Siddaganga Institute of Technology, Tumakuru

(An Autonomous institution affiliated to Visvesvaraya Technological University, Belagavi, Approved by AICTE, New Delhi, Accredited by NAAC and ISO 9001:2015 certified)

EARLY DETECTION OF DRY EYES THROUGH BLINK

A project report submitted to
Visvesvaraya Technological University, Belagavi, Karnataka
in the partial fulfillment of the requirements for the award of degree of
Bachelor of Engineering
in
Computer Science and Engineering
by

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CERTIFICATE

This is to certify that the Project Report entitled **" Early Detection of Dry Eyes through Blink "** is a bonafide work carried out by **Chayashree K(1SI18CS025), Harshitha U K(1SI18CS039), Mohammed Sayeed(1SI18CS057) and Nagaditya L P(1SI18CS058)** in the partial fulfillment of the requirement for the award of the degree of Bachelor of Engineering in Computer Science and Engineering, Visvesvaraya Technological University, Belagavi during the year 2021-22. It is certified that all corrections/suggestions indicated for the internal assessment have been incorporated in the report.The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the Bachelor of Engineering Degree.

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DECLARATION

We hereby declare that the entire work embodied in this dissertation has been carried out by us at **Siddaganga Institute of Technology** under the supervision of **Dr. Sumalatha Aradhya, Assistant Professor**, Department of Computer Science and Engineering. This dissertation has not been submitted in part or full for the award of any diploma or degree of this or any other University.

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Contents

Abstract

Blinks are the movements that happen involuntarily and can be used in many applications such as wearable computing, Human-Computer interaction, etc. Blinks can be considered as one of the changes that happen visibly when there are any abnormalities in our eyes. These abnormalities of blinks can be used for the early detection of eye diseases. Here, we are considering it as one of the major parameters in the detection of dry eyes. This can be achieved using cameras and sensors. To achieve high accuracy results using a camera, the resolution must be high which results in huge amounts of data. On the other side, sensors are less expensive as well as the data generated from sensors can be easily processed. Sensors are comparatively reliable and superior to other methods.

So, we are doing a comparative analysis of the following methods: EEG, EOG, and OpenCV. EEG sensors can be used in brain wave analysis through which blinks can be detected. OpenCV has vast libraries where users can perform various tasks like removing red eyes, extracting 3D models of objects, following eye movements, etc. So we are making use of an existing algorithm to detect blinks so that we can compare ML algorithms versus sensors. And the third method we are using is EOG where we are collecting data in the form of voltage and with the help of Coolterm software blinks will be detected. We have designed a website where users can use it in real-time applications.

List of Figures

Chapter 1

Introduction

1.1 Background Study

Dry eye disease[DED] is no longer confined to old-aged people but is an emerging health problem that is affecting the younger human population too. The impact of DED is beyond our vision where it is impacting the quality of life of an individual who's suffering from DED which may lead to other eye-related issues if it's ignored without being treated. Since India is an emanating economy with most of its population falling under the growing middle-class category and a drastic increase in the migration of people to urban areas and a large age-old population, the country is on the verge of a DED epidemic.

As we have all been suffering from pandemics for the past couple of years and we are all moving towards digitalization screen time has increased drastically. Increased usage of smartphones is strongly associated with DED, especially for children which is leading to early age eye diseases.

As dry eyes are closely associated with tear film where it has to be stable which can be achieved through spontaneous blink rate. Spontaneous blink is a rapid, automatic, and unconscious closing and opening movement of the eyelids which helps in the spreading of tears on the ocular surface. The major two factors which affect spontaneous blinking are age and mental activity. Low blink rate is one of the risk factors for the development of dry eye disease by increasing tear film evaporation. So blink rate has been considered as both consequence and cause of DED.As blink occurs at high speed (1 blink in ¡ 100ms), it is quite challenging to measure and analyze the parameters of blinks. So blink rate and inter-blink interval can be taken into consideration as parameters.So, we are considering both blink patterns and other clinical parameters for the analysis of dry eye disease.

1.2 Related Works

1. **EM Sensor**

   The idea behind this technique is to attach an EM sensor to items that will be worn on a daily basis. By observing the relative movement between the attached EM sensors, which results in a change in mutual impedance/inductance signal, the relative mechanical movement between eyelids may be tracked [21].

   Tools required –

   - Wearable glass
   - Two wearable false eyelashes with EM sensors attached on it
   - Ethernet cable to connect to the EM instrument.

2. **Infrared**

   The IR light reflected back from the eye is analysed in this manner. An IR light emitting diode (LED) that lights the eye surface, as well as an IR photo diode that detects IR light signals reflected back from the eye, are required for a typical IR eye blinks measuring equipment [17].

   - As a result, this sensor is attached to the goggles and worn by the patient whose record must be kept. The value is sent to the ADC, which is then sent to the microcontroller, where the eye blinks are displayed on the screen using LabVIEW software.
   - An ideal IR eye blink detector should be able to detect the full range of eyelid movement, the IR LED should also completely illuminate the surface of the fully opened eye, and the IR photodiode's field-of-view should include the entire eye area.
   - As the eye blinks, the variation throughout the eye will change. If the eye is closed, the output is high; if the eye is open, the output is low.
   - This can be used to determine if the eye is closed or open. The used eye blink sensor has an Adjustable Range with POT and a 5 Volt Operating Voltage. It has a logic output range of 0 to 5 Volts.

- A goggle is attached to the eye blink sensor. Three pins link the sensor to the PCB. The ground pin is connected to the other pin, which is connected to +5 Volts.
- The third pin provides the eye blink output, which is supplied to the controller unit's ADC. The patient who is being monitored must wear this goggle at all times.
- As a result, this sensor is attached to the goggles and worn by the patient whose record must be kept. The value is sent to the ADC, which is then sent to the microcontroller, where the eye blinks are displayed on the screen using LabVIEW software.
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- The third pin provides the eye blink output, which is supplied to the controller unit's ADC. The patient who is being monitored must wear these goggles at all times.

3. **Magnetic Sensors**

   Introduction:

   - The movement of a tiny magnet on the top eyelid is detected using a magnetic field sensor-based eyelid motion monitoring device.

- Custom gear and software are used to capture and analyse motion, enabling for both real-time and off-line data visualisation.
- The Eyelid Motion Monitor connects the blinking characteristics of eyelid movement with the system's output voltages.
- A magnetic field is formed when the magnet on the top eyelid approaches the bottom sensor, causing the voltage to rise (peak voltage indicates a completely closed eye), and as the magnet moves away from the sensor, the voltage drops until it peaks at a lower value (eye fully open).

Description of the system:
The designed portable system is made up of four parts:

- a tiny magnet
- For the patient, glasses with magnetic field detectors Hardware consists of digital and analogue cards that sample, process, store, or transmit data that is controlled by "eyelid device embedded software."
- "Eyelid Pro" is a dedicated program that provides a user-friendly interface for the MD.
- The EMM device built is not very expensive;
- It's simple to do in a typical clinical setting, and it may be easily created as a commonly available gadget for diagnosis and follow-up.
- The magnets used were so small that after they were placed on the eyelid, the individuals were completely oblivious of them.
- The examination does not require the use of chin supports or head fixation, and it is conducted in a normal setting without the use of any complicated or cumbersome apparatus.
- Through a specific software program, it gives a mathematical analysis of eyelid movement as well as a full thorough recording. The full examination takes 15 minutes to complete, including setup, measurement, and interpretation of the data.

4. **Electroencephalography (EEG)**

   EEG is a sort of electrical recording used to track brain activity, which is represented as voltage variations caused by ionic current flows within the brain's neurons [13]. Electrodes placed on the scalp over the brain can be used to record it (non-invasive). The EEG signals have an amplitude of 10 to 200 V and a frequency of 0.5 to 40 Hz. The brain's electrical signals are recorded in many frequency bands, including alpha, beta, gamma, and delta [9]. Delta waves (0.5 - 4Hz) are the slowest EEG waves, which are most commonly identified during deep and unconscious sleep. During sleep and silent focus, theta waves (4 - 8 Hz) can be detected. The alpha band (8-14 Hz) is produced during moments of relaxation when the eyes are closed but the body is still awake. During normal consciousness and active focus, the beta band (14-30Hz) emerges. Finally, electrical responses in response to visual stimuli are known to be stronger in Gamma waves (above 30Hz). Figure 3 depicts the EEG headset that the patient will be wearing.

   Visual stimuli elicited EEG records, as well as mental processes. When it comes to detecting blinks with sensors, there are numerous hurdles to overcome, as blinks can be voluntary[6] or involuntary, and the person wearing the sensor can be conscious, which will alter the blink rate and results [22] . As a result, the BCI headband met the majority of our requirements because it is non-invasive and low weight, and it does not alter the patient's bodily motions. The Brainsense is another BCI device that uses non-invasive electrodes, i.e. electrodes that can be implanted in the scalp of the brain rather than being injected into the brain tissues, and it is also a dry electrode that does not require any gel prior to usage.

   The patient should wear the headset at first so that the electrode present in the band (can be seen as a small silver circle in the black band) is at the front of the head. The clip shown in the figure should be fixed to one of the ears. Cells required for operation of the device are inserted and then the headset device is switched on. Now, the device and the system (pc or laptop) must get paired through Bluetooth connection. Once Bluetooth pairing is done, Neuroview software is opened in the system and blink data recording will start after selecting the required baud rate. Blink patterns can be seen on the software screen which will be in real time. Once after removing the headset device, all the data collected will get downloaded as Notepad text files to the desktop.

EEG's method of differential amplification, or recording voltage changes between distinct sites using a pair of electrodes, is used in blink detection [10]. One active exploring electrode site is compared to other neighboring or distant reference electrodes. EEG waveforms can only be discerned by monitoring variances in electrical potential. Blink detection can be done using the peak and trough of the waves.

Technical specification of EEG –

- Module : TGAM 1
- The two electrodes are the main electrode and ear clip electrode (Ground).
- Non-Invasive — Dry Electrode Type
- 3 AAA batteries - required.
- Setup time - 6 hours
- Bluetooth v2.1 connectivity
- Windows or Linux or Android or Raspberry Pi or Arduino compatibility
- EEG Bands (Alpha, Beta, Gamma, Delta & Theta)

Drawbacks of EEG –

- Analog wave output couldn't be tapped out in anyways from the device since the output coming from the built-in amplifier itself is digital.
- Since the device works with Bluetooth (i.e. data log files are generated and sent to PC via Bluetooth), data acquired may be delayed. Few blinks may not be recorded. Also, it's not reliable.
- Even though the wave reaches its peak as and when blinked, final data generated in the log file is un-interpretable, parameters are unknown.

5. **Google glass**

Infrared proximity sensors in Google Glass can detect eye blink. It keeps track of the distance between Google Glass and the user's eye.

There are two steps to this algorithm. The raw sensor signal is first pre-processed in the first stage. The blink time is extracted during the pre-processing stage. Then, using ground truth blink data, confirm the pre-processing results [23].

