Tranquillity at Home: Designing Plant-mediated Interaction for Fatigue Assessment

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ABSTRACT

This paper presents a human-plant interaction system that helps observe daily mental fatigue levels by enabling the synchronisation of human eye blink data with plant health. We want to facilitate introspection on our subjective well-being by leveraging plants' organic growth as a reflective medium. Based on users' daily fatigue levels assessed from their eye blink data, the system controls the quality and intensity of the grow LED installed on the sensor-augmented plant. Another LED placed in front of the planter also displays the plant's health, combining light intensity and daily average eye blink frequency. We aim to design a novel means to connect human biosignals with plant health and introduce human-plant interaction as a reflection on subjective well-being.

CCS CONCEPTS

• **Human-centered computing** → **Systems and tools for interaction design**.

KEYWORDS

Human-Plant Interaction, Human-Plant Synchronisation, Bio-Digital Hybrid Systems, Positive Computing

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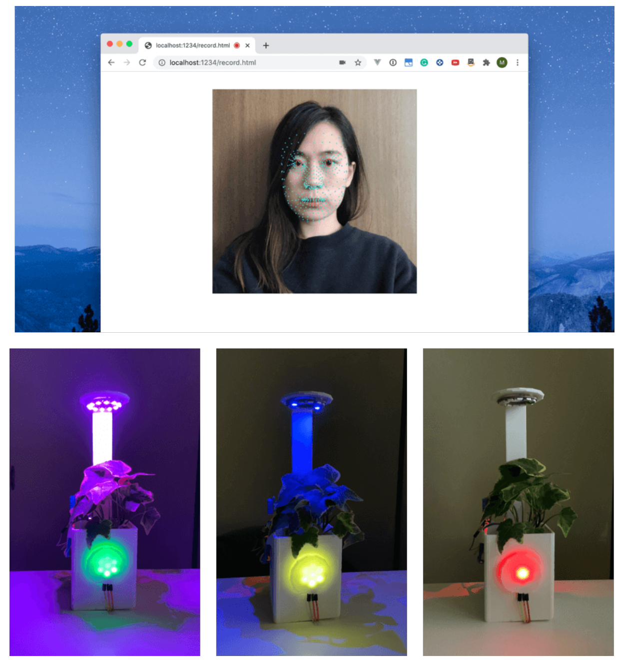

Figure 1: Browser-based eye blink detection using TensorFlow's face landmarks detection library (top). The augmented plant with a grow LED at the top of the planter and plant health LED indicator in front of the planter (bottom)

1 INTRODUCTION

Due to the prolonged social distancing measures and fear of the COVID-19, people are increasingly spending a significant amount of time at home during the pandemic. This imposed restriction has inevitably deprived many of one's agency, putting further strain on mental health. As a way to combat growing concerns about deteriorating mental health, we present a novel interaction system that supports reflection on one's subjective well-being while offering an opportunity to reconnect with nature at home through plants.

The therapeutic aspect of nature, including houseplants, has been well researched [12, 15, 18]. However, there has been little research into employing plants as a support medium for improving subjective well-being in the HCI field. Some works have attempted to facilitate healthy habits using plants as motifs [3, 8, 14]. Kaner et al., for instance, visualises an artificial plant on a water bottle to encourage users to drink more water [8]. While it is a rare example that incorporates a plant to promote well-being, a plant remains a motif rather than an interaction medium in this case.

There are also instances which incorporate physical plants as information displays [5–7]. Yet, they are mostly interested in plant movements for notifications or treating each plant as pixels in displays. Only a few have considered incorporating personal digital data into human-plant interaction [10, 11]. However, to the best of our knowledge, we are not aware of other attempts to synchronise human biosignals with plants.

The contributions of this work are as follows:

- Implementing an initial prototype that connects human biosignals with plant health to synchronise eye blink data (i.e. fatigue levels) from a user with lights to increase/inhibit plant growth.

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- Introducing and discussing human-plant interaction as a reflective medium for subjective well-being.

