LuminLeaf

Project by
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Prof. Anthony Vanky
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Executive Summary

The rapid pace of urban life often brings with it high stress and emotional strain, impacting the mental well-being of city dwellers. Traditional methods for managing these emotional states, such as meditation and outdoor activities, although beneficial, do not provide immediate relief or continuous support throughout the day. Recognizing the need for a more integrative and responsive approach to emotional wellness, this project introduces an innovative prototype—the "LuminLeaf".

The LuminLeaf is a technologically advanced installation designed to enhance urban environments by directly interacting with individuals' emotional states through real-time biofeedback. Utilizing Galvanic Skin Response (GSR) sensors, the LuminLeaf detects subtle changes in an individual's emotional state, which then triggers interactive elements within the installation to reflect these emotional variations visually and audibly.

Developed through a series of experiments conducted at various locations across Columbia University, the prototype demonstrated significant potential in modifying emotional experiences in real-time. Our findings indicate that specific settings, such as libraries or public gathering spaces, have varied impacts on participants' stress and anxiety levels, which the LuminLeaf effectively mitigated through its interactive features.

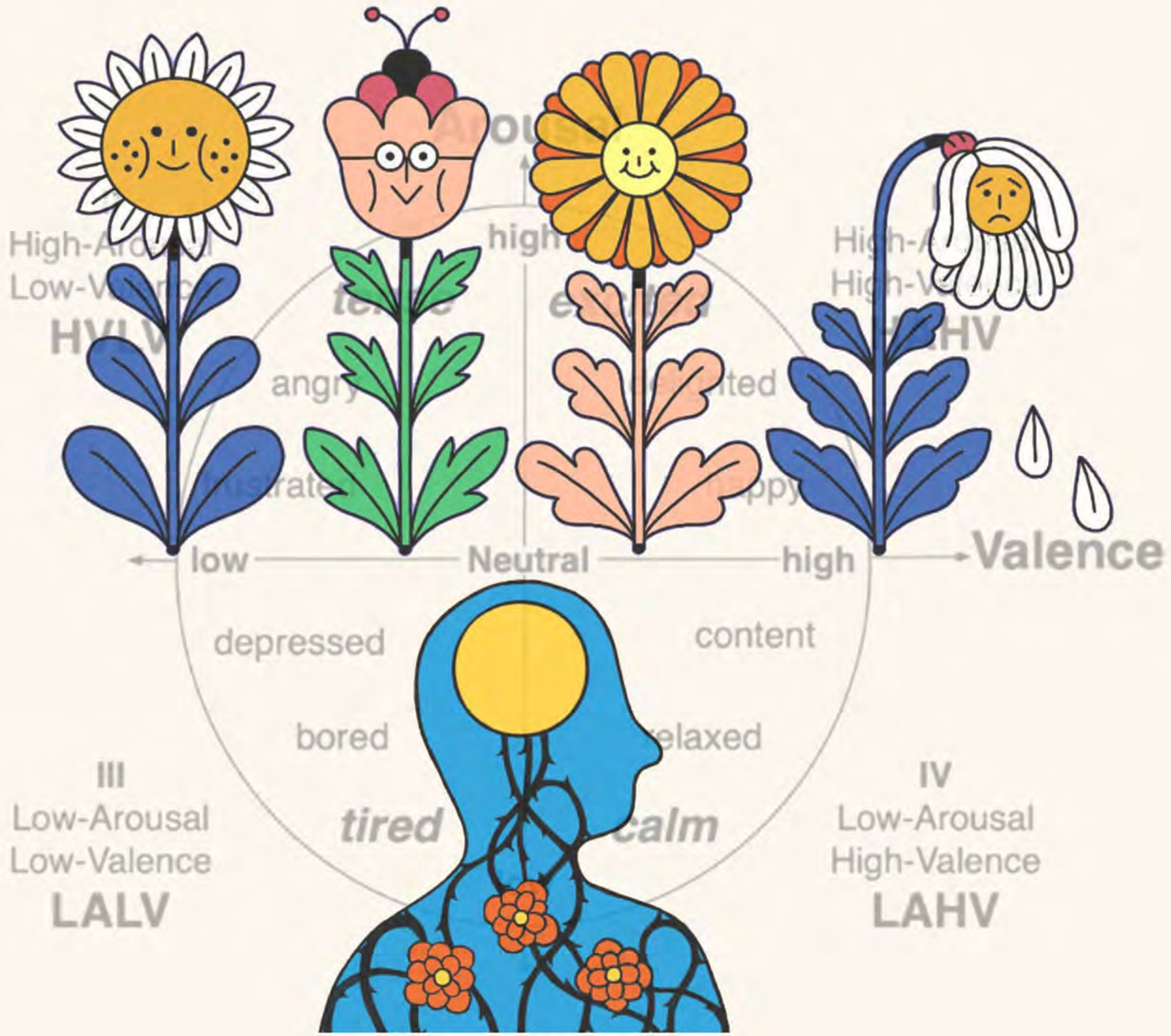
Furthermore, the LuminLeaf promotes a new form of urban interaction, where individuals can engage with the environment in a way that enhances their emotional well-being. The installation does not store any personal data, ensuring that interactions remain private and unrecorded, thus respecting individual privacy while providing emotional support.

By bridging the gap between technological innovation and mental health, the LuminLeaf offers a pioneering approach to enhancing life quality in urban settings, making it a valuable addition to smart city initiatives.

Introduction

Living in modern cities often involves significant stress due to economic pressures, leading to psychological and emotional issues that can escalate to depression, anxiety, or even suicide. Thus, the ability to regulate emotions, maintaining positivity and mitigating negativity, is crucial for mental health. Popular emotion regulation methods among urban dwellers include meditation, hiking, and spending brief periods, such as 20 minutes, in a park.

Despite these available methods, individuals may not immediately recognize when they are experiencing negative emotional states or realize the necessity for emotion regulation. Inspired by an iPhone application that tracks emotional changes throughout the day, we aim to develop a product that enhances individual awareness of their emotional states. This product will not only aid in emotion regulation but also foster a supportive environment where others can understand and respond empathetically to these emotional cues. This proactive approach is essential in promoting psychological resilience and well-being in urban environments.

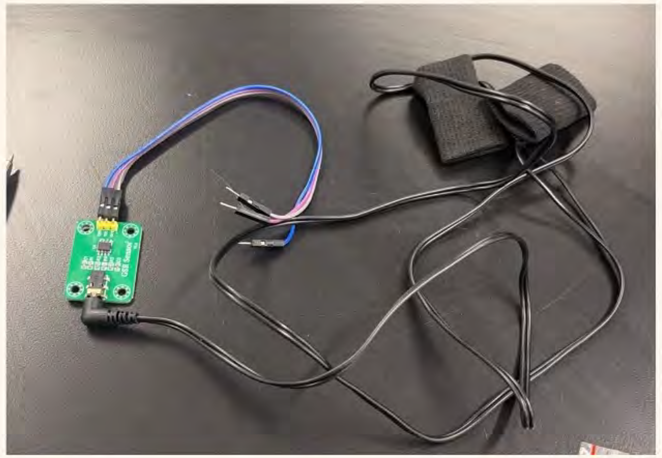


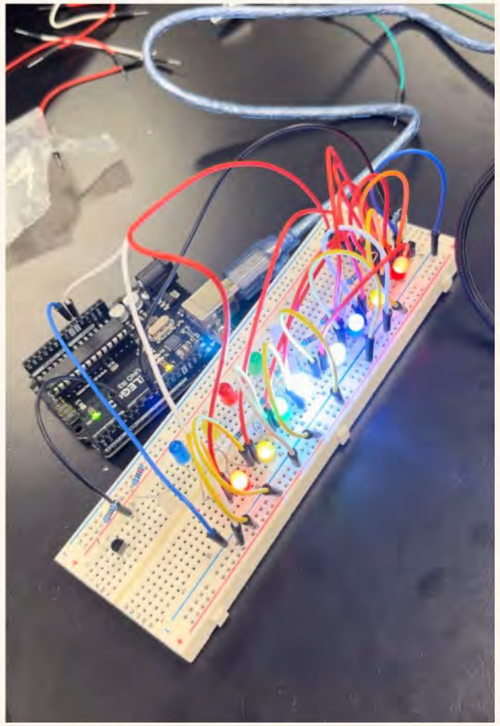
Technology

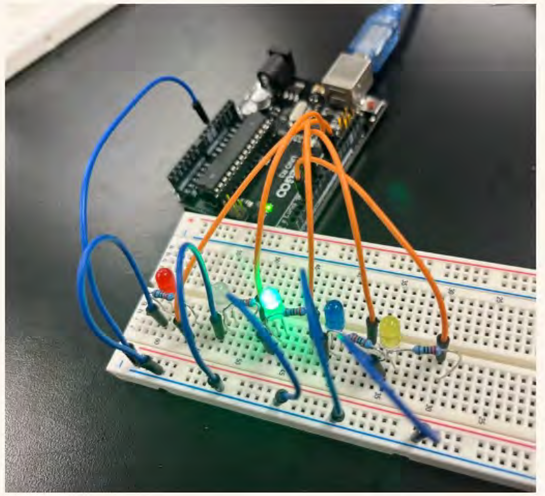
To monitor people's emotional status, we relied on the sensor, Galvanic Skin Response, or GSR. It can measure the skin's electrical conductance, which changes with moisture levels on the skin (e.g. sweating) driven by the autonomic nervous system. Therefore, the sweating response is linked to emotional states like stress or excitement.

