Eye-tracking to Optimize Lighting for Stress Management

Benjamin Ong

Hongpo Chen

Vaishob Anand

Luleå University of Technology

M7012E Pervasive Computing

Kåre Synnes

24th Mar 2023

Abstract

Measurement of eye movement can be helpful in studying mental health. In medical science pupillary tracking is helpful in detecting traces of depression, stress or anxiety. Many studies have been undertaken to study how different emotional states of a person affects the pupil movement. Similarly, multiple studies have also shown how different light can affect and improve a person's emotional state. With this knowledge, we are attempting to use eye tracking to measure emotional states and change the lighting respectively in response to the state, hence immediately alleviating negative emotions.

Keywords – eye detection, eye movement, lighting, pupil movement.

Introduction

In today's world of emerging artificial intelligence and machine learning, people are trying to make quality of life improve by having a network of physical objects embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. This is commonly known today as the Internet of Things (IoT). In this study we look to optimize the environment of an elderly person's room - particularly the lighting - to improve stress management for better well-being and health. Researchers have developed software which can track different body parts like head, eye, hand etc. of subjects, by analyzing these body part movements the condition of mental health of concerned person can be diagnosed (Šumak et al., 2021) and by tracking eye movements like eye

blink , eye gaze and pupil dilation, researchers are able to detect the present emotional state of a person (Skaramagkas et al., 2021).

The objective of this study will be to develop a system that monitors the user's eye movements to measure their stress level at any point of time. Once erratic eye movements are detected from the user, depending on the level of stress the user is determined to be undergoing, the lights will change accordingly to soothe their emotions.

Eye-tracking to Optimize Lighting for Stress Management

Having to present deliverables within the short time frame, the nature of this project did not allow us to prioritize data collection. Instead of collecting data with participants as with previous studies, we based our knowledge on previous research studies done on this topic and focused on the creation of a working prototype.

Methodology

Participants

The participants of this study were the members of our team, 3 males between the ages of 22 and 24. All participants had either normal or corrected-to-normal vision with no history of neurological or psychiatric disorders.

Apparatus

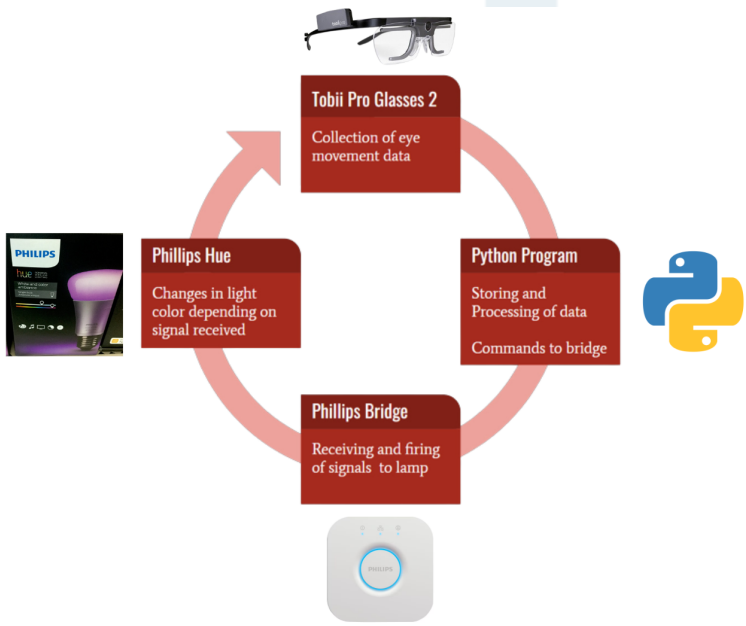


Figure 1.1 Apparatus used

The eye-tracking hardware that was used to measure the participants' eye movements was a Tobii Pro Glasses 2 which could measure eye movements and various metrics such as

pupil dilation. Participants were made to wear the glasses and calibrate it by looking at a calibration card provided. The glasses were then detected and connected to a computer by a Python program written with the Tobii Pro Glasses API, so that data could be fed to the computer and recorded.

The ambience lights in this experiment for the changing of color in response to stress was 2 Phillips Hue lightbulbs connected to power. They were connected to a Phillips account online using the Phillips bridge, so that we were able to fire a JSON webhook to send controls to the bulbs.

