, simplifying post-debugging.

House

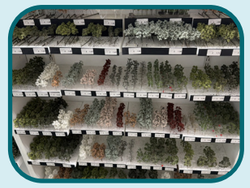
The character stands at a height of 22mm, and the house opening is sized at 25mm to ensure smooth passage for the character. When painting, spray a first coat of grey paint to facilitate easy adherence of subsequent layers.

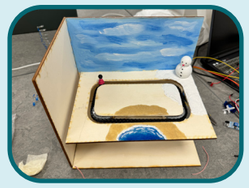
Snowman & Parasol

Both function as decorative items for scene setting.

Chrismas Tree

The base of the Christmas tree has a pre-designed hole matching the size of the magnet. This allows the magnet to securely snap under the tree, creating the effect of a key to a snowy day.





Art & Appearance Work Process

1. The sky effect on the wood sheets was achieved by drawing the blue and white colors in different ratios.
2. The clouds affixed to the LED tapes were crafted by stretching cotton to achieve the desired thickness and shape.
3. The beach and snow are created by combining PLA with sand and pigments, adhered to a wooden sheet.
4. The ocean is painted on a wooden sheet, and a layer of transparent nail polish is applied to the surface to create the effect of reflecting sea surface.
5. The woods are positioned to conceal the wires on the left side. We used foam to fill in the gaps and added branches on top to create a wooded effect.
6. Grass is created by using purchased turf, and stones are attached to the remaining area to enhance the overall stage appearance.

Adhesive Tools Used

Hot Glue Gun

Most of the appearance work was done using a hot glue gun due to its fast, clear, and strong bonding capabilities.

Soldering

LED strips, the gear motor, the speaker, etc., all utilize soldering to extend wires and secure electronics in place.

Main logic & Explanation of Code

7-second Block --- Lightning & Sunny

```
// lightning--blow on the microphone sensor once, the program is blocked by 7 seconds.
// During the period, white LEDs and blue LEDs blink, play thunder sound effect, and servo
// motor pull the clouds to move. Once the character walks into the house, the motor stops running.
int micState = digitalRead(5);
if (micState == HIGH){
    unsigned long startTime = millis();
    pdSendMessage("playSound", 1);
    while (millis() - startTime < 7000){
        unsigned long currentMillis1 = millis();
        if (currentMillis1 - previousMillis1 >= interval1) {
            previousMillis1 = currentMillis1;
            if (blinkState == LOW) {
                blinkState = HIGH;
            }
            else {
                blinkState = LOW;
            }
            digitalWrite(9, blinkState);
            digitalWrite(5, blinkState);
        }
        unsigned long currentMillis2 = millis();
        if (currentMillis2 - previousMillis2 >= interval2) {
            previousMillis2 = currentMillis2;
            if (servoState == 0.2) {
                servoState = 0.8;
            }
            else {
                servoState = 0.2;
            }
            pwmWrite(8, servoState);
        }
        if (digitalRead(3) == LOW)
        {
            digitalWrite(1, LOW);
            digitalWrite(14, LOW);
        }
        else
        {
            digitalWrite(1, HIGH);
            digitalWrite(14,LOW);
        }
    }
    pdSendMessage("stopSound", 1);
    pwmWrite(8, 0.8);
}
```

```
// sunny--Once the flame sensor detects fire, the program is blocked by 7 seconds.
// red LEDs(sun) light up, when the character arrives at the beach,
// it will stop under the parasol.
int flameState = digitalRead(15);
if (flameState == LOW){
    unsigned long flameStartTime = millis();
    pdSendMessage("playSound", 3);
    while (millis() - flameStartTime < 7000) {
        digitalWrite(11, HIGH);
        delay(10);
        digitalWrite(11, LOW);
        if (digitalRead(9) == LOW) {
            digitalWrite(1, LOW);
            digitalWrite(14, LOW);
        }
        else {
            digitalWrite(1, HIGH);
            digitalWrite(14, LOW);
        }
    }
    pdSendMessage("stopSound", 3);
}
```

The purpose of this logic is to create a controlled time delay of 7 seconds. Given that it takes 5 seconds for the character to complete one lap, we need to ensure that it has sufficient time for one lap and stops in the target areas. During this loop, the program will execute the code inside it repeatedly until the 7-second duration is reached. Here, we don't consider situations where multiple weather events occur simultaneously. Therefore, we refrain from triggering any additional weather events during the 7 seconds.