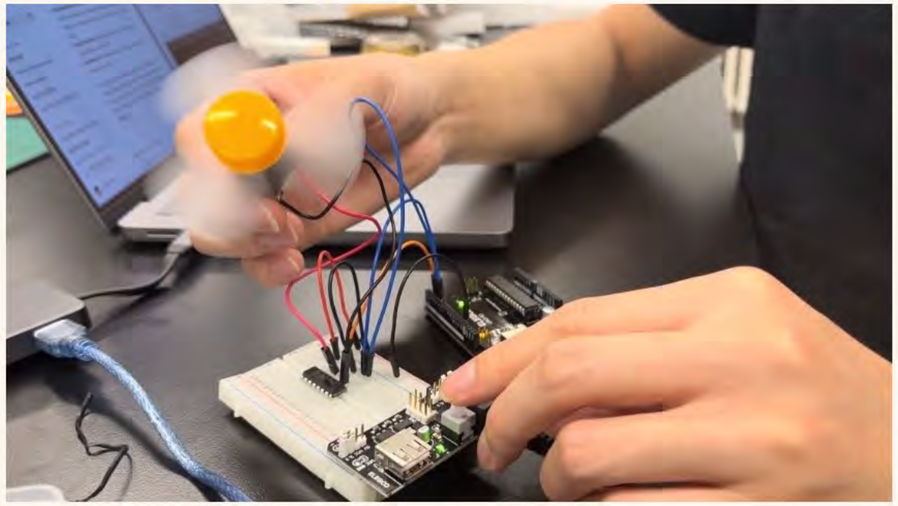
For our setup, we incorporated the GSR sensor into a system controlled by an Arduino UNO R3 Controller Board. This board is connected to a LED ring to display various colors and to a fan blade, which is driven by a DC motor and controlled by an L293D motor driver integrated circuit (IC).

Initially, our prototype used several single LEDs connected in parallel. We controlled their brightness collectively using a NPN Transistor PN2222. However, we found that the brightness was insufficient for our needs. To address this, we replaced the single LEDs with a LED ring, which not only provided brighter lighting but also simplified the wiring and connection process.

