Ambient Green – Screenless Device for Intuitive Communication of Environmental Conditions

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Abstract.
Air quality significantly affects our well-being, health and productivity. Measurements of air quality in classrooms on our campus showed overall negative conditions which usually stay unnoticed for an extended period. Yet, this could result in noticeable symptoms like fatigue, headaches or a higher risk of infection. The "Ambient Green" project has been developed as an alternative to standard air quality monitors, aiming to explore how awareness for indoor air quality can be raised in an intuitive, non-disruptive way while still providing all necessary information. To achieve this, two main approaches were employed. Firstly, experimentation was conducted on using moss as a natural indicator and air filter. Secondly, precise monitoring and concepts of visualizing indoor air quality through light were explored. In this manner, critical information on air condition becomes passively perceptible and naturally integrates into any surrounding. With modularity in mind, the concept features a design that is expandable and portable to accommodate different needs. Being aware of the current state of indoor air quality and its impact on our mental and physical well-being is a fundamental factor in adopting a more mindful approach.

Keywords: Air Quality, Reactive Lighting, Intuitive Data Visualization, Interactive Systems, Screenless Device, Environmental Communication.

1 Introduction

Air constantly surrounds us, yet it rarely receives conscious attention. However, indoor air quality significantly affects our physical and mental well-being, the risk of infection and our ability to concentrate [5]. Symptoms like fatigue or headaches are noticeable long before they are associated with air quality, resulting in measures being taken too late. Among the most relevant factors are CO2 levels, temperature and humidity, which interact closely. Measurements conducted in classrooms on our campus confirm this issue, showing poor conditions that went largely unnoticed by students most of the time [2].

A key reason for this lack of awareness might be due to how conventional air quality monitors present information. Most devices display information as numeric values or emoticons on small screens or rely on acoustic alerts. This could be perceived as disruptive and requires users to actively read the information on the screen. As a result, information on air quality often fails to translate into actual awareness or action.

The project “Ambient Green” aims to explore new concepts of communicating information on air quality in a non-disruptive, intuitive way through studies on moss, physical prototypes and interior lighting. It focuses on seamlessly integrating air quality monitoring into everyday workspaces while supporting a more mindful awareness of air and its impact on well-being.

2 Related Work

Given that people spend up to 90% of their time indoors, indoor air quality has become an important research focus with direct implications for health, comfort, and cognitive performance. Multiple studies confirm that air quality in public interior spaces such as classrooms is frequently insufficient, particularly with respect to CO2 concentration [5,13]. Measurements by the Saxon State Health and Investigation Office found that CO2 levels regularly exceed the recommended target value of 1,000 ppm, especially during colder months when consistent ventilation is harder to maintain [13].

Conventional approaches of monitoring indoor air quality commonly rely on small displays which provide numeric values about the current amount of CO2, humidity and air pressure. In some instances, the devices communicate unhealthy air quality by showing a sad emoji or by making a beeping-noise like the “Airvalent” air [11] (Fig. 1).

Fig. 1. Airvalent air monitor

Thus, they require the user to actively check on the display or might disturb them while being focused. On the other hand, “Ambient Works”, a UK-based startup, use more sensitive sensors for extensive measurements. They focus on long-term tracking of various pollutants in workshops instead of providing immediate insights [9] (Fig. 2).

Fig. 2. Ambient One – Portable air quality tracker and mobile app

As for moss, companies like “Alive Labs” (Fig. 3) use it in architecture to support biodiversity, store carbon and water, reduce air pollution and ultimately create more resilient environments [8].

Fig. 3. Alive Labs’ living moss panels used in architecture

This aspect is also made use of in the “Moss Air” humidifier by “mosslab” (Fig. 4). They created an air humidifier which, instead of essential oils, uses living moss to create a natural air purification effect [10].