Implementation

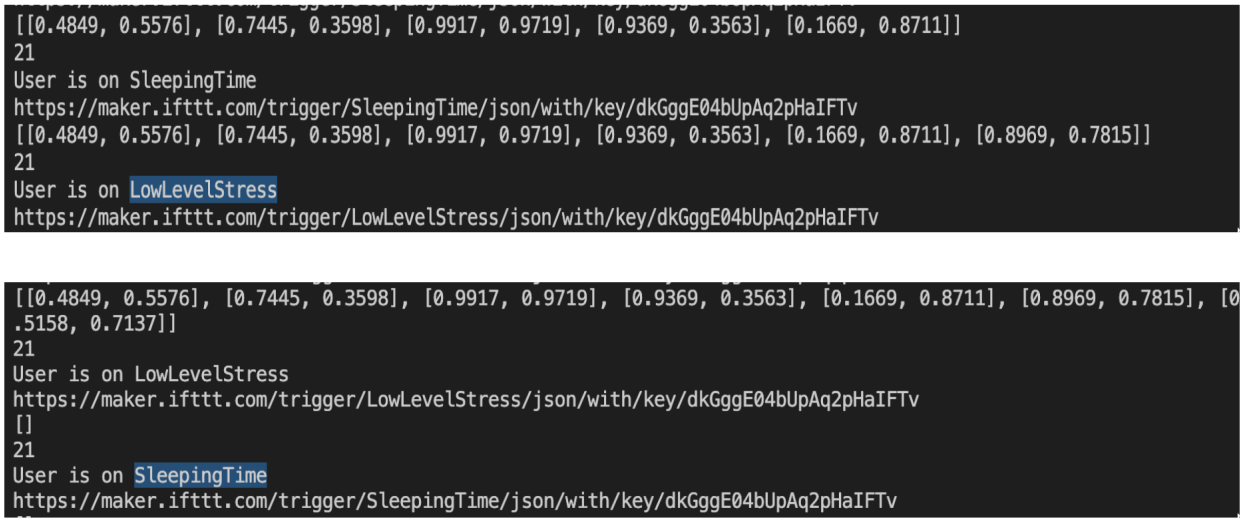


Fig 1.2 Data and Firing of Signals

The pupil movement data was collected and recorded on the computer, which was in the format of the relative distance from 0-1 with respect to the x and y axis. This data could be stored as it was collected live so that it could be compared with previous pupil location data, to calculate the movement of the pupil. When the pupil moved more than a certain threshold, the data was stored and this would be an indication of stress. As more and more stress data is collected, the program would be able to determine the current stress level of the participant and

check the current ambience lighting in the room. When the program deems the stress level high enough, the JSON webhook would be fired for the color of the Phillips Hue bulbs to change its color into a color that is proven to reduce stress. Furthermore, the default lighting color of the Phillips Hue bulbs also take into consideration the current time, taken from the computer's clock, to determine if it is white or yellow.

Results

We were successfully able to develop a system that monitors the user's eye movements to measure their stress level at any point of time. Upon multiple trials using test subjects in different scenarios, the system was able to accurately identify the user's stress level based on their level of erratic eye movements, before adjusting the ambience lighting accordingly.

Scenario 1 - High Stress Level, Day Time

Since it is day time, the ambience lights would be originally white. When the erratic eye movements of the test subject were determined to be "High", the JSON webhook would fire, causing the ambience lights to turn pastel blue. Blue color is chosen due to the calming effects that it has (Lubos, 2012). As a result of this environmental change, the test subject reported feeling more at ease, demonstrating a significant calming effect.

Scenario 2 - Medium Level Stress, Night Time

When the computer clock corresponds to "night time" at the user's location (anytime between 8pm and 8am), the color of the ambience lights would change from white to yellow. When the eye movements of the subject correspond to "Medium", the webhook fires to change the color of the ambience lights to pink. Pink is also deemed by studies to have a calming effect