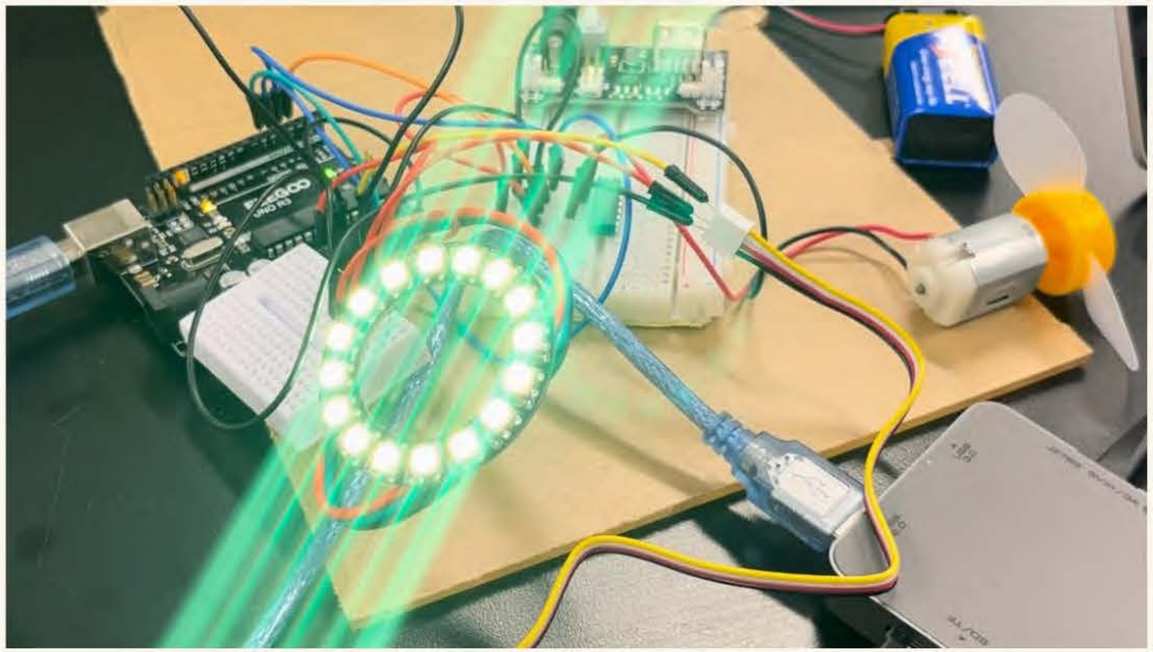


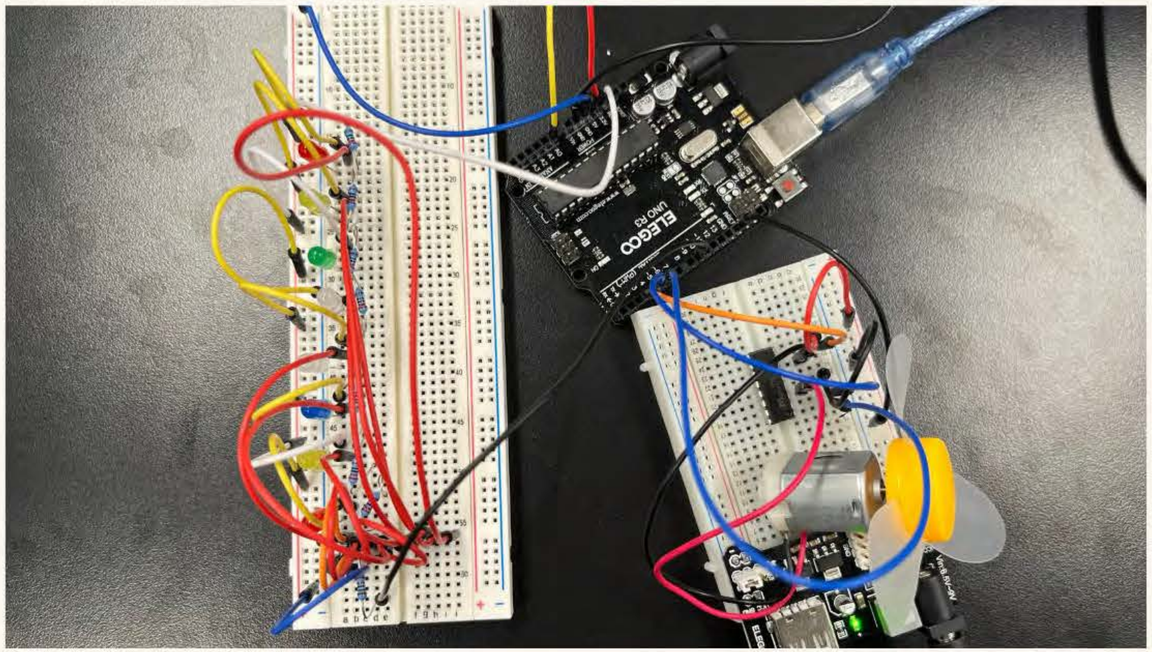


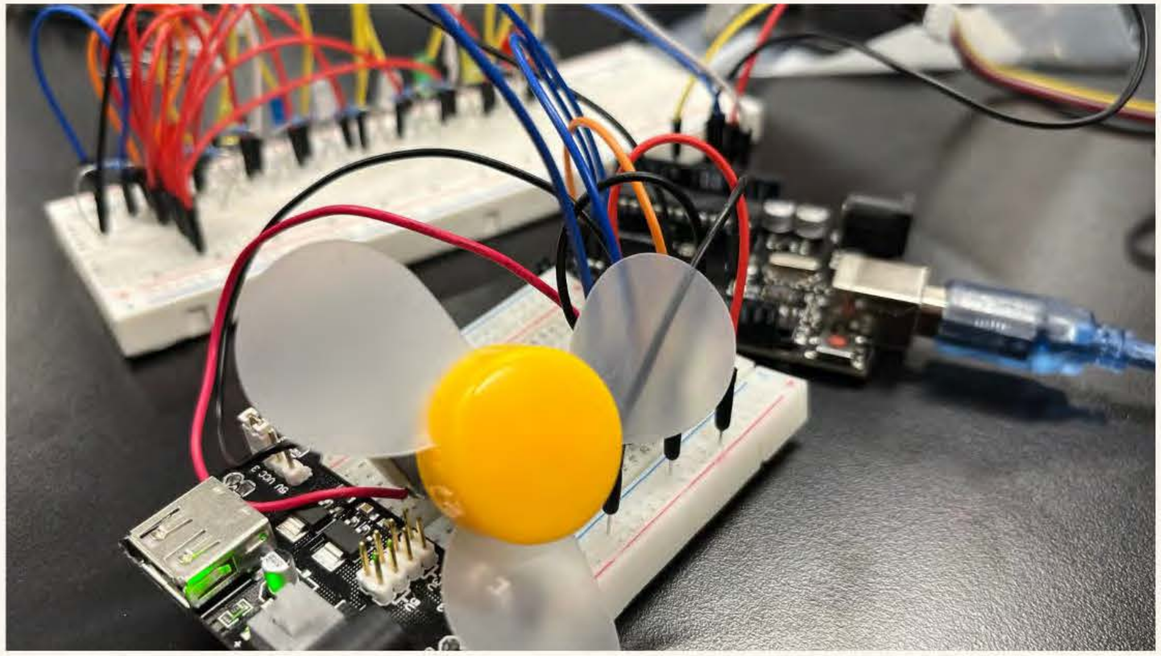


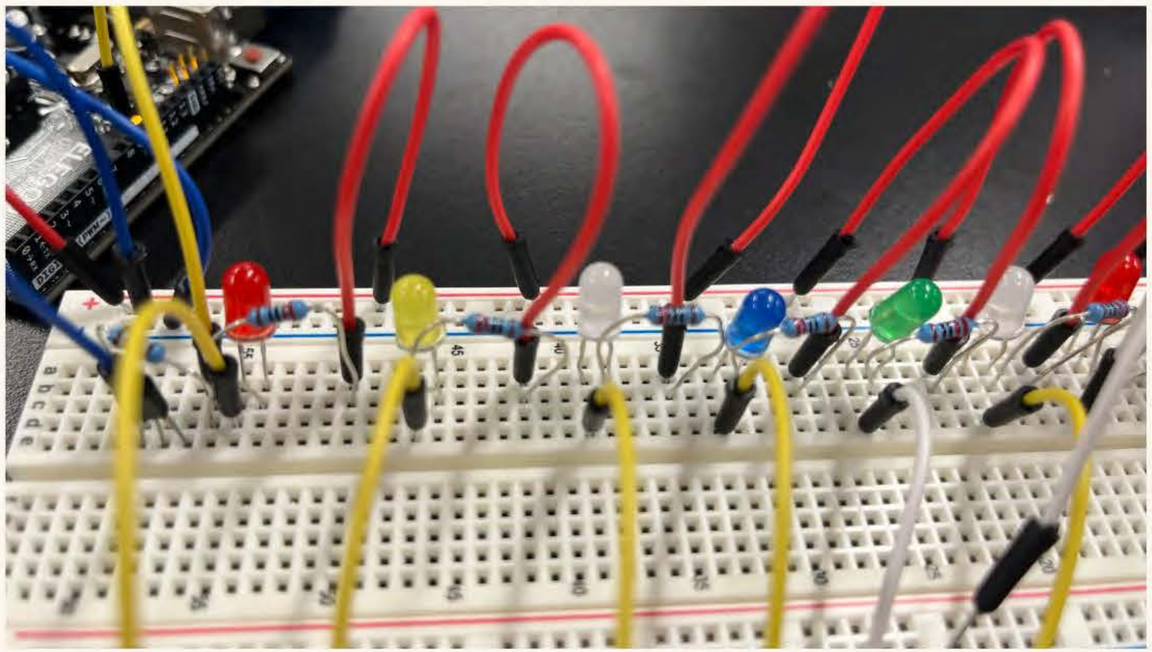


Technology

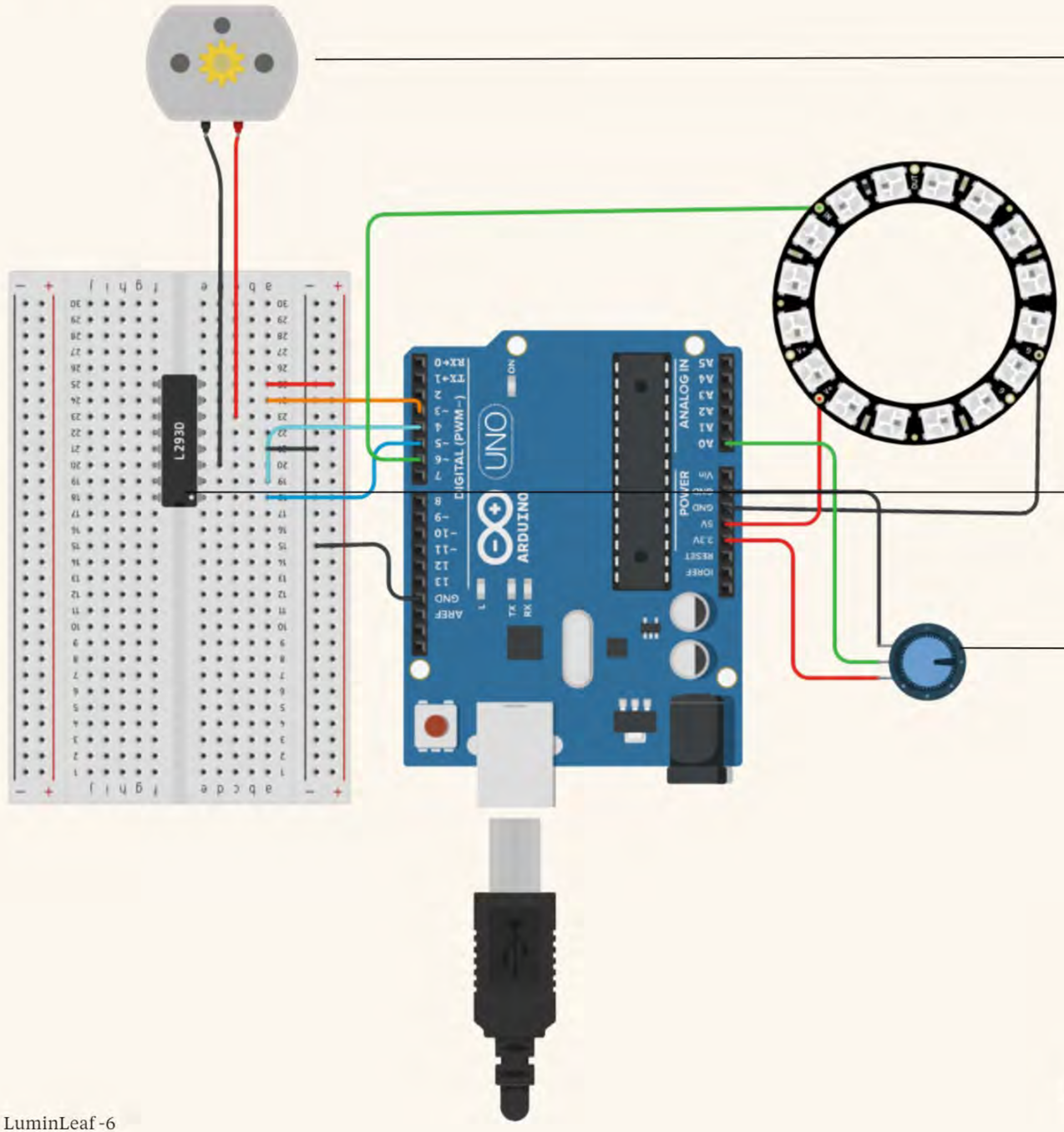








Technology



The DC Motor for the Fan Blade

The LED Ring

The motor driver IC
(integrated circuit) L293D

The GSR Sensor (Imitated)