Blink detection

- Blinks are recognized during pre-processing using the raw infrared proximity sensor input. We move a sliding window across the sensor data stream and watch to see if the centre point of each window is a peak or not, as defined below.
- The distance between one sensor value of the window's centre point and the average value of other points is calculated. Because the sensor readings of the previous and succeeding points of the centre are frequently affected by the centre point, they are removed from the average computation.
- The centre point is defined as a blink if the distance is greater than a threshold range from 3.0 to 7.0. Because each user's face shape and eye location differ, the optimal threshold for peak detection differs.
- By analysing the accuracy based on the ground truth data, we determine the appropriate threshold (in 0.1 steps ranging from 3.0 to 7.0). This method can only be used in off-line testing. We require a few seconds for calibration before detecting in on-line mode. Glass encourages the user to blink to match some timing throughout the calibration period. We evaluate the optimal threshold using sensor values and real blink timing obtained from calibration.

1.3 Problem Statement and Objectives

Problem Statement: Comparative blink analysis using EEG, EOG, OpenCV.

Objectives:

- To find suitable different sensors and respective compatible devices to detect the eye blinks.
- Collection of blink data required for blink analysis and making sure the data collected will be from both healthy patients and ones who are diagnosed with eye diseases.
- To analyse the data collected from the selected device and extract blink-related information in real-time.
- Based on the features that can be extracted from the data analysed, predicting the level of dry eyes in a user.
- To build a software application that can take the input from the user and give results as the level of dryness in their eyes.

1.4 Organization of the Report

An overview of blink analysis using sensors and related work is presented in the first chapter of this report. It covers the problem statement and the objectives that need to be met in depth.In the second chapter, the papers which are referred to and which contain the related works to the blink analysis and sensors are EEG, and EOG are descriptively mentioned with respect to the paper.In the third chapter, the high-level design of the project is described. It includes the architectural design of the project, its module descriptions, software development methods, and the project execution methodology. There are also non-functional and functional requirements discussed in this chapter.The fourth chapter provides an overview of the project's implementation. It includes tools and technologies used for project development, experiment setup, the standard of coding, how the integration of code is done, the workflow of implementation, execution results, and some non-functional requirements.The fifth chapter discusses the testing of the project. It describes the Test work flow and test case details.In the sixth chapter, the project's conclusion and future scope are discussed.

Chapter 2

Literature Survey

Chapter 2 briefs about the literature survey on the existing technologies of the project and the parameters used to detect blinks.

2.1 Brain Wave Classification and Feature Extraction of EEG Signal by Using FFT

In [1], The author talked about how to categorise brain waves and extract information from them. Electroencephalography is a technique for measuring electrical activity or signals that the brain produces up to a certain voltage level. whenever the brain performs any mental work. When there is multitudation in the brain's neuronal population, the EEG is created. The electrodes or channels positioned on the patient's scalp or, in certain situations, on the cortex are used to record the brain signals. The EEG signal is the output waveform that is captured using any computer component. EEG is, in essence, a test that looks for and flags irregularities in the electrical activity of the brain. Using cutting-edge digital signal processing techniques like the Fast Fourier transform and others, the EEG signal is classified as brain waves and has features extracted from it. The typical EEG signal voltage amplitude ranges from 10 to 100 uV. Typically, the amplitude range of 10 to 50 uv is utilised. The EEG signal's frequency spectrum shifts from ultraslow to ultrafast frequency components.

2.2 EEG Signal Processing Model for Eye Blink Detection

In [2], The following is a description of the signal processing model that the author used to identify eye blinks. Noninvasive Electroencephalography (EEG) tools like the Muse Headband, Emotiv Epoc, NeuroSky TGAT1/TGAM1, and Cyton Biosensing board (OpenBCI V3) record electrical signals produced by the brain as the user engages in any activity, including blinking, meditating, or even simply staring at a light with a range of frequencies. These signals, however, are unprocessed data that contain a significant amount of noise from the EEG amplifier or other outside sources. In this sense, multiple filters must be used to clean the data before the signals collected by the EEG equipment may be used in practical applications. As the user makes voluntary blinks, this research aims to apply several filter models, including as high-pass, band-pass, and band-stop filters to clean the signals collected by the OpenBCI V3 and classify those signals into two distinct groups, i.e., short intended blinks and long composed blinks. Since eye blink brain signals have a variety of practical applications, we have opted to research them.

2.3 Eye blink characterization from frontal EEG electrodes using source separation and pattern recognition algorithms

In [3], The author used source separation and pattern recognition techniques to demonstrate how to characterise eye blinks from frontal EEG electrodes. When performing boring and repetitive jobs, diminished attention or mental tiredness develops as task time increases (TOT). This is a long, cumulative process that can result in a severe decline in performance by causing shallow or even defective information processing. Even when workers are operating heavy machinery, operating a vehicle, or performing security duties, it can result in serious, life-threatening incidents. The physiological signs of different levels of weariness have been exploited by monitoring systems. They include measures of brain activity including electro-encephalography (EEG) band power characteristics, which are precursors to weariness. Additionally helpful for identifying states of mental weariness or sleepiness are indicators of ocular activity, such as spontaneous eye blink characteristics, captured by (near) infrared eye-tracking devices or electro-oculography (EOG). Eye blinks in particular are recognised signs of alertness. In fact, depending on the operator's level of mental weariness, their frequency, duration, amplitude, closure or opening time, and speed characteristics might change.

2.4 Identifying Eye Blinks in EEG Signal Analysis

In [4], In EEG Signal Analysis, the author has discussed techniques for recognising eye blinks. The best test for analysing neurological disorders is the electroencephalogram (EEG). Due to the scalp's bioimpedance, the electrodes in electroencephalogram tests also pick up the electrical potential of eye blinks along with the brain rhythm signals. Although it can happen in most electrodes, this contamination manifests itself more strongly in the frontal electrodes. In this instance, an eye blink is an artefact on the EEG test that has a greater amplitude than the brain rhythms. Therefore, it may be mistakenly perceived as an epileptiform activity, which is a defining feature of an epileptic episode, in the interpretation of the EEG exam. Extraction of eye blink artefacts from EEG data has been the focus of several investigations. Reviews and comparisons of the techniques for eliminating eye blinks are provided. Review Higher Order Statistics, Multi-Layer Perceptrons, Standard Error Backpropagation Supervised Training Algorithm, Cross Validation, and ROC Analysis briefly. About ten to twenty times per minute, the spontaneous or involuntary eye blinks without any external stimulation, and its purpose is to clean, lubricate, and oxygenate the cornea. With some assistance from Müller's muscle, the levator palpebrae superioris is primarily responsible for lifting the top eyelid.

2.5 Implementation and Analysis of an Electrooculography (EOG) Signal on FPGA

In [5],the author has presented the EOG biomedical signal, which can be used to assist paralysed and physically handicapped people in employing their eye movements, is discussed in this research report. To establish a communication with HCI for healthcare, the specific action can be performed utilising these movements. The EOG samples used were obtained from the physionet database and were in the form of comma separated values in an excel document. These samples' number formats are in Floating point, and they are transformed to binary values in Xilinx ISE for further processing of the EOG signal. The two phases of Discrete Wavelet Transform and Linear Predictive Coding (LPC) are used to reduce noise from the signal. Even in LPC, two denoising modules, DWT and IDWT, are utilised, and the signal is sent to a Time Variable Independent Module to retrieve the original signal. The retrieved features from these algorithms allow us to classify motions into eight directions (up, down, left, right, up-left, up-right, down-left, and down-right) as well as a blinking signal. There is a comparison between DWT and LPC in terms of area and time.

2.6 Communication Technologies Based on Voluntary Blinks: Assessment and Design

In [6],the author has told about the communication technologies based on the voluntary blinks.Some people with severe disabilities are limited to a state where speech is nearly difficult, requiring them to communicate solely through their eyes or through the use of sophisticated systems that translate ideas into words. People with and without disabilities participated in the tests, which examined the systems' functionality, usability, and manner of voluntarily blinking (long blinks or sequence of two short blinks). The best accuracy (99.3%) was obtained using Infrared-Oculography (IR-OG), while the worst accuracy (85.9%) was obtained with the EEG headset, and there was a statistical influence of technology on accuracy. With the exception of EOG, the use of long or double blinks showed no statistically significant effect on accuracy, and the time required to complete double blinks was lower, resulting in a potentially much speedier interface. People with impairments had similar results, but they were more variable. Video-Oculography (VOG) and lengthy blinks were the chosen technologies and blinking methods, respectively. Several Open-Source Hardware (OSHW) devices have been developed, as well as a new method for recognising voluntary blinks that surpasses the majority of the publications in the studied literature.

2.7 Eye blink detection for different driver states in conditionally automated driving and manual driving using EOG and a driver camera

In [7], the author has described about methods of identifying eye blinks during different driver states in conditionally automated driving and manual driving. In this paper, we look at how different eye blink detection algorithms perform under various constraints. The purpose of this research was to see how well an electrooculogram and camera-based blink detection system performed in both manual and conditionally autonomous driving phases. Another comparison was made between alert and drowsy drivers to see how sleepiness affects the effectiveness of blink detection algorithms in both driving modes. The researchers used data from 14 monotonous manually driven sessions (mean 2 h 46 minutes) and 16 monotonous conditionally automated driven sessions (mean 2 h 45 minutes). We investigated the blink detection performance of 24 reference groups, as well as two data sampling frequencies for electrooculogram measures (50 vs. 25 Hz) and four alternative signal-processing methods for camera footage. The movies were analysed using highly specific definitions of eyelid closure occurrences. In the drowsy (minus 2% or more) and conditionally automated (minus 9% or more) phases, the correct detection rates for the alert and manual driving phases (maximum 94%) declined dramatically. As a result, fatigue and automated driving have a considerable impact on blinking behaviour, resulting in less reliable blink detection.

2.8 Blink: Characteristics, Controls, and Relation to Dry Eyes

In [8], Regarding eye blinks, the author has discussed the traits, restraints, and relationship to dry eyes. The complicated phenomena of blinking is impacted by a variety of endogenous and exogenous stimuli. It has been studied in the context of cognition, emotion, and psychological states; as a symptom of fatigue and sleepiness; in visual tasking; and ultimately as it pertains to tear film stability and ocular surface health. This is especially true in the automotive and transportation industries. Because it is so diverse and receives information from so many various sources, analysis can be difficult. This overview explores the behaviour of blink in a few of these systems and concludes with a discussion of how these traits impact blink in the context of dry eyes in each case. Blinking is crucial for a person's quality of life, optimal functioning, and the health of their ocular surface. Whether as a cause or an effect, blink disturbances impair tear film stability, optical clarity, and vision.