Fig. 4. Mosslab Moss Air Humidifier

3 Experiment Setup

3.1 Sensors and Electronics

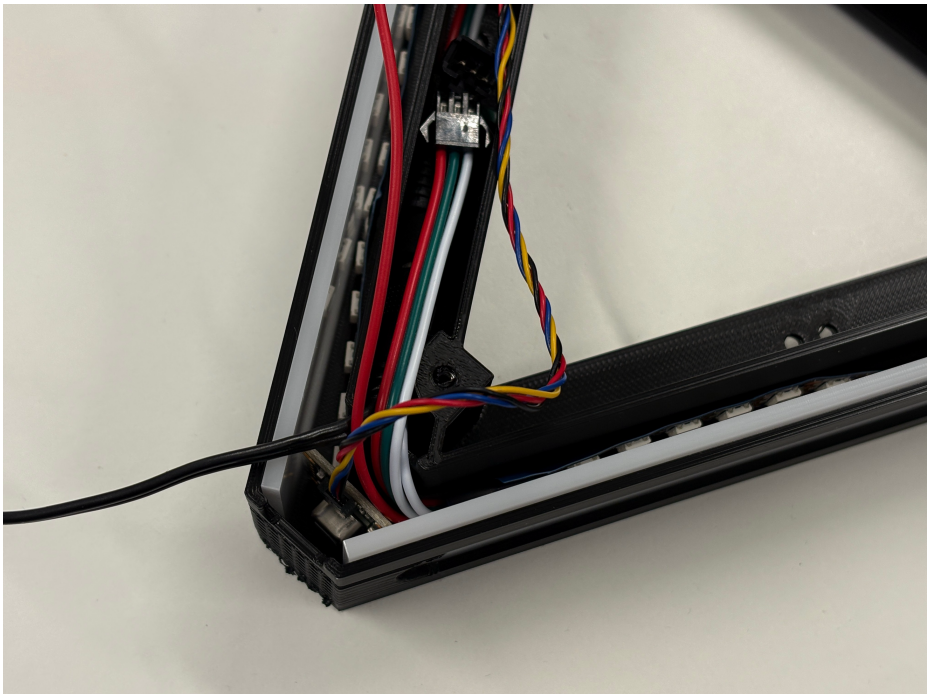

Fig. 5. 3D-printed PLA shell with Adafruit SCD-40 sensor connected to an ESP32-C6 and LED-strip

All sensors and electronics are housed within a 3D-printed PLA shell [Fig. 5]. An Adafruit ESP32-C6 Feather [3] receives values for CO2, temperature and humidity

from an Adafruit SCD-40 sensor [4]. The Arduino then controls an WS2812E LED-strip [12] based on the current CO2-values. Precise monitoring of CO2-levels indoors is communicated through cues in ambient lighting, indicating when action such as ventilation is advisable. This way, information on the current air quality can reside in the periphery of a user's attention and move to the center only when relevant. This happens in subtle, gradual steps to be non-disruptive and make information passively perceptible. The Arduino receives data on the CO2-levels in real time and changes the light respectively. Each device was programmed and controlled in Arduino C++. There are 5 different status-modes:

1) static light: CO2-levels below 800 ppm
2) gentle pulse: CO2-levels between 800-1000 ppm
3) fast pulse: CO2-levels between 1000-1400 ppm
4) blinking: CO2-levels above 1400 ppm
5) red light: signals an error state

3.2 Hardware Setup

The prototype consists of two 3D-printed PLA shells [Fig. 6]. The outer shell houses the sensor and electronics, while a smaller inlay holds the moss and provides back ventilation. This ensures that the electronics are safe from moisture while also making it possible to remove the shell with the moss to wet it or to completely exchange it if needed. The triangular shape of the prototype allows user to arrange and connect multiple of them in versatile compositions and makes it portable. It can be placed upright, laid down or mounted on a wall.

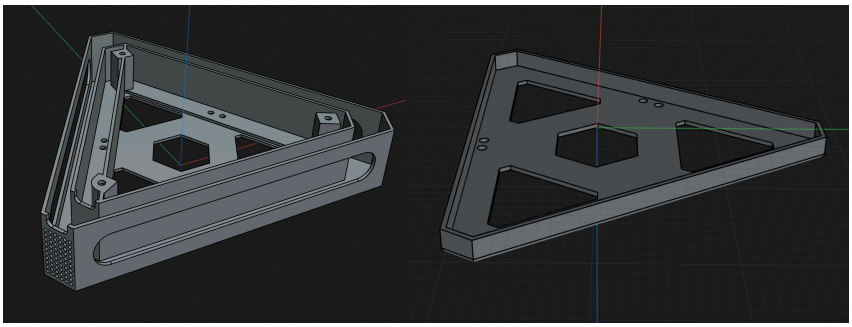

Fig. 6. CAD renders of the 3D printed shells. Left: Outer shell. Right: Inlay

The PLA shells are cladded with plywood [Fig. 7] to give the casing a natural and organic look. Furthermore, the light is diffused by frosted acrylic glass plates [Fig. 7] which sit in front of the LED-strip. Both materials were precisely cut with a laser and later onto the 3D-printed shell.