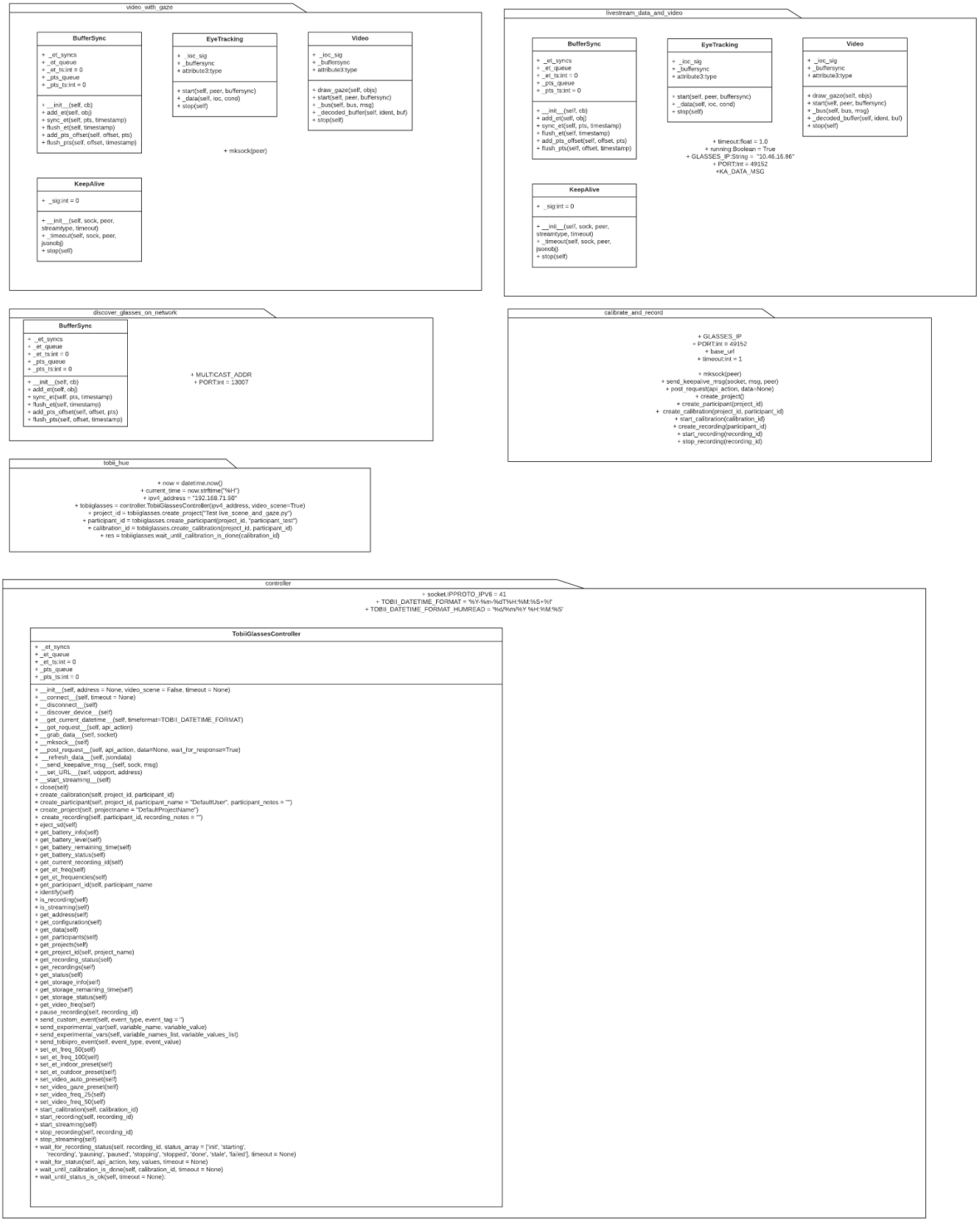
that is significant albeit lower than that of blue (Lubos, 2012). This made the test subject feel more relaxed, allowing them to fall asleep easier.

Discussion

The present study was conducted to measure emotional states of people, and control their anxiety effectively. The results of this study show that it is possible to develop a system that manages the smart-home features of a home (specifically the lighting) such that their mental health is prioritized. This is important in the modern day and age where life can be very fast-paced and unforgiving. Several limitations of the study include the lack of time to facilitate an in-depth data collection phase, as well as to carry out rigorous tests of the prototype on new test subjects. Potential future extensions to the project can include additional means of determining stress level, such as monitoring sweat gland activity, heart rate and breathing.

More time could have also been used to research the specific choices of colors for the stress levels. While there has been research on this topic in the past, carrying out our own individual trials could have confirmed the effectiveness of the specific shades of the colors - only generic colors like ‘pink’ and ‘blue’ were mentioned but we were unable to verify whether we had used the most effective shades of colors possible.

Appendix I - UML Class Diagram



References

Lubos, L. C. (2012, July). (PDF) the role of colors in stress reduction - researchgate. The Role of Colors in Stress Reduction. Retrieved March 8, 2023, from https://www.researchgate.net/publication/314578015_The_Role_of_Colors_in_Stress_Reduction

Skaramagkas, V., Giannakakis, G., Ktistakis, E., Manousos, D., Karatzanis, I., Tachos, N., Tripoliti, E., Marias, K., Fotiadis, D. I., & Tsiknakis, M. (2021). Review of eye tracking metrics involved in emotional and cognitive processes. IEEE Reviews in Biomedical Engineering, 16, 260–277. https://doi.org/10.1109/rbme.2021.3066072

Šumak, B., Brdnik, S., & Pušnik, M. (2021). Sensors and artificial intelligence methods and algorithms for Human–Computer Intelligent Interaction: A Systematic Mapping Study. Sensors, 22(1), 20. https://doi.org/10.3390/s22010020