2.9 Relationship Between Eyelid Pressure and Ocular Surface Disorders in Patients With Healthy and Dry Eyes

In [9], The author has discussed whether a blepharotensiometer, a device for measuring eyelid pressure, may identify changes in the eyelid pressure in various ocular surface illnesses. In order to maintain the integrity of the ocular surface and to distribute tears properly, blinking and eyelid motions are crucial. 1,2 When you blink, your top and lower eyelids rub against the surface of your eye, creating frictional force. By dividing the normal force applied to the surface by the coefficient of friction, the frictional force's magnitude is determined. The purpose of this study was to evaluate the blepharon-capacity tensiometer's to spot variations in eyelid pressure caused by various ocular surface illnesses. In order to achieve this, we compared the pressure on the eyelids in healthy, dry, and LWE eyes.

2.10 Detection of eye blink artifacts from single prefrontal channel electroencephalogram

In [10], Eye blink artefacts can be recognised using a single channel EEG, as the author has explained. Eye blinks are among the most significant sources of artefacts in electroencephalograms (EEG) taken from frontal channels; as a result, eliminating eye blink artefacts is seen to be a crucial step in raising the calibre of EEG data. The proposed approach offers two key advantages over the established ones. Firstly, it does not require electrooculogram references and uses single-channel EEG data. The adoption of this technique in brain-computer interface applications that employ headband-style wearable EEG devices with a few frontal EEG channels may therefore be particularly advantageous. Second, this technique was able to precisely quantify the eye blink artefact ranges. Our experimental findings showed that the artefact range calculated by our method was more precise than that from the conventional methods, and as a result, the overall accuracy of detecting epochs contaminated by eye blink artefacts was significantly improved in comparison to conventional methods.

2.11 Non-intrusive Driver Drowsiness Detection based on Face and Eye Tracking

In [11], The author has discussed how face and eye monitoring can detect tiredness by detecting eye blinks. Abstract— Annually, there are a disproportionately high number of traffic accidents attributable to distracted driving. As a result, academics have suggested a number of techniques for identifying sleepiness in drivers. These techniques include hybrid, vehicle-based, subjective, physiological, and behavioural techniques. Recent road safety reports, however, continue to point to drowsy driving as a significant contributor to collisions. This is reasonable given that the driver drowsiness detection (DDD) technologies available today are either obtrusive or expensive, which limits their ability to be used everywhere. This research fills the gap by acting as a test-bed for developing an inexpensive, non-intrusive DDD solution. A behavioural DDD approach is suggested based on monitoring the driver's face and eye status. The goal is to make this research the beginning of widespread DDD. The driver sleepiness detection video collection from the National Tsing Hua University (NTHU) Computer Vision Lab was used to accomplish this. The films were subjected to a number of video and image processing techniques in order to identify the drivers' eye condition.

2.12 Eye blink frequency during diVerent computer tasks quantized by electrooculography

In [12], The author has discussed how the frequency of eye blinks changes depending on the work at hand. Abstract— Annually, there are a disproportionately high number of traffic accidents attributable to distracted driving. The study's goal was to assess electrooculography (EOG) as an automatic technique for calculating the human eye's blink frequency (BF) during passive and active computer tasks carried out at two screen heights. In a controlled simu- lated office setting with a temperature of 23°C and a relative humidity of 30-35 percent, ten healthy volunteers (5 men and 5 women) took part in the study. Each test subject engaged in two 10-minute computer tasks that required active work and three 10-minute tasks that required passive viewing of a movie on a video display device (VDU). Two viewing angles were used for both tasks: standard and low. A reference electrode was put behind the ear, and two Ag/AgCl surface electrodes were positioned above and below the right eye to collect EOG signals. Eye blinks were manually tallied from the video recordings of the trials and compared to the EOG readings. The studies were videotaped.

Chapter 3

High-level Design

3.1 Software development methodology

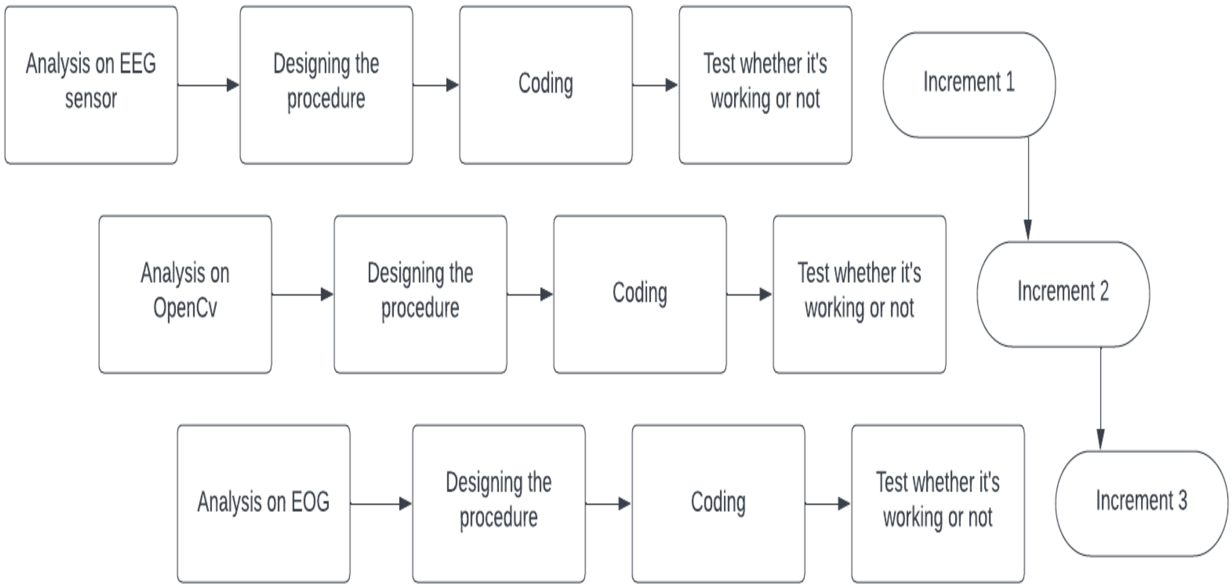


Figure 3.1: Simplified Application Architecture

The project workflow is finished using this software development methodology incrementally. Software will continue to be designed, implemented, and tested until the project is finished. It also covers product maintenance and development. The software development life cycle categorises requirements into many groups. The steps of requirements, design, implementation, and testing will be completed for each stage. Additionally, following every update to the program or product, progressively more features are added to the prior version until all criteria have been met. The first increment is often considered complete whenever the fundamental operations of the finished product are finished. After reviewing these features, the client decides on the subsequent incremental cycle. The subsequent instalment will elaborate on the complementing functions. The project is finished after all the requirements have been satisfied.The incremental model is shown in figure 3.1.

So we followed an incremental design approach throughout our project which helped us in getting timely results which in turn helped in judging whether to continue with that approach or not. Initially we started with EEG sensors and did some analysis on the method. After testing the data that we were getting from the EEG device that we had selected, we concluded that the data is in log format as it's very hard to convert it to digital data. Because of the drawbacks of the EEG sensor we moved to OpenCV and we tested that method. Then to increase the efficiency we opted for EOG sensor where data analysis is easy compared to EEG sensor so we ended up finding blinks in an efficient method. We followed the same incremental method while designing the website too.

Activities performed during the incremental phase are:

- Requirement analysis: A list of the required set of features is understood and collected.
- Design: Some high-end designs are made in this phase.
- Implementation: Coding of the features/product is carried out.
- Testing: once the functionalities are completed in each increment, they are tested to see if it is fulfilling the given requirements.

When should we use incremental model?

- Requirements of the product are understood properly.
- The software developer team is not very well skilled or equipped.
- Early release of some features of the product is required.
- High-risk features and goals are involved.

3.1.1 Why Agile Model is Required?

Traditional models should be replaced with the more effective agile approach. It is trustworthy, effective, and simple to use. Agile is a model that adapts to the changes taking place and is now used to alter the impending change that takes place in accordance with the demands of the company. This increases the case for picking this model by one. Most studies show that an agile approach increases the efficacy and efficiency of the team members. The agile approach has event flexibility, and the entire cycle is designed to be brief and sensible so that it can be communicated quickly. Agile model integration of development processes is a method for removing or keeping up a variety of strategies from exercise that may not be necessary for this task and forbidding any pointless or taxing exercise.

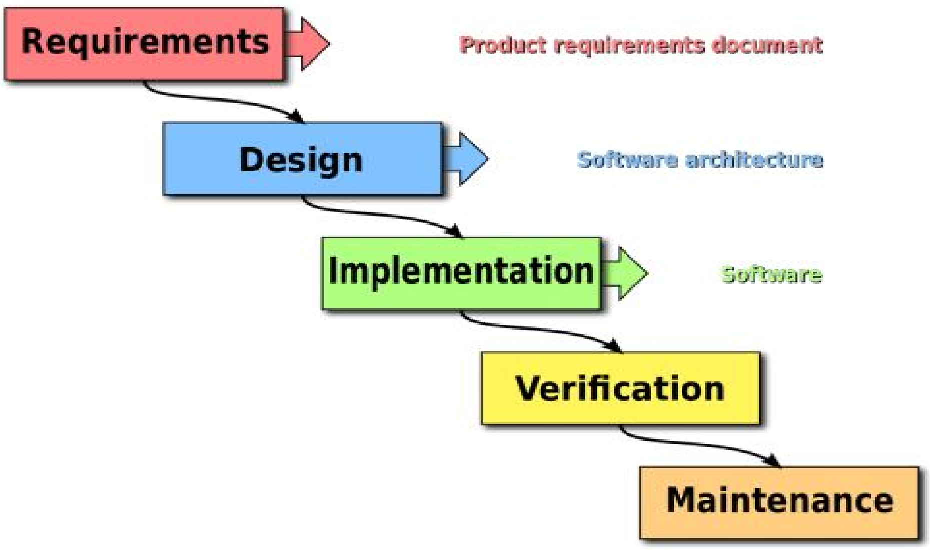


Figure 3.2: Agile Model

Effective human communication is more significant than resilient mechanisms, according to the Agile Manifesto. Collaboration with clients and team members is more crucial than the previously mentioned arrangements. It is crucial to develop an efficient solution to satisfy the needs of the client. The agile model development team is united by a shared vision.