Debouncing Button --- Rainy & Snowy

```
//rainy--hold the button, blue LEDs(rain drops) light up,
//white LEDs go out and the rain sound is played. During this time,
//Once the character walks into the house, the motor stops running.
int rainState = digitalRead(4);
int house = digitalRead(3);
if (rainState != lastButtonState){
    rainstartTime = millis();
    delay(debounceDelay);
  }
if (rainState == 1 && millis() - rainstartTime > debounceDelay) {
  if (!soundPlaying1) {
      digitalWrite(0, LOW);
      digitalWrite(2, HIGH);
      pdSendMessage("playSound", 0);
      soundPlaying1 = true;
  }
  if(house == LOW){
      digitalWrite(1, LOW);
      digitalWrite(14,LOW);
  }
  else{
      digitalWrite(1, HIGH);
      digitalWrite(14, LOW);
  }
}
```

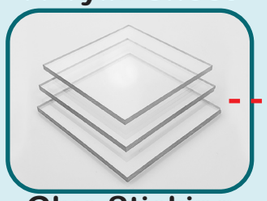
```
// snowy--hold magnet on chrismas tree touch the hall sensor, chrismas sound effect is played
// Once the character arrives at the snow area, the motor stops running.
int snowState = digitalRead(12);
if (snowState != lastsnowState){
    snowstartTime = millis();
    delay(debounceDelay);
  }
if (snowState == 0 && millis() - snowstartTime > debounceDelay) {
  if (!soundPlaying2) {
      pdSendMessage("playSound", 2);
      soundPlaying2 = true;
  }
  if(digitalRead(12) == LOW){
      digitalWrite(1, LOW);
      digitalWrite(14, LOW);
  }
  else{
      digitalWrite(1, HIGH);
      digitalWrite(14, LOW);
  }
}
else {
  pdSendMessage("stopSound", 2);
  soundPlaying2 = false;
}
```

The debouncing logic prevents rapid changes in the rain button's state from being immediately processed. It introduces a delay to ensure that the detected state change is stable, reducing the likelihood of false positives caused by noise or bouncing. Applying this logic to the hall sensor also allows us to consider the hall sensor as a debounced button.

Challenge & Solutions

1

Acrylic Sheet

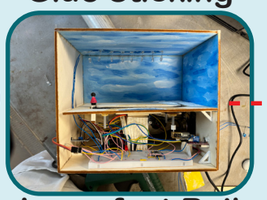


Wooden Sheet

The initial setup involved using acrylic sheets to encase the stage due to their transparent material and excellent light transmission. However, there were drawbacks. The transparent material made it challenging to conceal wires, and the acrylic boards were prone to staining with fingerprints, affecting the overall aesthetics. Consequently, the structure was revised to an open design with three wooden sheets and one exposed side. The open design offers the advantage of easy addition of elements and future modifications to the stage.

2

Glue Sticking

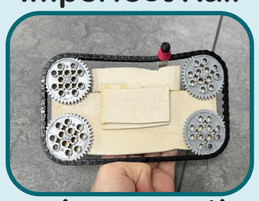


Magnetic Strip

The initial setup involved using acrylic sheets to encase the stage due to their transparent material and excellent light In the initial plan, we intended to seal the front board with hot melt glue to hide the electronic parts. However, the day before gluing, our front board went missing. Then, a new idea was born, we cut a new board and redesigned it to incorporate two magnetic strips for securing the front board. This modification offers the advantage of easier access in case of issues and showcases the internal structure and circuits.

3

Imperfect Rail

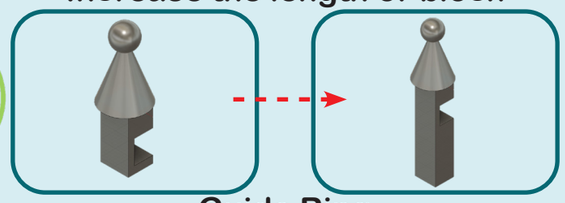


Inaccuracies

Since the chain was purchased online, it tended to wobble during moving because of the chain's low strength and its assembled nature. Additionally, there were some errors in the track gaps, causing the character to hit the edges or get stuck at certain positions. Consequently, we measured and polished the track edges multiple times to ensure a smooth movement for the character.

4

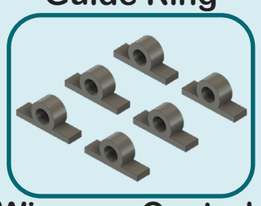
Increase the length of block



Our initial design of the character featured only a groove and a relatively short extended part. However, during the testing, we discovered that the fixed infrared sensors couldn't detect the passage of the character. To address this, we extended the length and area of the block beneath the character and subsequently printed a new one. This modification ensures that the infrared sensor can accurately detect the presence of the character.

5

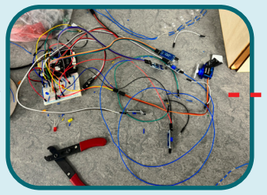
Guide Ring



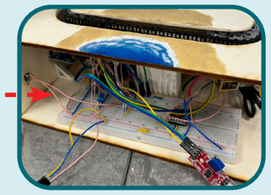
We needed to set the cloud in motion using a taut nylon line connected to a servo motor. However, we realized that taut line hanging over the stage would be unsightly and challenging to conceal. To address this, We created models of 'guide rings' and 3D printed them to thread the line through and adhered them to the inner wall. This method guided the line to remain taut along the inner wall while maintaining a neat appearance.

6

DuPont Wires



Coated Steel Wire



Initially, we utilized DuPont wires for connections and testing. However, we discovered that the fixed length of DuPont wire occupied unnecessary space and appeared messy. Additionally, its elastic nature caused warping to a certain height, affecting the movement of the character. As a solution, we switched to coated steel wires for connections because they can be shaped, allowing us to control its length. The orderly arrangement of wires is also convenient for debugging.