2 APPROACH

One important characteristic of the human mind is that it has significant fluctuations in productivity and capacity. Our mind has ebb and flow and is affected by various factors, some of which we do not even realise. For example, when it comes to judging one's fatigue levels, people seem to be quite unreliable [22]. There are a variety of technologies that can be used to assist fatigue assessment by measuring biosignals [2, 17, 21, 22]; however, the examples that successfully integrate such technologies into human-plant interaction systems are close to none. Thus, we devised a human-plant interaction system to synchronise human eye blink data (as a proxy of fatigue levels) with plant health. To assist people with effectively assessing their fatigue levels, we link users' cognitive state to plant attributes in their environment by providing a more visible representation of the fluctuations in productivity and capacity. We focus on assessing fatigue and mapping fatigue levels to plant health in this prototype.

3 PROTOTYPE DESIGN

The key parts of the system involve effectively measuring mental fatigue levels and visualising them with plants to create a sense of human-plant synchronisation. To implement these parts, a reliable biosignal sensing method and intuitive visual feedback are necessary. We used a browser-based eye blink data collection to assess human fatigue levels and use the data to control the grow LED installed on top of a plant. We will elaborate on the setup and interaction design in the next section.

3.1 Setup

The system is comprised of following components: 1) an augmented plant with sensors (light, humidity and temperature sensors) and actuators for monitoring and visualising plant health, 2) a grow light (LED) to regulate plant growth, 3) and the software for computing human fatigue levels based on daily eye blink data and sending it to the augmented plant. An ivy plant was chosen for this setup since it is well suited for growing indoor and can develop a discernible growth within a relatively short period time (e.g. two leaves per week [20]).

3.2 Measuring Mental Fatigue Levels

For measuring mental fatigue levels, we built a browser-based eye blink detection system using face landmarks detection library from TensorFlow.js. Since the library does not compute eye blinks, we applied the algorithm proposed by Soukupová and Čech [19]. The algorithm utilises a metric called the eye aspect ratio. It computes the absolute distance between each set of vertical eye landmarks (the difference between P2 and P6, P3 and P5 in the figure 1) and divide the sum of each vertical distance by the multiple of 2 of the absolute distance of horizontal eye landmarks (P1 and P4 in the same figure). The equation for the eye aspect ratio is as follows:

$$EAR = \frac{||p2 - p6|| + ||p3 - p5||}{2||p1 - p4||}$$

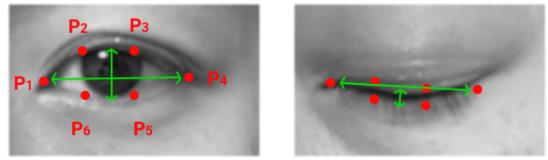

Figure 2: Implementation of eye blink ratio based blink detection (based on Soukupová et al.[19])

3.3 Synchronising Fatigue Levels with Plant Health

To communicate mental fatigue levels with a plant, we employed a grow LED in two colours: 1) purple (the combination of blue and red) for no or minimal fatigue, and 2) blue for increased fatigue levels. The rationale for choosing these colours is that they are known to influence plant growth; purple facilitates plant growth [13, 16], and blue inhibits it [4, 9]. In other words, an optimal cognitive status is linked to facilitating plant growth, and a deteriorating cognitive status is linked to inhibiting plant growth. Upon determining the colour of the grow LED, the threshold was set to 15 blinks per minute since it has been reported as normal spontaneous blink rate [1, 17]. If the average blink rate per minute of a user is higher than 15 (indicating fatigue), the LED turns to blue (inhibiting plant growth). If the blink rate is equal or below the blink rate threshold, the LED turns to purple (promoting plant growth). The blink rate threshold can be adapted for individual users in future work.

As for determining plant health, we employed pseudo metrics to visualise changes in daily plant health observable to human eyes. In addition to representing human fatigue levels, the two grow LED also influence plant health in this prototype. Based on the grow LED intensity read from the light sensor and eye blink frequency thresholds, the augmented plant visualises its health status in green, yellow, and red, indicating good health, diminishing health, and need for attention respectively.

In short, by showing the direct link between human fatigue levels and plant health, the system offers a means to reflect on one's subjective well-being and aims to show how plants and human well-being can improve together as a result of human-plant synchronisation.

4 CONCLUSION & FUTURE WORK

In this paper, we introduced the concept of human-plant synchronisation and how an interaction system supported by this concept can visualise subjective well-being. This research delved into approaches that enhance a symbiotic relationship between humans and plants through visualising the connection between human biosignals (i.e. eye blink data) and plant health. Future work will involve an in-the-wild evaluation study to observe the changes in both human subjective well-being and plant growth over the long period of time. It will also evaluate how a degree of human-plant synchronisation will affect human subjective well-being.

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