3.2 Architecture

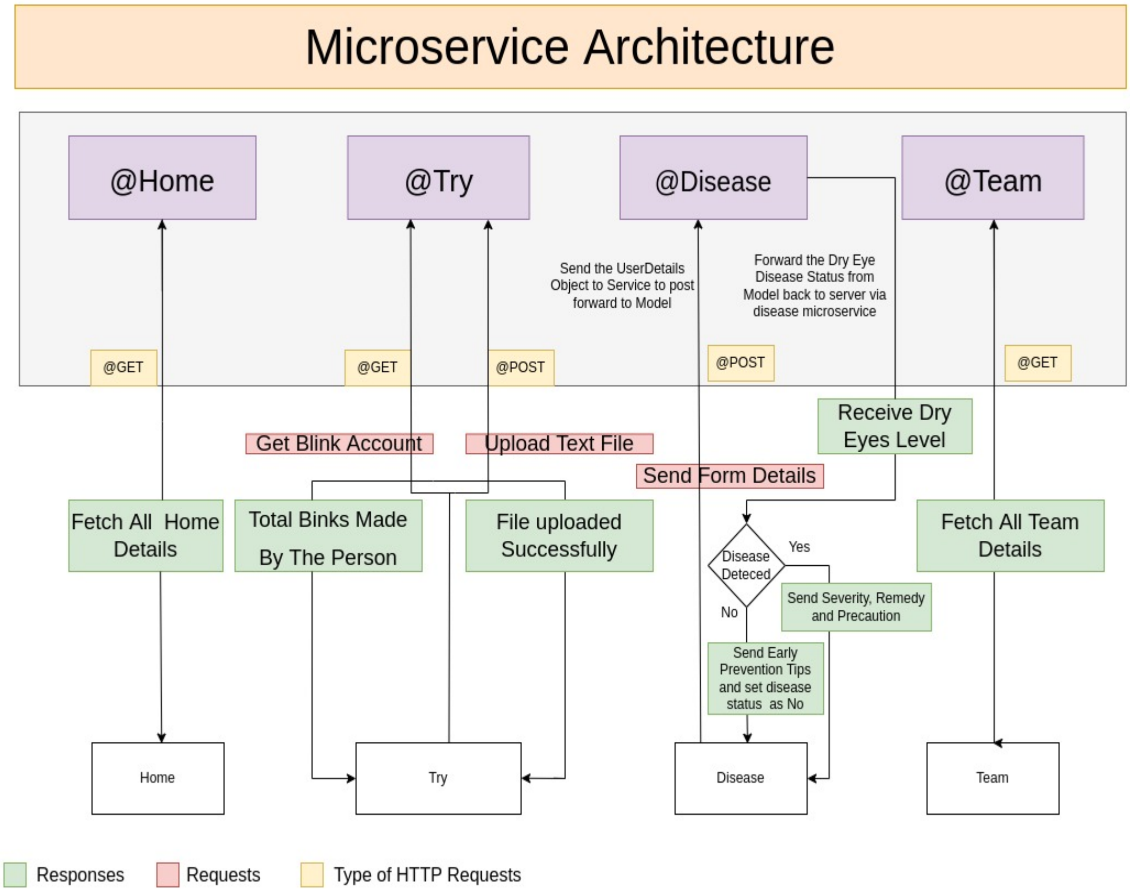


Figure 3.3: UML diagram

Architecture used in the project is The **Microservices Architecture**.

The Four different routes present in the application are Home, Try, Disease and Team. In Home route, few details related to blink action and its importance are present. The user can shift to any other routes by clicking on the links in the Navbar. Try route mainly deals with the analysis of the data file generated by using EOG electrodes i.e. try route finds the blinks count per minute which is nothing but the blink rate from the data file given by the user. Blink rate is used as one of the parameters in the dry-eye disease prediction. User is supposed to upload the data file in text format.Once it's uploaded successfully, total blinks made by that person will be displayed. Disease route is mainly concerned with dry-eye disease prediction. User is supposed to fill a form in the application so that necessary details for disease prediction will get collected at the server through the post request which acts as the test parameters to the model along with calculated blink rate. If the model predicts the presence of disease, then remedies and also the precautionary measures will be given for the patient. Otherwise, early prevention tips will be issued to the user. Team route simply consists of details related to the team members.

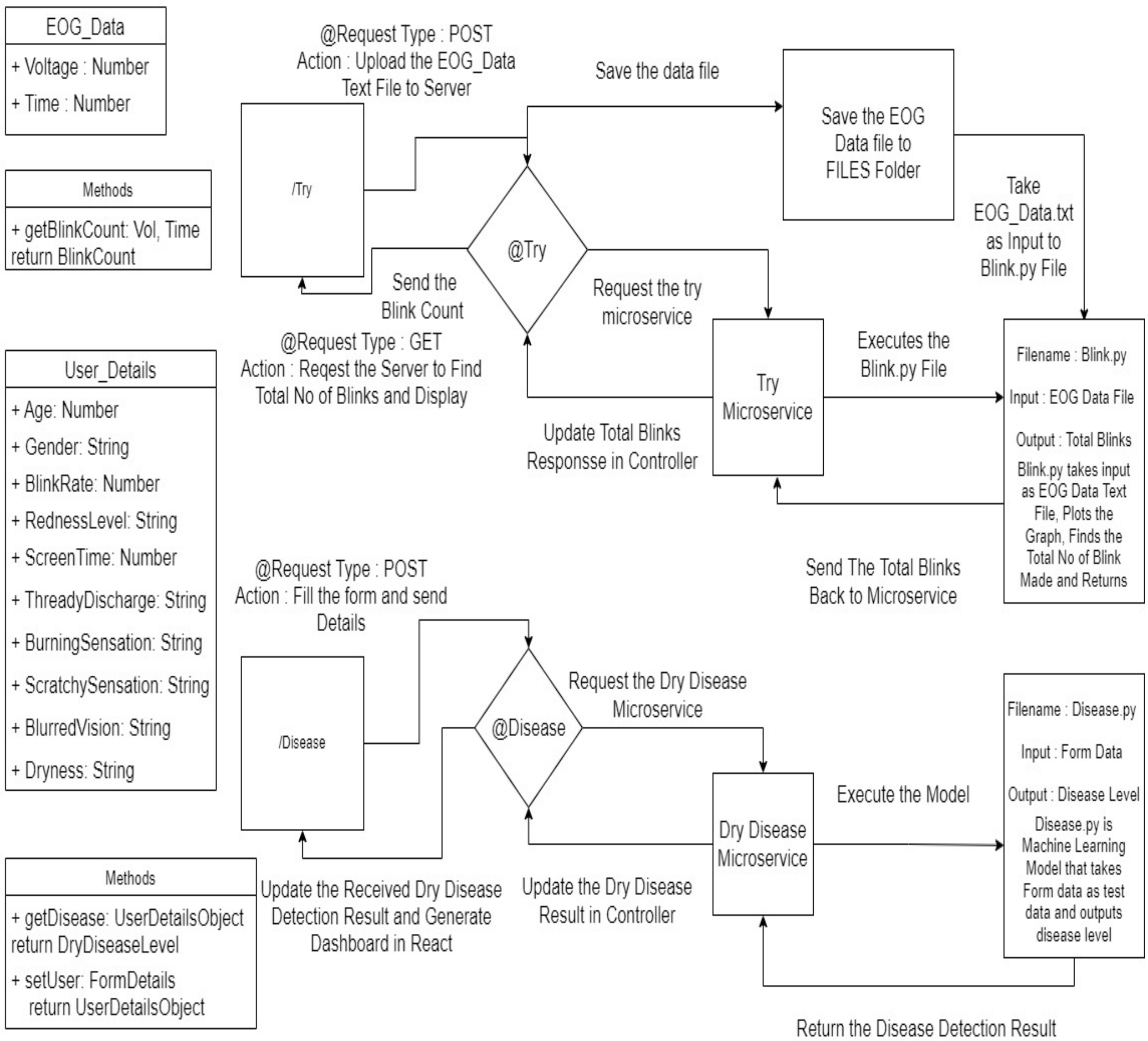


Figure 3.4: Detailed architecture of the application.

3.3 Functional Requirements

1. **File uploading**

   Function - The application user should be able to upload the EOG data file recorded from electrodes so that it can be analyzed and conclusions can be drawn.

   Purpose - To analyse blink information from EOG data file.

2. **File Re-uploading**

   Function - After uploading an EOG data file, if the user wants to upload a different file, or if the user has uploaded a wrong file, then he should be given the option to re-upload the file. So that the newly added file will be considered for analysis and the previous file will be automatically deleted.

   Purpose - Data files can be uploaded many times so that desired file can be uploaded and user need not spend much attention while uploading the file.

3. **Get blink count**

   Function - The EOG data file consists of two columns. The first column is the Timestamp values in milliseconds and the second is the Voltage values in volts. Plotting Voltage v/s Timestamp will give the blink wave pattern. The Get blink count function is used here to find out the number of peaks which in-turn gives us the total number of blinks.

   Purpose - Blink count is used as a parameter in detecting dry eye disease.

4. **Get blink pattern**

   Function - Plots the graph of Voltage v/s Timestamp by considering values present in the EOG digital data file.

   Purpose - By looking at the blink pattern,variation of voltage wrt time can be visualised. Also, by looking at many blink patterns, we can compare them with various blink parameters like blink amplitude, blink frequency, blink interval etc.

5. **Form filling**

   Function - To predict the presence of dry eye disease, values of certain parameters need to be considered. The best way to take those parameters from the user is through a form. Users need to fill all the required details through the form which can be accessed in the backend.

Purpose - Access parameters required to predict the dry eye disease from the user.

6. **Get disease prediction result**

   Function - User is able to see his disease prediction result which will say whether he has mild or severe dry eye disease or he is free from the disease.

   Purpose -To see the user's disease status and take suitable measures based on the result.

7. **Access disease dashboard**

   Function - User can access the dashboard which will mainly tell his disease's status and also the precautionary measures need to be taken.

   Purpose - To see the user's disease status and also the precautionary measures based on it.

8. **Download report**

   Function - Disease status seen in the dashboard can be seen and downloaded in pdf format as a report. Users can download this report and save the same for further and later use.

   Purpose - Users entered parameters, along with obtained disease's status and precautionary measures can be collectively saved as a single pdf.

9. **Hardware Interface**

   Function - The main functionality of hardware interface is to act as an intermediary between electrodes and the system. Raw electrodes output needs to be amplified and filtered which is done by the Bioamp EXG Pill and its output is sent to the Arduino where actually the Arduino UNO board takes input in analog format and it is visualised in Arduino IDE where required code is written.

   Purpose - To amplify, filter the raw EOG and to visualise the blink wave pattern.

10. **Sensor Interface**

    Function - 3 EOG electrodes are fixed to one side of the face and these electrodes are used as sensors that detect eye movements. Sensors sense the blink made by the patient and send the same with an increase in voltage.

    Purpose - Sense eye blinks made by the person.

3.4 Non-Functional Requirements

- **Scalability:** It refers now to the model that is trained with the part of the dataset and can be further updated. After updating, the model will continue to give the output based on the input received from the user. Currently, the application can predict the level of dry eyes for a given user input but the application can be scaled such it also supports the prediction of similar eye diseases. The application can be also scaled by considering input from different devices like EEG, EM sensor, etc and providing output for the same.

- **Maintainability:** The application can be maintained without any change in complexity, and new features can be added in the future. Maintenance is easier as the modular approach is followed in the project. As we are using a version control system(Git) with suitable and timely commits which results in a well-documented project. Currently, the data is stored in a CSV file which requires to be stored in the database in the future as the size of the dataset increases.