The Arduino Uno Board

Drawing by Daoxin using the platform Autodesk Tinkercad

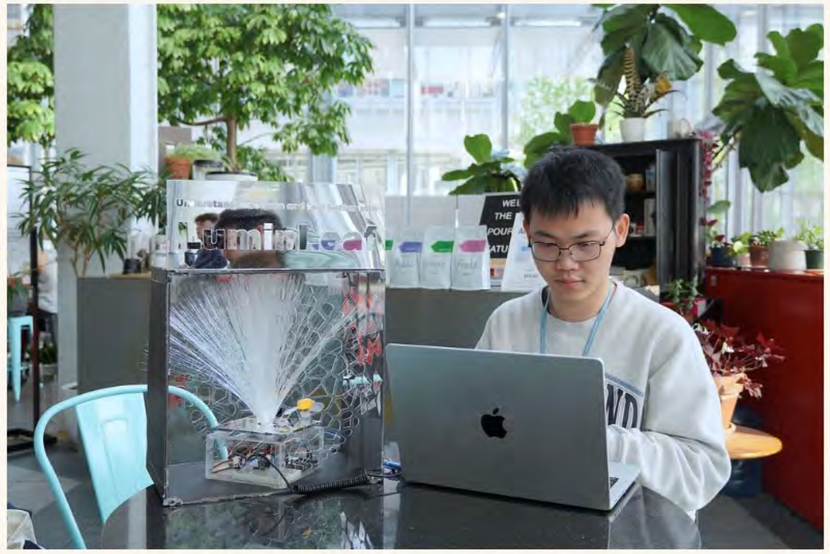
Local Interactions

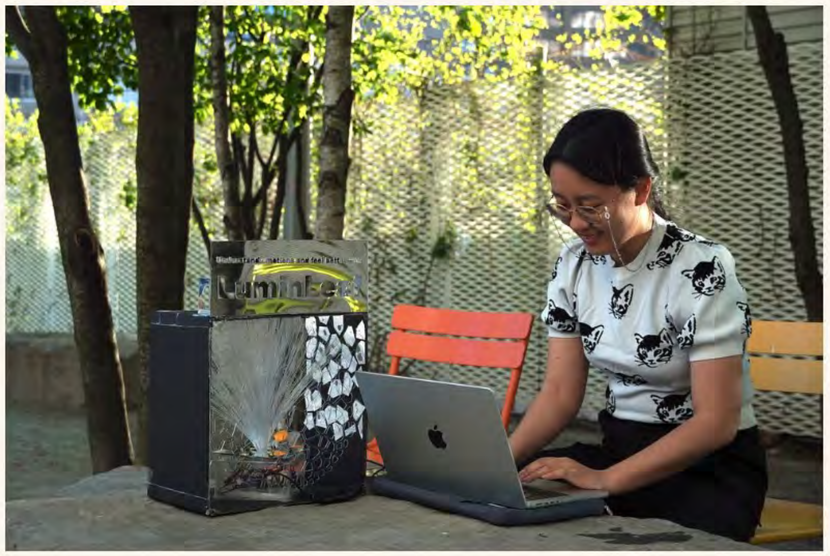
LuminLeaf enables versatile local interactions. It accommodates various settings and supports different activities within the same environment. Designed for both indoor and outdoor use, it fits comfortably on a table.

In a 1m scale interaction, LuminLeaf's color changes allow users to track their emotional fluctuations during an activity. This feedback assists in identifying the most suitable space for that specific task. Positioned at the edge of a table, it senses the user's emotional changes, enhancing personal experiences.

In a 10m scale interaction, within a small classroom with other people, a user's emotions are visible to others when the LuminLeaf is in use. This visibility may stimulate interactions with the user, influencing the emotional atmosphere.

In a 100m scale, for instance, at a library or outdoor squares, groups can gather around the device for discussions, treating it as an entertainment facility. Individuals can take turns using the GSR sensor to understand their own emotions, adding an element of enjoyment for everyone.





Prototype

The prototype consists of three primary components:

- Arduino box
- Fiber optics and reflective materials
- Black box with a slogan board

The Arduino box contains a light-emitting device and a GSR sensor. The two black finger sheaths extending from the box collect the user's GSR data. After measuring this data, the system will trigger LED lights of varying colors and may activate the rotation of the Motor Fan.

The fiber optics and reflective materials amplify the light emitted by the LED lights in the Arduino box, enhancing the light transmission and reflection effects. This creates a dynamic and engaging display.

The black box serves to highlight the light display, while the slogan board on top reads, "Understand emotions and feel better with LuminLeaf", inviting nearby users to engage with the device.

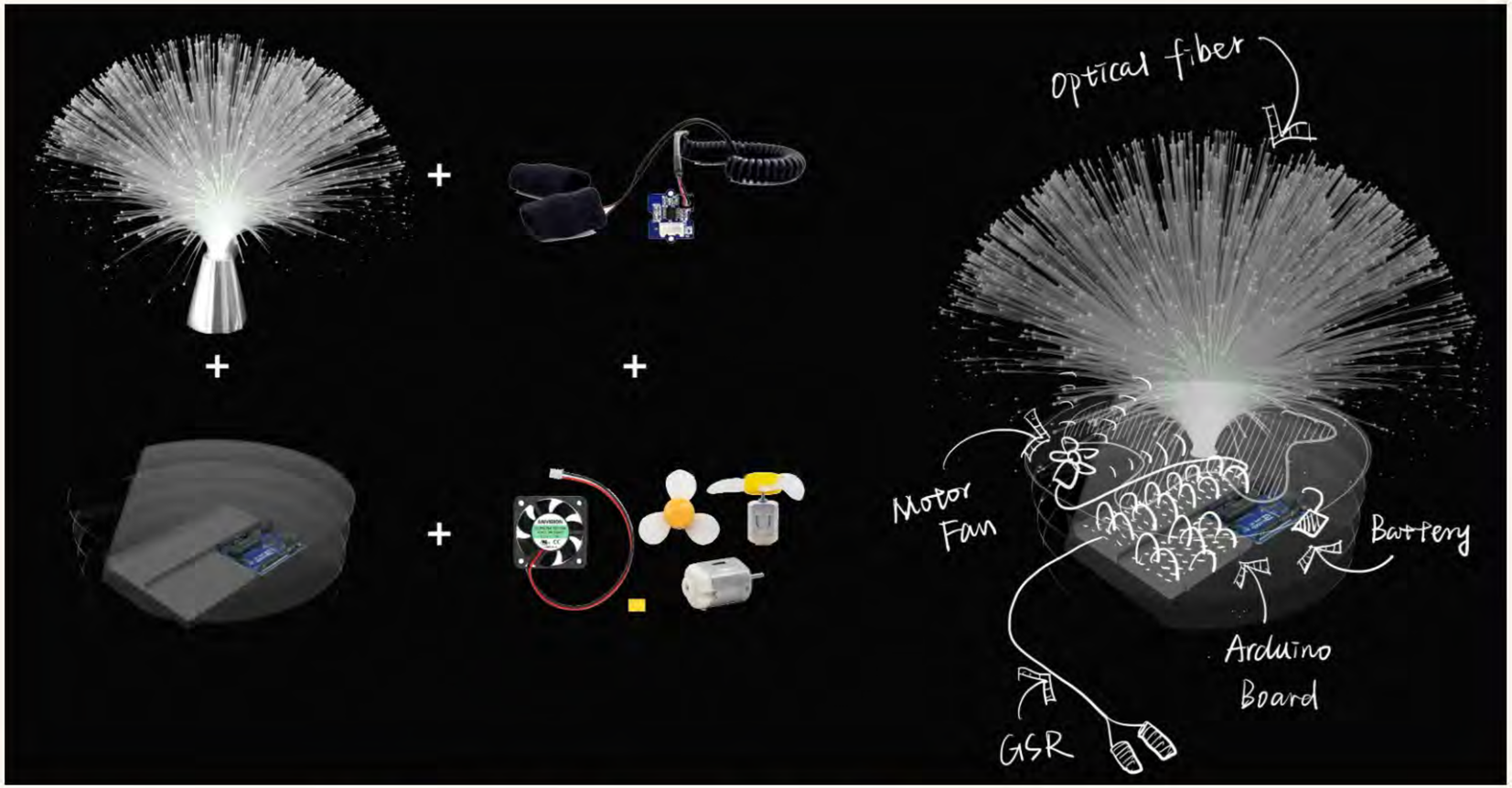
Hardware Design

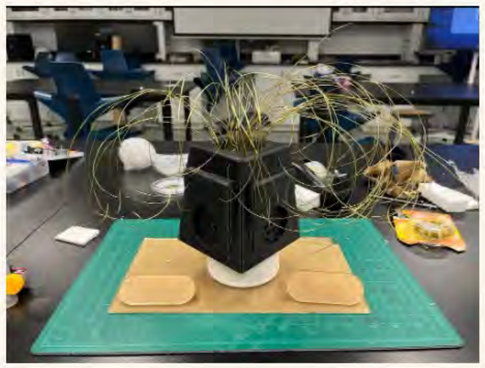
The hardware design has evolved through a series of stages.