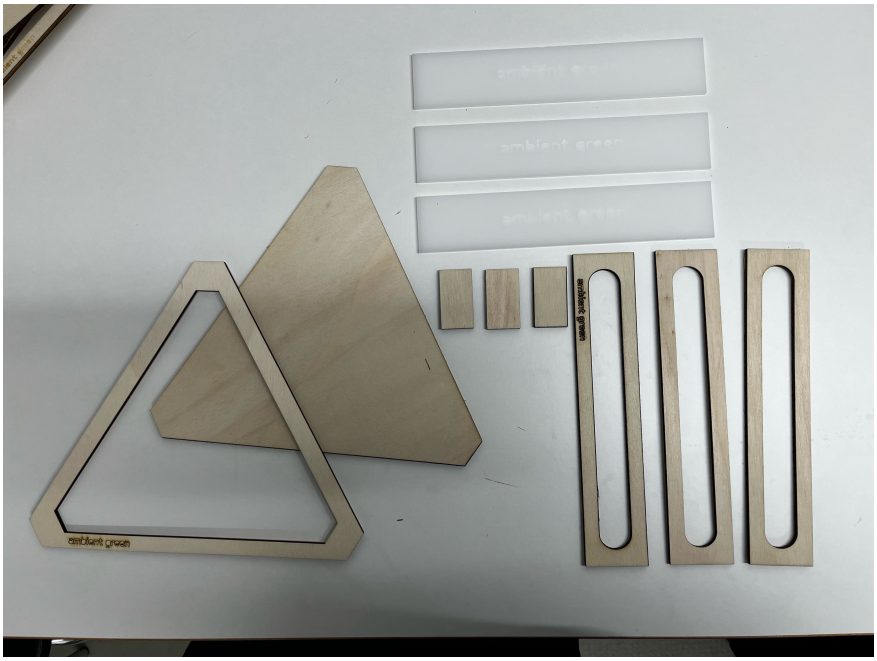

Fig. 7. Plywood cladding and acrylic glass parts before assembly

3.3 Moss

Prior research has demonstrated a range of benefits associated with the use of moss in built environments. Moss has been shown to reduce CO2 levels, filter airborne pollutant particles, and positively affect mental well-being and mood [6]. In addition, it contributes to the regulation of indoor humidity and exhibits sound-absorbing properties, thereby improving indoor acoustics [1,7].
In this project, different types of moss were tested for their suitability regarding our prototype. Aquatic mosses require a constantly high humidity, whereas woodland mosses grow particularly well with regular air circulation. Additionally, they only need to be sprayed with water up to twice a day which made them best suited for our prototype. Therefore, Dicranum Scoparium and Leucobryum Glaucum were propagated to be used and tested in the prototype. Dicranum Scoparium has an even surface, while Leucobryum Glaucum grows in clumps. Combining both creates a calm but texturized look.

3.4 Variants

We explored different, organic shapes to make the prototype feel more natural [Fig. 8]. Ultimately, we opted for the triangular shape in favor of modularity and ease of production.

Fig. 8. Left: Early-stage AI rendering made with Gemini. Right: Reference images of shapes

4 Results and Interpretation

The "Ambient Green" prototype demonstrates an innovative approach on communicating information on environmental conditions using a screenless device. Through the modular and portable design, measuring and understanding air quality becomes accessible and accommodates the needs of a wide group of users. The research findings clearly indicates that air conditions, especially CO2-levels, within most public interior spaces are not optimal. Considering those workspaces are where many people spend most of their time, it is likely that there is a persisting need for monitoring, understanding and being aware of air quality indoors. This requires more devices which intuitively communicate environmental conditions like the one developed in this study. However, not just as a prototype, but as fully developed and market-ready products.

5 Conclusion and Future Work

The product is supposed to be launched as a startup in near future, targeting offices, private households and educational institutions. Until then, research and development of the prototype continues. Future work will focus on adding additional sensors and refining material choice. Moreover, it is intended to make the prototype compatible with smart home systems to enable long term tracking and automated air quality regulation. As the impact on air quality of small patches of moss isn't significant, it is considered to create multiple, interchangeable inlays for the panel. Those could feature different types of plants or displays with extended features.

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