- **Performance:**The performance of the application can be improved with the addition of more rows of data to the dataset which further increases the accuracy of the output given by the model. Currently, the model used for early detection of Dry Eye disease only considers data of very few members. And since the data here considered was collected randomly the values of the target variables are not equally distributed. Hence the performance can be improved by adding the data of patients who are diagnosed with Dry Eyes.

- **Flexibility:** The current application built is a web application and it can be accessed on any device using any web browser. It is a responsive application. This application has a user friendly interface which makes the users easy to use it.

Chapter 4

Detailed Design

4.1 Interface design

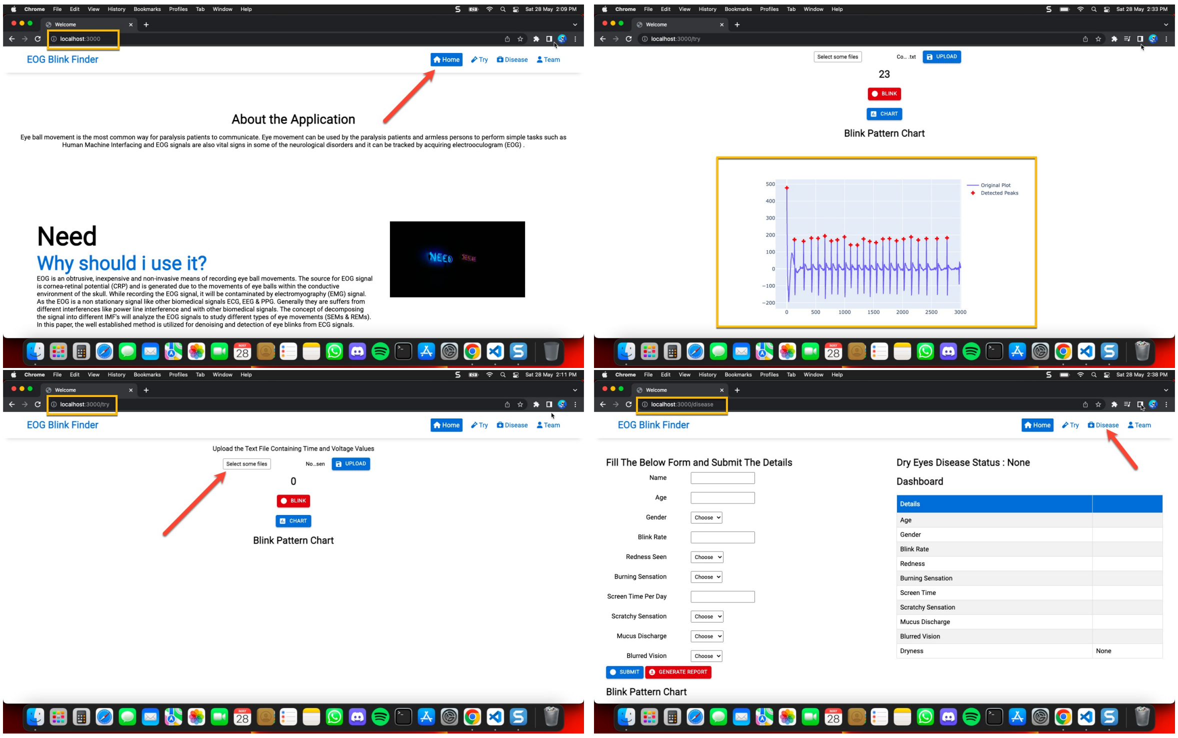


Figure 4.1: Application User Interface

The start page of our application, The Home Page consists of a description of our application, blink introduction and also the importance of EOG in blink analysis. The user can scroll down to see the complete description about blinks. There are 3 buttons other than the current Home button in the navigation bar of this page, namely - Try, Disease and Team. Each button navigates to each different route. Try button navigates to the Try route whose main functionality is to find out the number of blinks present in the blink waveform i.e. the number of blinks made by the patient in unit time. Here, the user is supposed to upload a EOG digital data file, i.e. the data file consisting of timestamp and voltage values captured using EOG electrodes. Once the file is uploaded, user can click on to the BLINK button which returns the number of blinks present in the uploaded patient's data file and later click on the CHART button which displays the Blink waveform generated from the data file. Similarly, Disease button in the Home page navigates to the Disease route. Here, a form is displayed where the user is supposed to fill in all his details which are necessary for predicting the disease. At the right side of this page, a dashboard is present which will display all the filled details. As and when, a field is filled by the user, the same is displayed in this dashboard. At the top of this dashboard, Dry eyes disease status will be displayed. At the bottom of the form, two buttons are present. SUBMIT button submits all the entered details and thereby makes way for displaying disease's status. Likewise, GENERATE REPORT button generates the patient's report consisting of all his details and the dry eye disease status. The report will be downloaded in the pdf format. Lastly, Team button in the Home page navigates to the Team route where details of the project team members are displayed.

4.1.1 Activity Diagram

The home page is the landing page of our application. This application consists mainly of three routes - The try, Disease, and Team routes.

In the Try route, first, the patient needs to select the EOG data file. Then it needs to be uploaded. If there are more data files, they can be uploaded. To get the blink count, the patient needs to press the GetBlinkCount button, and GetBlinkPattern displays the chart or the blink waveform.

In the Disease route, the first step is to fill all the required details in the form. After confirming dashboard details, the form has to be submitted by clicking on the Submit button. Then the Dry eye disease status of the patient will be displayed. Later, the user can download the report by clicking the Download report button.

In the Team route, details of the project team members will be displayed.

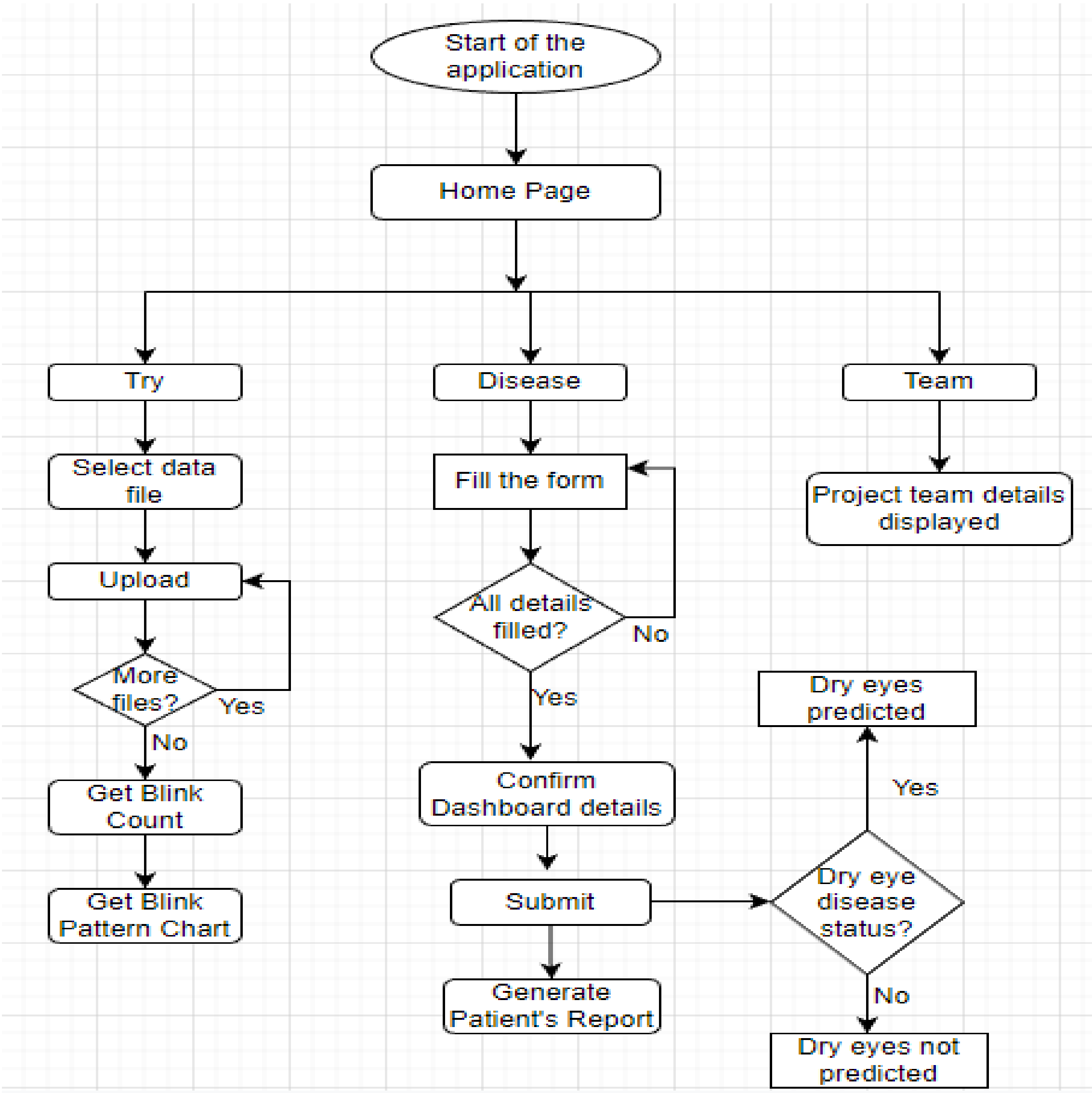


Figure 4.2: Activity diagram

4.2 Data Structures and Algorithms

Our project aims at predicting dry eye disease in the patient by collecting blink count data through EOG. In order to predict the presence of disease and its intensity, certain parameters need to be considered on which the disease depends. Values of those parameters need to be taken by the patient to predict the presence of disease in him.

A machine learning model is required, as and when target variable predictions need to be made based on certain parameters known as attributes. Machine learning models predict the value of the target variable based on the dataset given to it. Hence, a dataset is required for the machine learning model. More the instances in the dataset more the accuracy of predictions made by the model.

4.2.1 Dataset Used for Processing

We have framed our own dataset by considering Name, Age, Gender, Blink Rate, Redness seen, Burning sensation, Screen time per day, Scratchy sensation, Mucus discharge, Blurred vision as the parameters. Age can be an important factor in predicting the disease. As a person get older, he might suffer with dry eyes only because of his age even though other parameters are good. Gender is one more thing which can affect dry eye disease. Blink Rate is the main parameter we have considered in prediction of the disease. Blink is mainly responsible for the secretion of tears inside the eyes. Person blinks less when he concentrates more on a particular thing. Reduced blinks lead to less tear secretion which further leads to increase in dryness inside the eye. Reduced blink rate is a risk factor to dry eye disorder. Normal person blinks 10 to 16 times every minute whereas while using digital gadgets, it will reduce to 5 times. Number of hours a person looks into the screen is one more important parameter. Similarly, redness seen, burning sensation, scratchy sensation, mucus discharge, blurred vision also contribute to the disease.