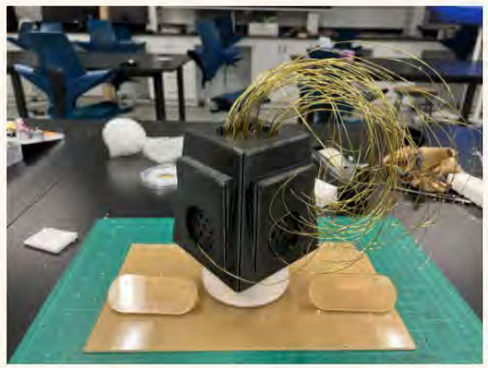
Initially, our concept was desktop plants that could sense user emotions. To realize this, we used 3D printed vases and metal wires for our prototype. Our intention was to use an internal motor to move the metal wires, creating sound to influence the user. However, we found it challenging to express human emotions through sound alone.

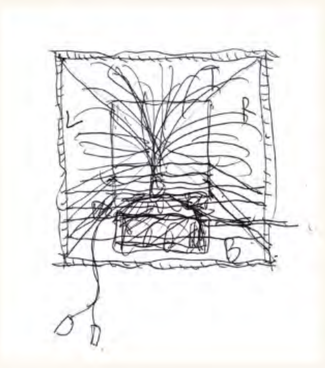
Consequently, we revised the design. We replaced the vase with a transparent black box and the metal wires with optical fibers. We also incorporated reflective materials to enhance reflectivity.

Regarding the Arduino component, we were determined to showcase it. We believe the connections between various electronic components and circuits in Arduino are aesthetically pleasing and technologically fascinating. Displaying it is also suitable for the prototype stage of the product.



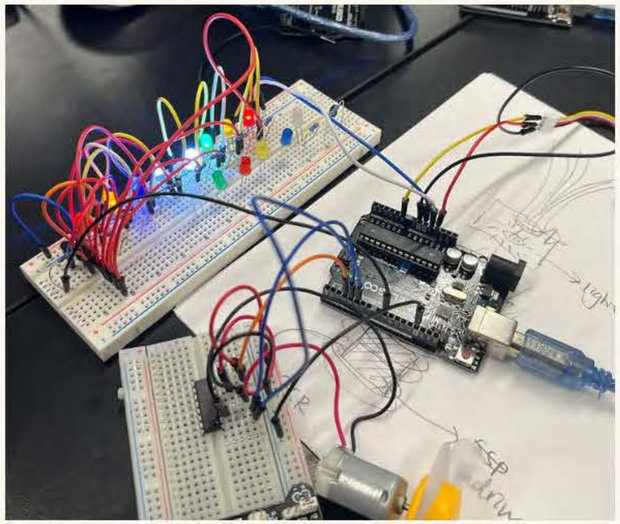


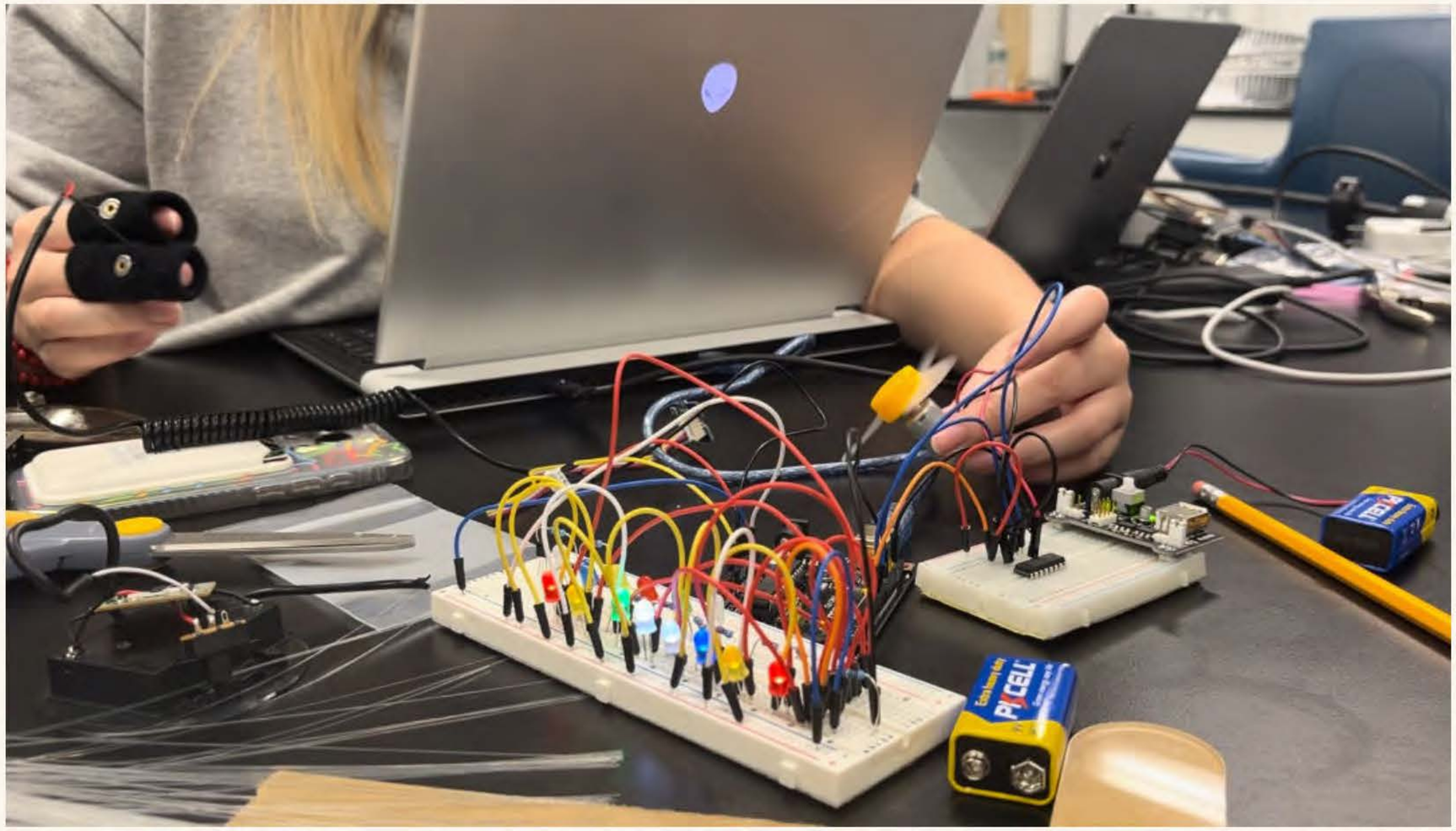




Prototyping and Sensing Technologies

We seperately wrote the codings for collecting data through GSR, for adjusting the LED lighting and for controlling the fan blade and then put them together. All the coding are written in Arduino IDE. Through setting number of RGB.





