


Developing a Near-IR Eye Tracker to Analyze Eye Movements Related to Suicide Risk Assessment

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Abstract. *This project's aim is to develop and evaluate an eye-tracking system to record different eye parameters. The use case for the developed eye-tracking glasses is to detect pattern between people with and without suicidal risk. The eye-tracking glasses use near-infrared to track the pupil and record the eye parameters. The system will be evaluated through a study. The question to be investigated is whether people with suicide risk show different eye parameters during a psychological interview than people without suicide risk. Additionally, during the study participant's heart rate will be measured. The research will involve recruiting a sample of individuals with a history of suicidal ideation and/or attempts as well as a control group of individuals with no history of suicidal behavior. This project is carried out by the regional hospital KABEG and the Carinthian University of Applied Sciences and the results project will have implications for the development of new tools for assessing suicidal risk. If there is a significant difference between the eye patterns of the two groups, the findings of this research will contribute to the development of more effective interventions for preventing suicide.*

Keywords. Eye-tracking-system, near IR, suicide risk assessment, heart rate, oxygen saturation

1 Introduction

Technology in mental health has seen significant growth in recent years. One such technology is the near-infrared camera, which can measure the precise pupil position, its relative size, and other parameters such as blinks or saccades. These parameters have been studied as potential indicators of various mental states, including suicidal ideation [1].

Suicide is a serious concern, and early detection and intervention are crucial to preventing this act. While traditional methods of detecting suicidal ideation, such as self-reporting, professional questionnaires, and psychological tests are today's standards to assess one's suicidal risk, they have limitations, including the need for highly skilled and trained psychotherapists and the establishment of a very safe and well-thought-out environment. This is taking a big toll on both the doctors and the group at risk.

Despite the great effort in the past to systematically try to assess one's mental state, e.g., through mimic or vital parameters such as heart rate [2], the idea of trying to identify suicidal risk by both analyzing eye movement alongside the heart rate remains insufficiently investigated.

Building a near-infrared eye camera for detecting parameters related to suicidal ideation requires a multidisciplinary approach involving knowledge of optics, image processing, and mental health.

In this project, the goal is to build a near-infrared eye camera and develop algorithms to analyze the data collected from it. The hope is that this technology could possibly be used in clinical settings to help identify individuals at risk of suicide and provide appropriate interventions.

2 Methods

For building the IR-Eye tracker, the following components were used:

- 4 x 100 Ohm Resistors
- Normal glasses frame (plastic)
- Microcontroller (ESP32 Cam)
- rotary potentiometer to regulate the IR LEDs brightness.
- 4 x Infrared LEDs
- IR Camera (OV5640)
- USB Socket
- USB-Type A to USB-Type A Cable
- WLAN Router (802.11b/g/n)

The ESP32 microcontroller can transfer data through various communication interfaces such as UART, SPI, I2C, Ethernet, and Wi-Fi.

Since the initial thought was to make this eye tracker completely wireless, the chosen data transfer method was Wi-Fi. The video stream can be easily accessed by calling the IP address of the connected microcontroller.

After assembling the components together, the next challenge is to develop the corresponding software.

For this project, the chosen programming language is python for the whole process, from creating the API to the image processing. This poses some challenges, but it also makes the development consistent. The first step was to decide if the graphical user interface (GUI) library would allow interaction with the eye tracker. A popular library “PyQt5” was used to construct the whole GUI. PyQt offers a rich set of widgets, a flexible workflow, a customizable design, and a multithreaded-safe approach, of which its importance will be explained in short. Furthermore, it offers its own plotting library “pyqtgraph”, which utilizes the GPU power to allow for much faster and smoother line real-time rendering [3].

The software is required to be multithreaded since there are four main processes that ought to be running in parallel. First, the camera thread, which receives the stream data directly from the ESP32 Cam system. Secondly, the GUI interaction is a separate process that, in no case should affect the video stream. Then the image processing module, which is important for pre-processing and image pre-filtering. Finally, the saving process, which allows the data to be saved/recorded in the background.

The software design is illustrated in Figure 1.



Figure 1. Software design concept for the Eye tracker system

The next step is to develop an algorithm that detects the eye parameters. This is not an easy task since there are many relevant parameters that aren’t directly detectable and always contain some error (e.g., the pupil size when the person is looked at from the sides).

The importance of using IR images can be seen by looking at Figure 2, the pupil is much easier to separate and detect. Also, the noise effects are drastically reduced using IR.

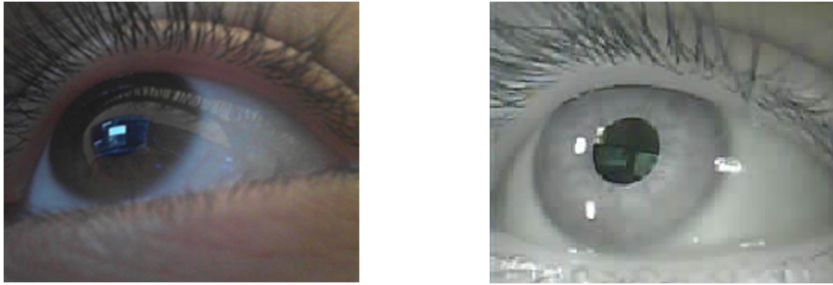


Figure 2. a) without Infrared

b) with Infrared

Since the images are captured with an IR sensor, the intensity of the pupil is clearly visible and different from the other parts, meaning that it should be possible to detect it by using simple image processing techniques (erosion, binary filtering, ellipse fitting, etc.). For now, the “simple blob detection” algorithm was used, which basically detects blobs (big objects) in an image that share common properties such as color, connectivity, and distance. Some additional tuning parameters, such as the circularity, convexity and inertia of the desirable object can be manually tuned.

Essentially, the following parameters were used:

- Minimum Area: 500
- Maximum Area: 5000
- Threshold: 0-120
- Circularity: 25
- Convexity: off
- Inertia: off

3 Results

The design for the eye tracker took many iterations, in Figure 3, the final concept can be seen and its realization.



Figure 3. a) 3D Visualization of the eye tracker concept b) Real implementation of the eye tracker concept

The software derives video from one or both eyes. Currently, the glasses consist of one camera. With the video of the eye the eye parameter can be constructed. The heart rate is measured by a conventional pulse oximeter. Furthermore, the voice of the participants will be recorded to divide

the segments into the corresponding number of questions. Also, the metadata of the participants will be noted, such as their sex, age, suicide risk, diseases, and types of taken medication of the participants.

4 Discussion

The further steps in this project are to develop a website or another platform to analyze the recorded eye parameters and other measured vital parameters such as heart rate and oxygen saturation. This website should represent if there is a significant different pattern between people with suicide risk and people without. The project is currently in the middle of implementation phase and should be completed in June 2024 at the earliest.

References

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