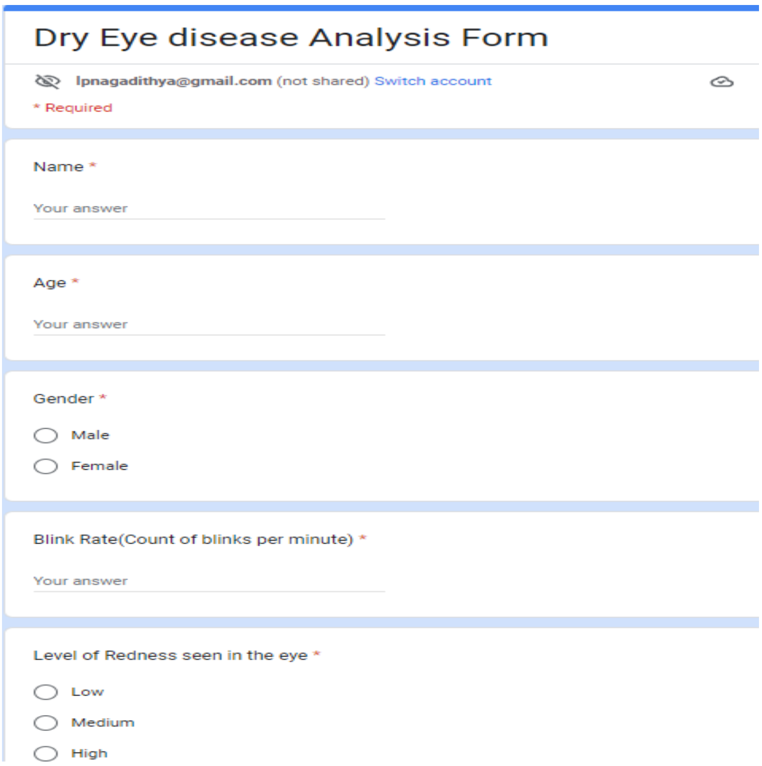
In this way, by collecting values for these parameters, a dataset consisting of 99 instances is framed and used in predicting the disease of the new patient which will be the test instance.

4.2.2 Algorithm Applied

The algorithm used in dry eye disease prediction is KNN (K-Nearest Neighbour). It is a supervised machine learning algorithm. It will predict the value of the target variable for the new test instance by considering K nearest neighbouring instances. While classifying a new instance, this algorithm will not take into consideration all the instances present in the training dataset. Euclidean distance will be calculated for the new instance to be classified and all other instances present in the training data. Based on the distance, only those K instances are considered which are very near to the new instance. Out of those K instances considered, the value of the target variable that appears more will be assigned as the value of the target variable of the new instance. KNN algorithm is considered as Lazy

Age	Gender	BlinkRate	RednessLevel	ScreenTime	BurningSensation	ScratchySensation	ThreadyDischarge	BlurredVision	Dryness
21	Male	14	Low	10	No	Medium	None	No	None
31	Female	15	Medium	12	No	Medium	Medium	No	High
21	Male	12	Low	12	No	Low	None	No	Low
22	Male	23	Medium	18	No	None	None	Yes	None
20	Male	10	Low	5	Yes	Medium	Medium	Yes	Medium
24	Male	27	None	4	No	Low	Medium	Yes	None
22	Male	24	Low	8	No	Low	Low	Yes	High
21	Male	12	Medium	9	Yes	Low	Low	No	Medium
23	Male	15	Medium	12	No	None	Low	No	None
29	Male	8	Low	8	No	None	Medium	Yes	Medium
23	Male	10	None	10	No	None	None	Yes	Low
22	Female	25	Low	8	No	Low	Low	No	None
28	Male	17	Medium	11	Yes	Medium	None	Yes	Medium
24	Male	10	None	14	No	None	None	No	None
19	Male	20	Low	6	No	None	None	No	None
19	Male	2	Low	13	No	Low	Low	No	Medium
19	Male	20	None	7	No	None	None	Yes	Medium
22	Male	25	Low	5	No	Medium	Low	Yes	Medium
22	Female	8	Low	10	Yes	Medium	Medium	No	Low
22	Female	21	Medium	10	No	Low	None	No	None
22	Male	17	Medium	10	No	Medium	Low	Yes	Medium
21	Female	13	Low	4	Yes	Medium	Low	Yes	Medium
21	Female	10	Low	6	No	Medium	Low	No	None
21	Female	19	Medium	4	No	Medium	Low	No	None

Figure 4.3: Dry Eye Disease Dataset


Dry Eye disease Analysis Form

lpnagadithya@gmail.com (not shared) Switch account

* Required

Name *

Your answer

Age *

Your answer

Gender *

- Male
- Female

Blink Rate(Count of blinks per minute) *

Your answer

Level of Redness seen in the eye *

- Low
- Medium
- High

Figure 4.4: Google form used for data collection

Learning Algorithm as the classification of new instances is postponed till it arrives and the algorithm will not learn anything from the given training data until a test instance is arrived at. It will never construct a general hypothesis based on the given training instances. Therefore, the presence of dry eye disease and its intensity is predicted by the KNN algorithm, by using the constructed dataset.

4.3 Data Source, Database used and Formats

We have constructed the dataset for dry eye disease prediction. This dataset contains 11 attributes which are considered by doing a literature survey on the disease and also by contacting a few eye doctors and considering their suggestions. The feature attributes considered in this dataset are Name, Age, Gender, Blink Rate, Redness in eyes, Burning sensation, Screen time per day, Scratchy sensation, Mucus discharge, and Blurred vision. The level of dryness is considered the target variable. The data was collected for about 2-3 weeks from people with varying blink count and screen time.The dataset at present contains 99 rows of data. As a future update to the application, we plan to get permission from any medical institution and collect the data of patients having a medium and high level of dry eye disease. Data is collected using a google form and also few disease samples were collected from the doctor.

Chapter 5

Implementation

5.1 Tools and Technologies

5.1.1 Software

Python (3.10.4)

Python is a very popular programming language which is easy to learn, interpreted, dynamically typed and high-level language. It supports object oriented and functional programming. Python has a large number of built-in packages and modules. It is widely used in Machine learning. We have used python majorly in detecting peaks from the blink waveform and also in predicting dry eye disease's intensity based on the form details filled by the patient.

Javascript (ES 17)

Javascript is the world's most popular and most widely used programming language. Today, websites we see are dynamic only because of the involvement of JS in it. Websites are designed using HTML and CSS whereas they are made interactive using javascript. Application Programming Interfaces (APIs) are present in this for working with Document Object Model (DOM). Our entire application is built using javascript. It can be used both in frontend as well as backend i.e. client side and server side.

React JS (18)

It is a very popular front-end Javascript library for building user interfaces. One of the best features in React JS is that it uses Component based architecture and allows the programmer to write Javascript inside HTML which is known as JSX. Our entire client application has been built using this technology. We will try to implement this algorithm to the real-time dataset by collecting data from the device from various users.Trying to derive the formula for data filtering, sampling, and analysis of blinking data.Determination of all the attributes that have been obtained in the form of a CSV file from an EEG headset.Comparing considered algorithms against various algorithms and also concerning existing and proposed approaches.Studying various applications of blink Designing a mobile application that allows users to make use of headset devices efficiently.

Node JS (16.14.2)

It is a runtime environment that allows us to run javascript outside the browser which helps us to interact with file systems and thereby allows us to build servers. It is widely used in server-side-scripting. Our entire server application has been built using this technology. Restful API's are also written using node js.

Visual Studio Code (1.6)

It is the world's most popular, open-source developer environment built by Microsoft. It supports a variety of programming languages including Java, Javascript, Go, Node js, Python, C++ etc. Syntax highlighting, bracket matching, intelligent code completion, debugging are some of its attractive features. Our entire client and server application code has been written in VS Code editor.

Google colab (1.0.0)

Google colab is a Jupyter notebook environment that runs entirely in the cloud. No space is required for the application in the local storage. It is one of the best platforms to run python code in the cloud. We have used this platform to run peak detection code and also in applying machine learning model to predict dry eye disease.

Machine learning

Machine learning can be seen as a part of artificial intelligence where the system learns from a set of training instances. How much the machine has learnt is tested by using test instances. The machine or the system has to predict the value of the target variable based on the target values of the training instances. Actual target values of the test instances are compared with predicted values and accuracy is found based on the correct predictions made. If accuracy is too low, then it means that the machine has to learn more and more training instances are needed. We have used ML in predicting the intensity of dry eye disease in patients based on blink count and other necessary parameters. K-Nearest Neighbouring is the algorithm used which considers K nearest instances and predicts the value of the test instance based on the majority value in those nearest instances.

Coolterm software (1.9.1.964)

It is a serial port terminal software. It is used whenever there is a need to exchange data with hardware connected to serial ports. In our application, coolterm software is used in capturing real time digital data obtained from EOG electrodes. Captured data will be saved to a notepad text file so that it can be used for further processing.

Arduino IDE (1.8.19)

As the name itself suggests, it is an integrated development environment which makes it easy to write and upload the code to the Arduino board. We have used this to write code to visualise the blink waveform.

5.1.2 Hardware

EOG Electrodes

EOG is actually a signal produced by the eye movements and recorded by placing electrodes near the eyes. ElectroOculoGraphy is a technology which detects the ocular movements.3 EOG electrodes are fixed on one side of the face to detect forward movement of the eye. 1.5 mm wire is used as the strain-relieving electrode cable to connect electrodes to the Bioamp EXG pill.

Arduino UNO

It is an open source microcontroller board with sets of analog and digital input/output (I/O) pins. We have used it to connect EOG electrodes to the system.Microcontroller used is ATmega38P- 8 bit AVR family microcontroller. Input voltage limits to the board are 6-20v. Six analog input pins are present in the board(A0-A5) and there are 14 digital I/O pins(D0-D13).

Bioamp EXG Pill

It is capable of recording biopotential signals like ECG, EMG, EOG and EEG. We have used it to record EOG signals.

5.2 Implementation

The corneo retinal standing potential, which occurs between the front and the rear of the human eye, may be measured using the electrooculography (EOG) method. The signal that results is known as EOG. Common electrode placement for vertical EOG recording is shown in figure.