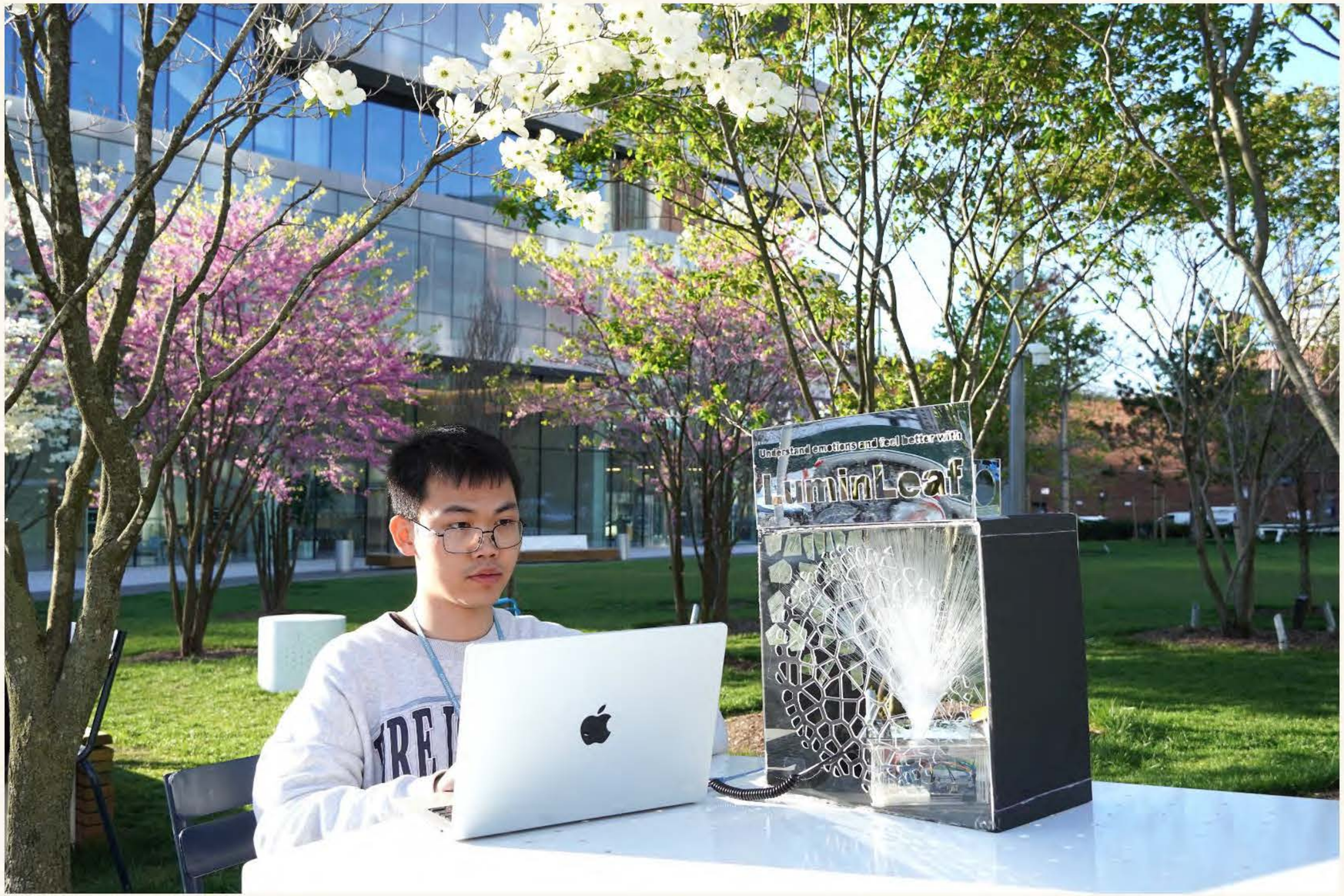
Write Up on the Pilot

We created a test pilot with our prototype. Below is an overview of the chosen study site for our pilot, considerations, data collection, analysis and the key findings from the pilot.

Consideration, Motivation:

The motivation of the pilot:

- To test how the prototype visualize and interact with the subject's emotion status?
- To test what factors (environments and tasks...) can impact subject's emotion status?
- To test how other surround people react when the subject is wearing the prototype and having different emotion status.



Methodology

Pilot Site: Libraries, Classrooms in GSAPP, Columbia University Morningside & Manhattanville Campus

Time: April 18, 2024 - May 1, 2024

Number of Participants: 4

Number of Experiments: 12

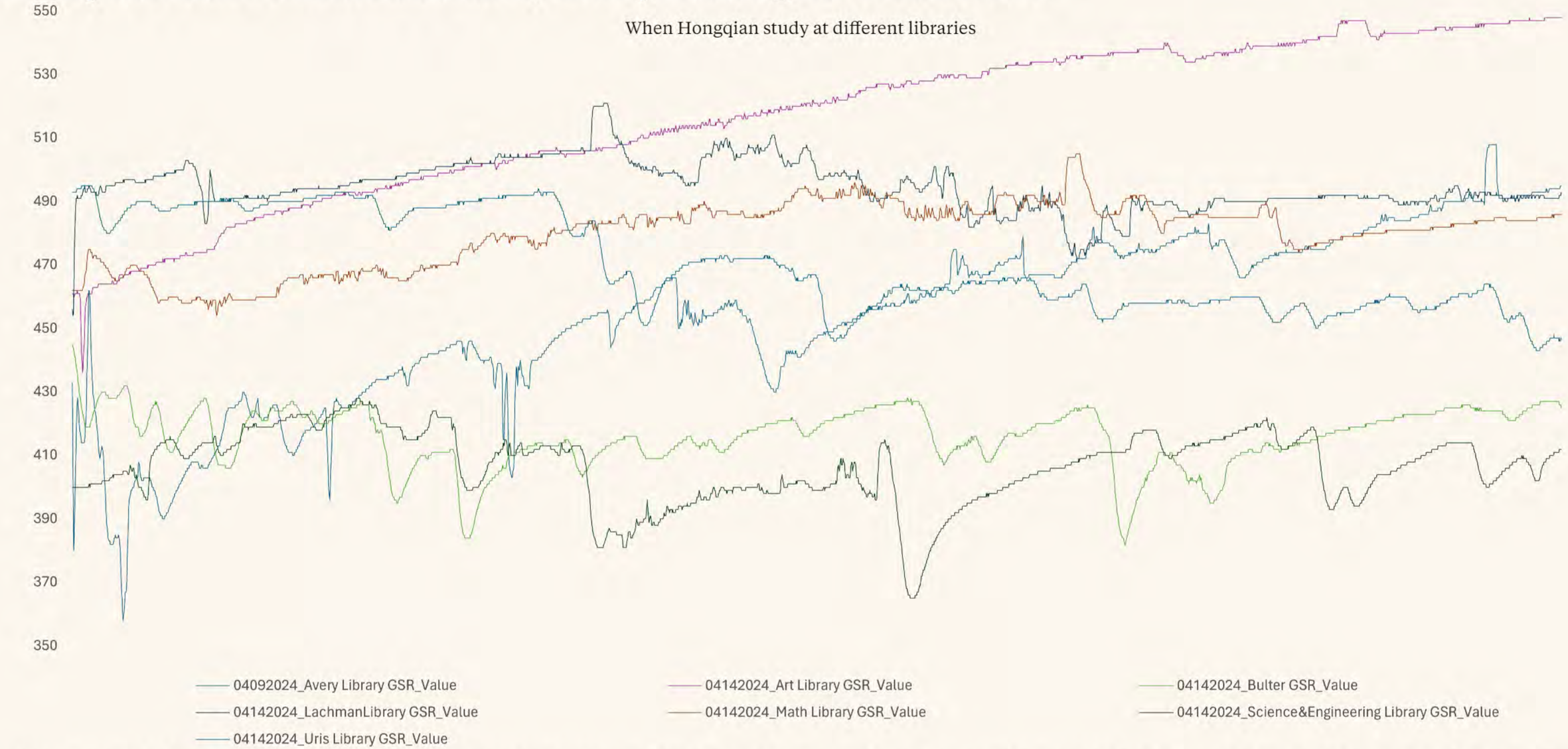
Experiments:

Experiment: Wearing the prototype while doing assignment and observe the prototype's interaction and how the the emotion status change in response to the prototype interaction(lighting changes, fan spinning...)

Experiment: Wearing the prototype while doing the same type of work in the different environment settings.

Experiment: Wearing the prototype while doing different types of work in the same environment setting.