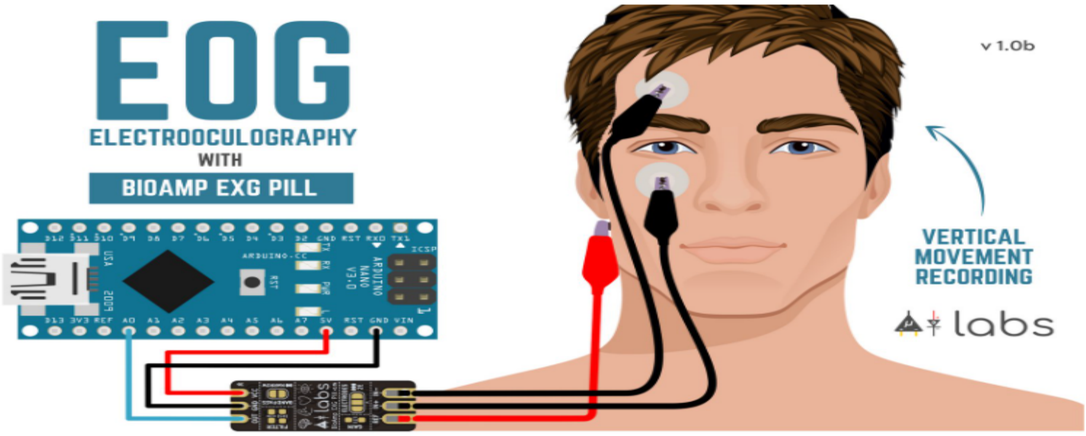


Figure 5.1: EOG electrodes attached to a person

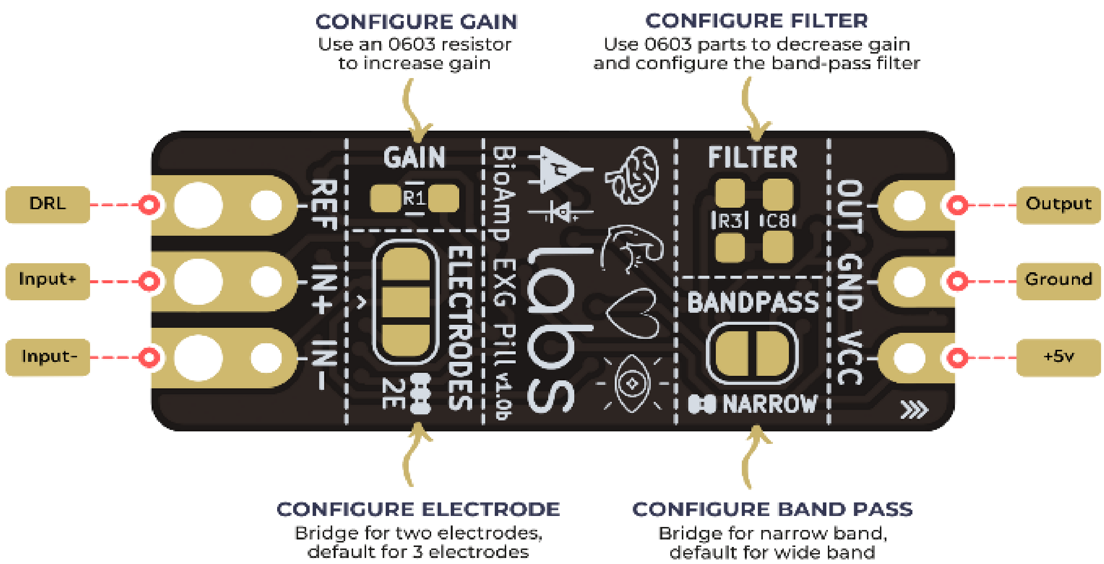


Figure 5.2: Bioamp EXG Pill

Vertical eye movement can be observed using 3 EOG electrodes placed in positions as shown in the above figure. As and when the eye moves from the center position either upwards or downwards, the electrode sees the positive side of the retina, and the opposite electrode sees the negative side of the retina. As a result, a potential difference exists between the electrodes. If the resting potential is assumed as constant, then the recorded potential is the measure of eye's position.

EOG electrodes are connected to a Bioamp EXG Pill. Topmost electrode is connected to –IN(negative input), the middle electrode is connected to +IN(positive input) and the side bottom electrode(which is red in colour) is connected to reference input. On the other end of EXG pill, output pin is connected to A0 input of Arduino UNO, ground(GND) pin is connected to the ground pin of Arduino and VCC(+5v) pin is connected 5volts pin of Arduino.

BioAmp EXG Pill is a powerful, small analog biopotential signal acquisition board that can be paired with any 5v MicroControllerUnit with an ADC. It can record EEG,EOG, EMG and ECG signals. Because of it's small size, it can be used in projects where there will be space restrictions.Analog input pins and digital input/output pins are mentioned in the GPIO diagram 5.4 and 5.5.

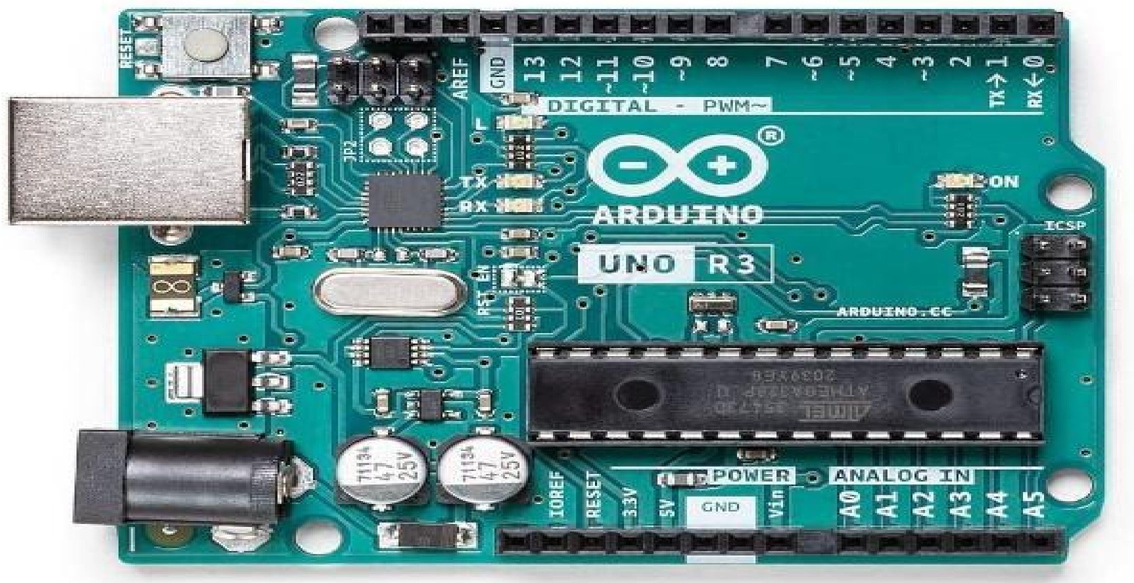


Figure 5.3: Arduino UNO

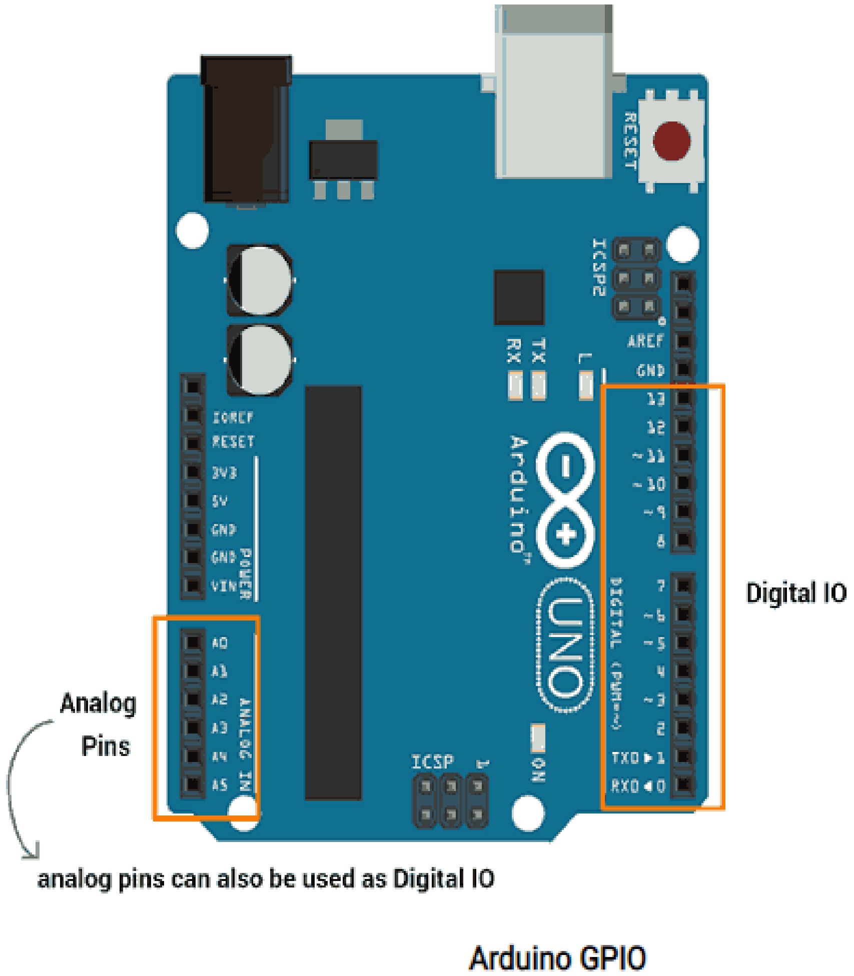


Figure 5.4: Arduino GPIO

The USB cable which is used in connecting the arduino to the computer, helps in two ways. One in supplying the power and another in acting as the serial port. There are 6 analog input pins(A0-A5). Through the VIN pin, input voltage is supplied to the board through an external power supply. The 5v pin is used as a regulated power supply to the board as well as its components. The 3.3v pin is used to supply 3.3v to the board. Ground pin is used to ground the Arduino board. There are 14 digital input or output pins(D0 - D13).

Arduino UNO is a microcontroller board which is low-cost, flexible and easy-to-use. It's mainly used in electronic projects. Board contains a USB Interface. A USB cable is used to connect the board with the computer. Arduino IDE(Integrated Development Environment) software is used to program the board. The unit consists of 32KB flash memory

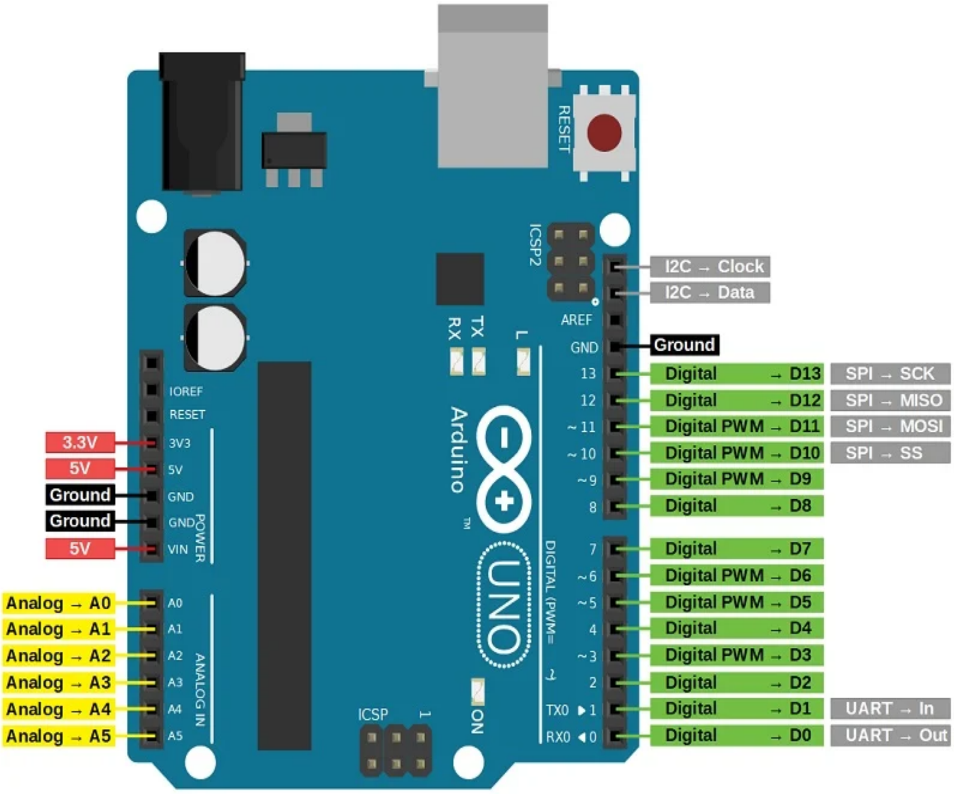


Figure 5.5: Arduino pin configuration

which will store the number of instructions and 2KB SRAM and EEPROM 1KB. Input voltage may vary between 6V and 20V whereas the circuitry operates at 5V. Blink wave pattern can be seen in Arduino IDE by connecting EOG electrodes to Arduino UNO through Bioamp EXG Pill and by connecting Arduino UNO to Arduino IDE.