Analysis and Visualization/Storytelling of Your Data

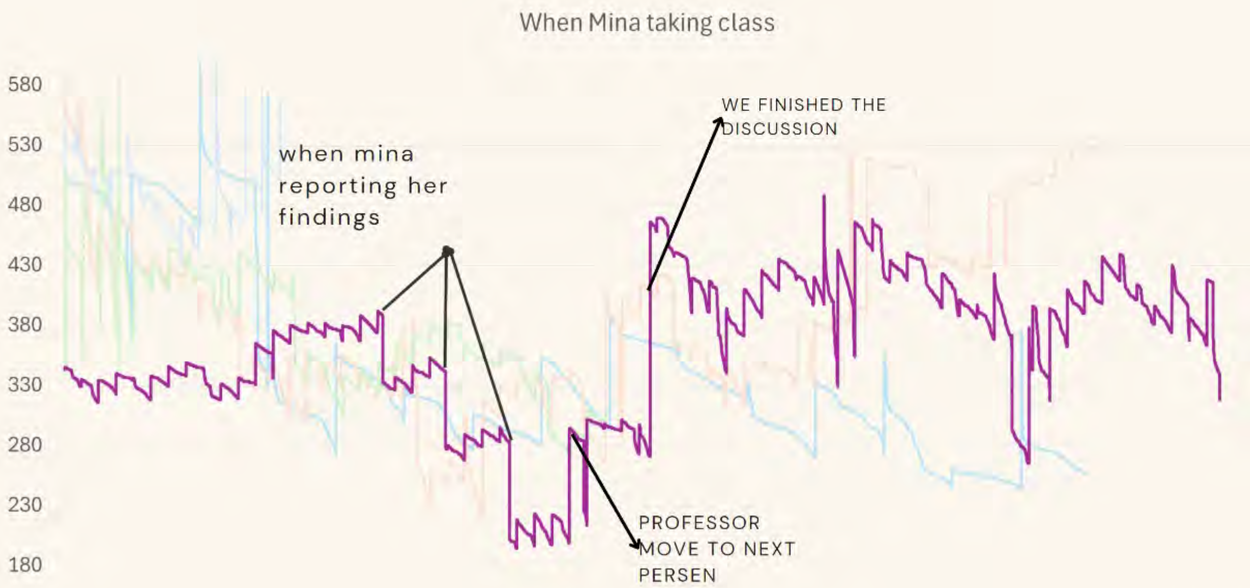


This experiment delved into measuring GSR values across seven distinct environmental settings, each representing different libraries at Columbia University. While there was a degree of similarity in the GSR values across these settings, discernible differences emerged, indicating the impact of environment on emotional states. Notably, the GSR readings were higher in the art and music library, suggesting a more positive emotional state within that environment. Conversely, lower GSR values were recorded in the science library, implying a less favorable emotional disposition. These findings underscore the potential effectiveness of environmental modifications in influencing emotional well-being. For example, if the prototype detects negative emotional conditions, adjusting the environment could serve as a practical strategy for promoting a more positive emotional experience.

Analysis and Visualization/Storytelling of Your Data

In this line graphs, which refer to Mina taking different classes, analysis, we can observe three consecutive decreases in the experimenter's physiological data (GSR values) during answering the professor's questions, showing a reduction in the experimenter's nervousness during public speaking. When the professor turned to the next student to ask a question, the experimenter's nervousness decreased significantly. Notably, there was a significant rise in the data at the end of the discussion, indicating an improvement in the experimenter's emotional state.

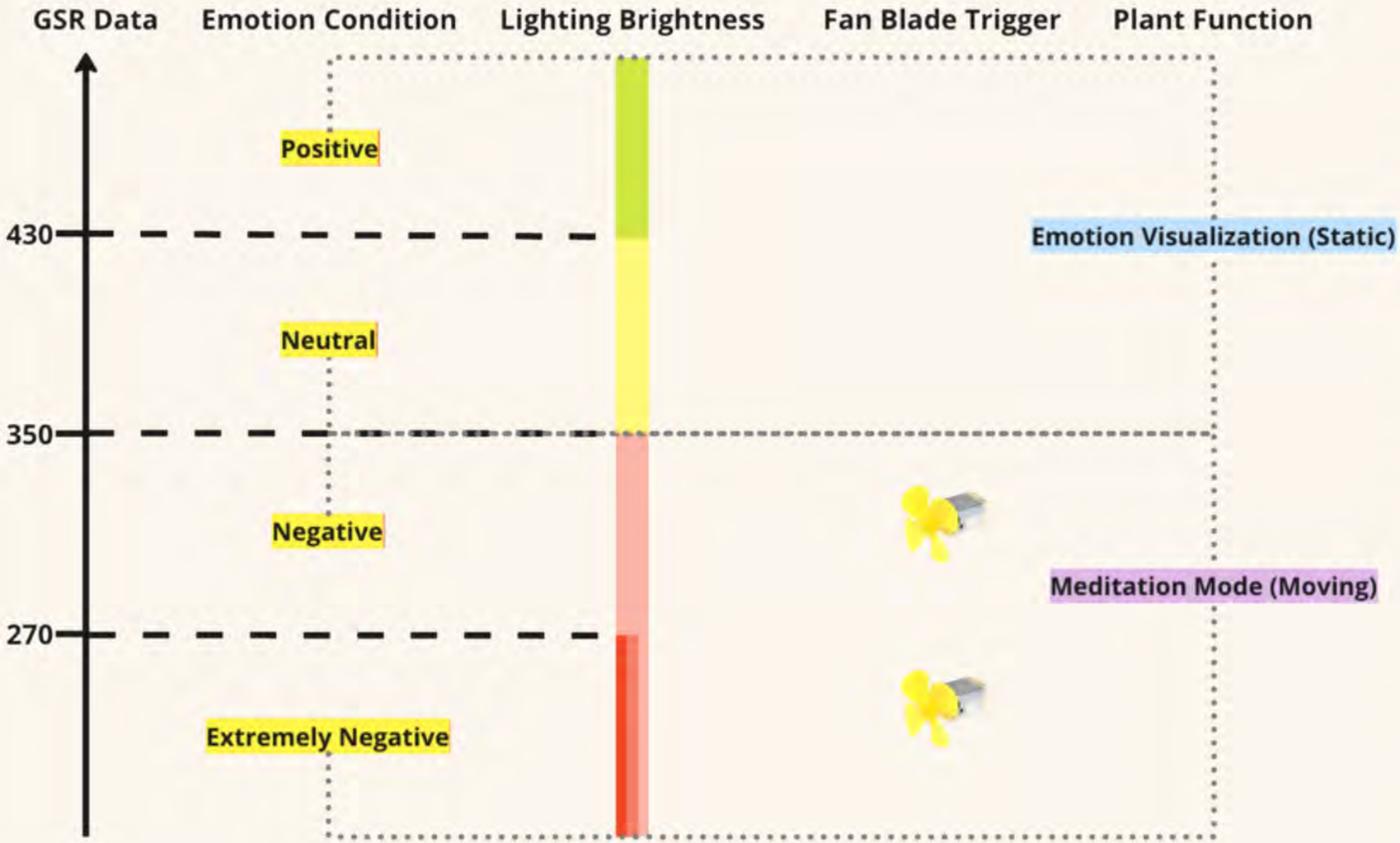
In addition, the report paid particular attention to the change in the mean of the data before and after the statements. The data showed that the post-speaking mean was higher than the pre-speaking mean, suggesting that the experimenter's mood improved after adapting to the speaking environment. This observation emphasizes the influence of the environment on emotional states and its potential role in alleviating the stress associated with public speaking.



Analysis and Visualization/Storytelling of Your Data

We analyzed the effects of environment and events on emotional states through three case studies. It can be observed that the environment and specific events have a significant effect on people's moods, while the effect of events on moods is particularly prominent. By looking at GSR (skin resistance) values, we are able to understand the emotional state of individuals. Lower GSR values indicate that an individual is in a negative emotional state (e.g., anxious, tense, etc.), while higher GSR values indicate that an individual is in a positive emotional state (e.g., relaxed, happy, etc.). This analysis provides visual evidence of the association between environment and mood and highlights the role of specific events in shaping our emotional states. With this data, we can better understand and design environments and events that are more supportive of positive emotions.

Analysis and Visualization/Storytelling of Your Data



After several rounds of testing the GSR data and correlating it with self-reported emotional states, we established a standard for visualizing the data with different colors of lighting.

We defined GSR readings above 430 as indicative of a positive emotional state, which triggers green lighting. Readings between 350 and 430 signify a normal emotional state, activating yellow lighting. If the data falls below 350, it indicates a negative emotional state, triggering red lighting. Additionally, if the subject is experiencing an extremely negative emotion, with the data under 270, the red lighting will blink. Through this method, we established a relationship between GSR data, emotional status, and visual effects, laying the foundation for a semi-quantitative approach to data analysis.

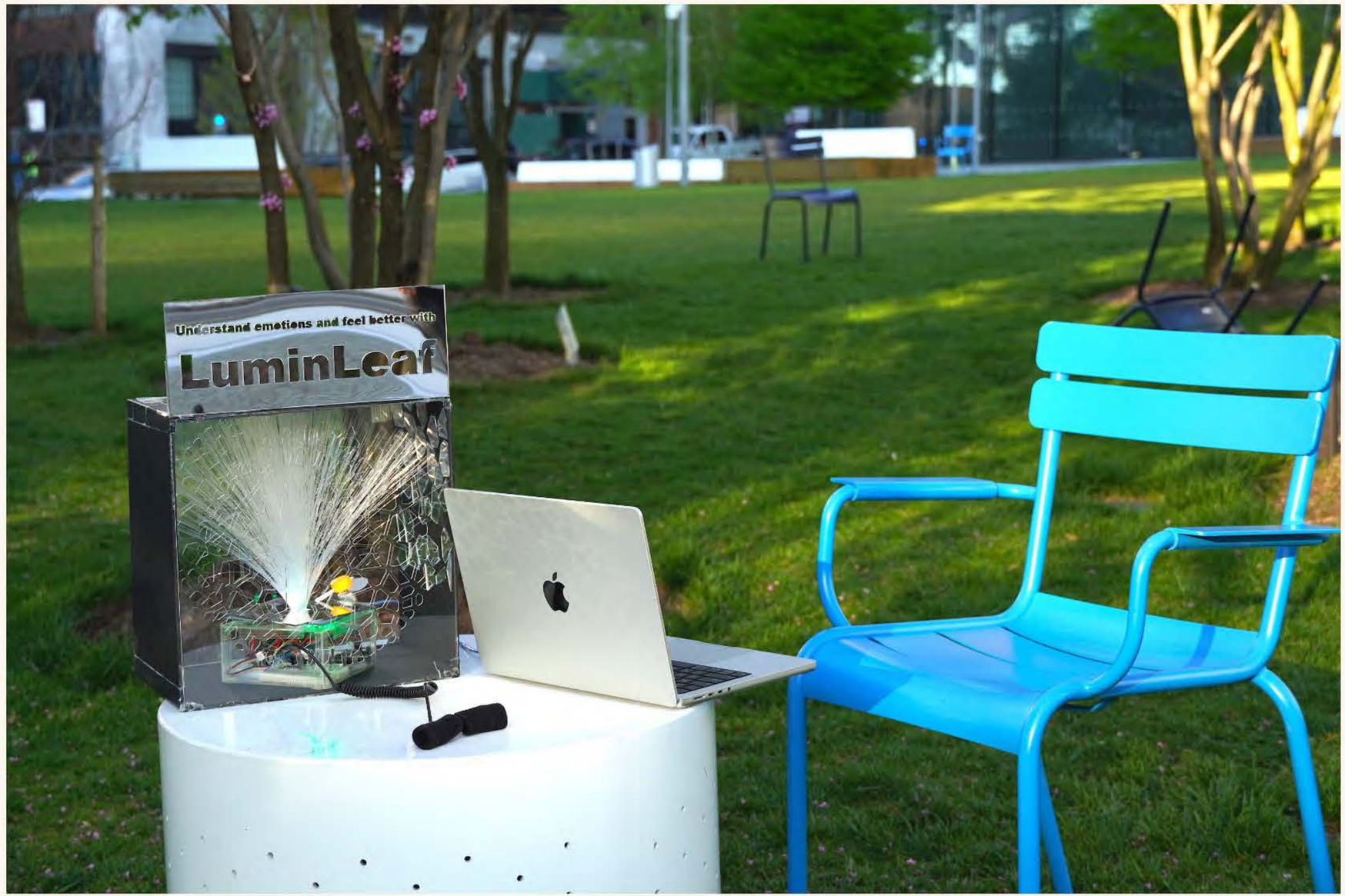
Depending on the emotional data, the plant will enter different modes. When the data is under 350—indicative of negative or extremely negative emotions—the fan blade is activated to move the leaves of the plant, creating a calming, meditation-like environment.

Anecdotes

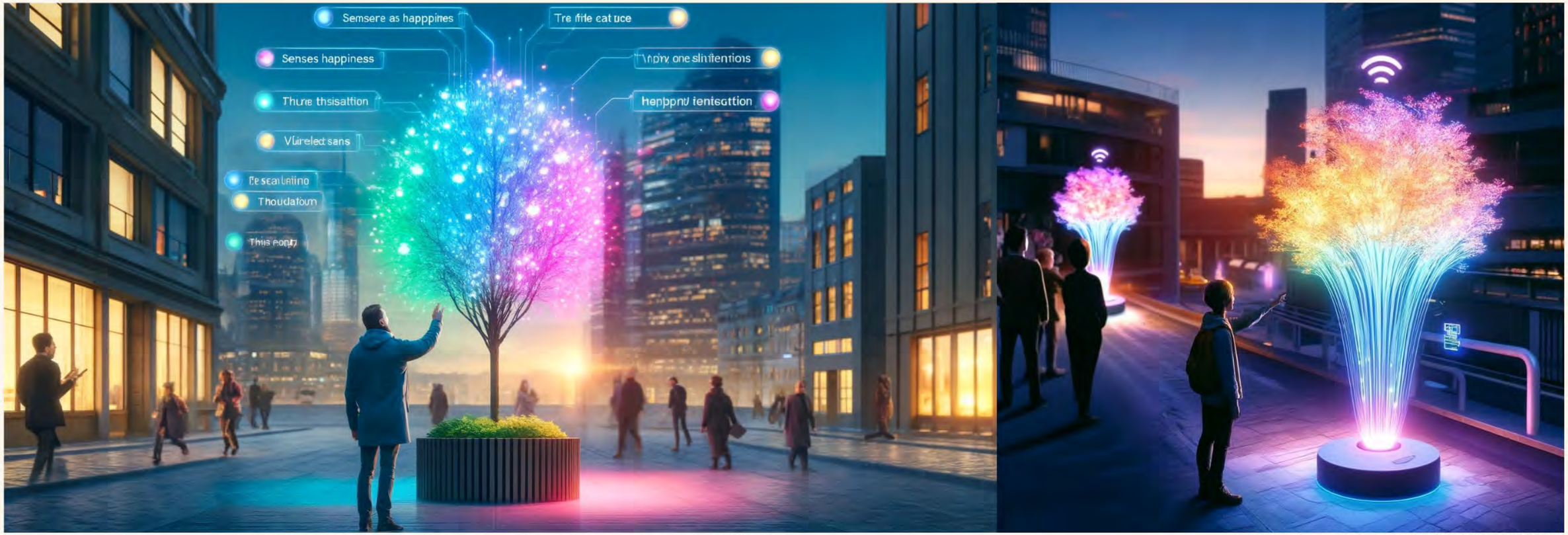
As the emotion issue is a common problem that people living in the modern city can confront, the prototype can be used in a urbna scale.

Although the prototype is one personal product that can be put on the table, it can be scaled up with a larger size to put in public space (e.g. park, square) in the urban setting. What needs to be changed is the way of detecking people's emotion. Instead of using GSR attached to the fingers, a more intuitive way of detecting emotion will be adopted to make it suitable for the public space.

The basic function of the installation is to detatct and visualize the emotional status through using different colors of lighting. If multiple installations can connected with each other, it can became a web of emtional data visualization. When one installation detecting positive emotions, it can be transfered to installations in other places to disseminate the positive emotion.



Urban Interaction



Images generated by ChatGPT-4

We expect the product to serve as a bridge between the user's emotional state and the necessary actions, not only to help individuals with self-understanding and emotion management, but also to provide healthcare professionals with an adjunct to support a more holistic approach to mental health management. When placed in public spaces such as offices and studios, it can provide reminders for individuals and groups to manage negative emotions.

It can also be placed in urban spaces as an art installation. We will remove the negative feedback from the product and only feed positive emotions. Imagine that when a passerby puts their hand on the sensor, their positive emotion will light up the "Tree of Joy" on the installation and spread this light to another corner of the city. Our vision is to make it easy for people to share their happiness through this device.

It is worth emphasizing that although data is collected during the experimental phase, no data will be stored in the final product. The data will only be used to instantly reflect emotional responses to ensure that people can share happiness without worry. Respecting and protecting personal privacy is our primary principle and we are committed to not inadvertently or intentionally recording, collecting or analyzing personal data.

Limitation

GSR, or Galvanic Skin Response, is a method that quantifies the electrical conductivity of a person's skin. While it serves as a valuable indicator of physiological arousal, it may not always provide an entirely precise reflection of an individual's emotional state.

Due to limitations on time, we still need more experiments to test our product viability in reflecting people's emotions and examining how people interact in response to our our product (lighting, fan spinning).

The current user experience can also be improved. Right now the user experience of having users to stick their fingers into the GSR hand gloves is not very ideal. Next iteration, we will focus on making the testing experience more user-friendly.

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mPath, https://www.buildempathy.com/sensors

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