In the Arduino IDE, code should be written, consisting of sample rate, baud rate and considered input pin of the Arduino UNO. Also, a function must be written related to EOG Filter functionality. Once code is completed, select the Tools menu and check whether the Board option is set to 'Arduino UNO'. Also, in the Port option, check whether the correct port is selected to which the Arduino device is actually connected. Else, it needs to be correctly selected. Once after making sure that Board and Port options are correct in the Tools menu, the code should be compiled. If no errors are found, the IDE will return a message 'Done Uploading'. To see the blink waveform of a person who is wearing the EOG Electrodes as shown in figures 3 and 4, the Serial Plotter option in the Tools menu needs to be selected. An increase in the amplitude of the waveform is observed as and when the person blinks.

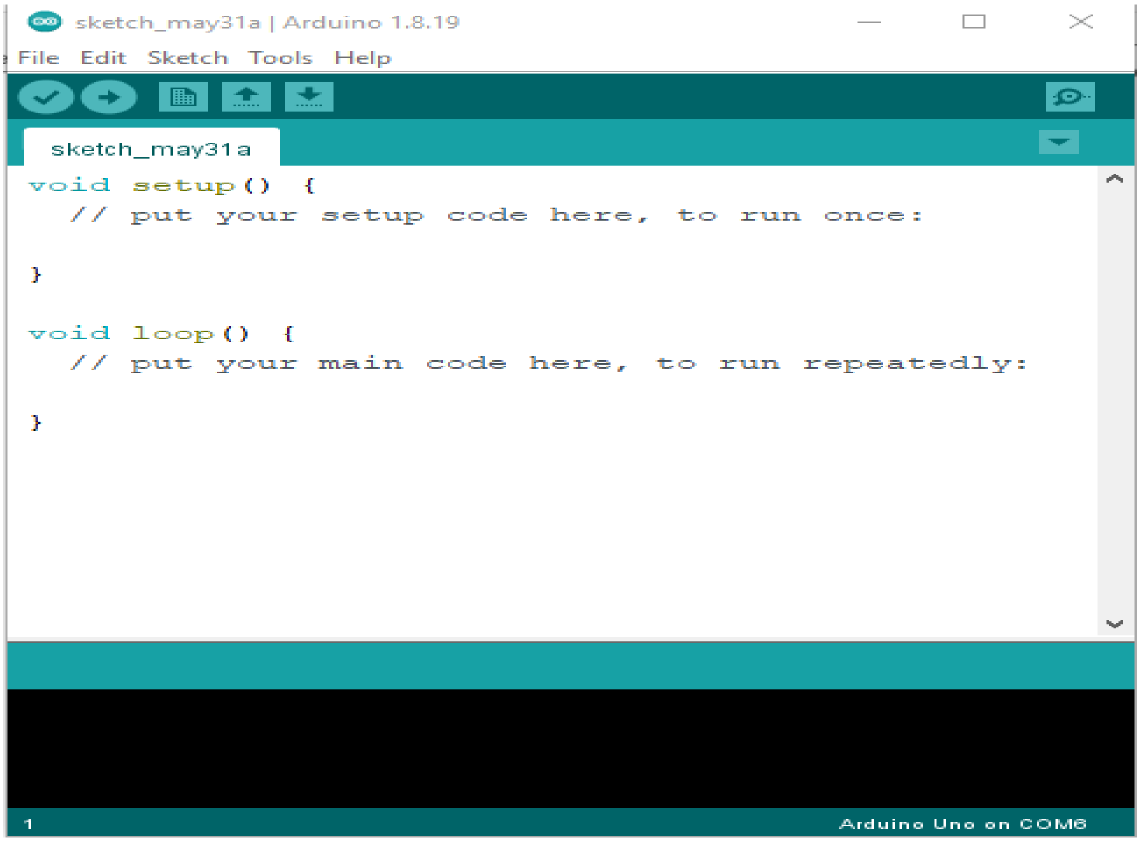


Figure 5.6: Arduino IDE

Coolterm app to capture digital data :

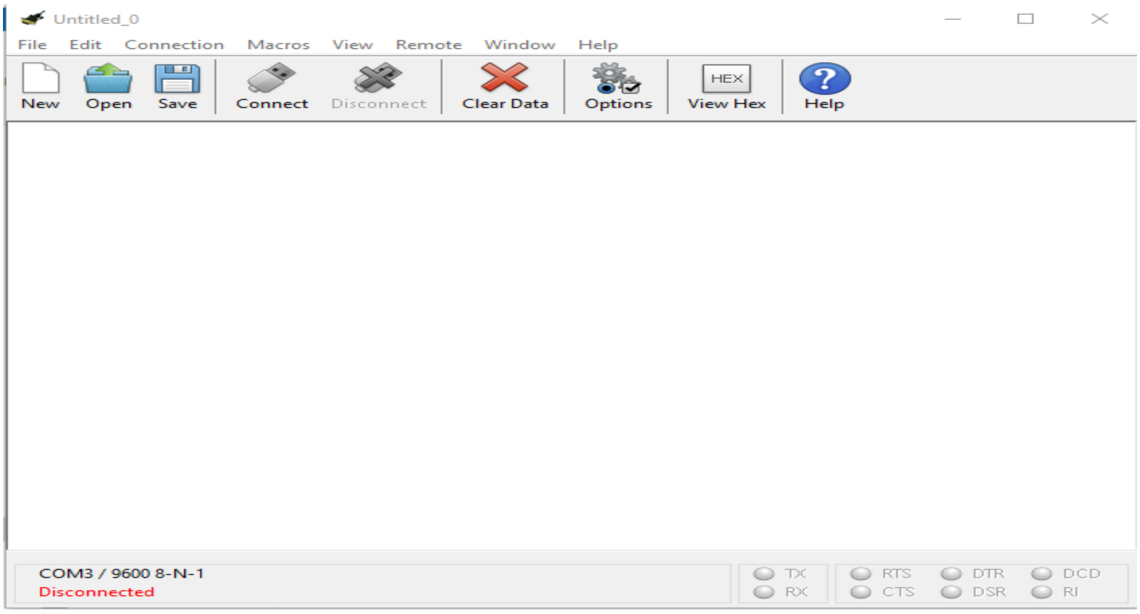
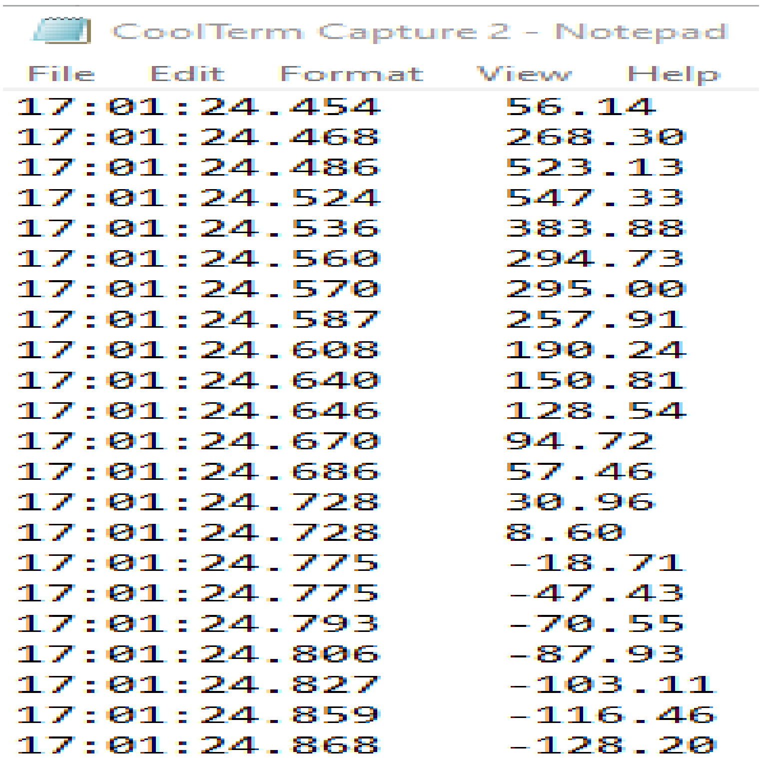


Figure 5.7: Coolterm Software

Coolterm software can be used to capture digital data in real-time. First, go to the Connection Menu and select the Capture to Text/Binary File option. It asks for the desired location where the file needs to be saved. Then, click on Options menu, a dialog box will open. In the Serial Port option, port and baud rate need to be selected as per the code written in the Arduino IDE. In the Receive option, select Add timestamps to receive data in both Receive Buffer Size and Capture File Options Menus. Capturing format type can also be selected as per the requirement. After options are done, connection must be established by clicking on Connect. Data will start to record and once after data collection is done, established connections need to be disconnected by clicking on to Disconnect. By clicking ctrl+s on windows, data will get saved permanently onto the file. Data file will be a notepad file in text format. This data can be used for further analysis to find blink count and other blink related parameters.


CoolTerm Capture 2 - Notepad
File Edit Format View Help

17:01:24.454	56.14
17:01:24.468	268.30
17:01:24.486	523.13
17:01:24.524	547.33
17:01:24.536	383.88
17:01:24.560	294.73
17:01:24.570	295.00
17:01:24.587	257.91
17:01:24.608	190.24
17:01:24.640	150.81
17:01:24.646	128.54
17:01:24.670	94.72
17:01:24.686	57.46
17:01:24.728	30.96
17:01:24.728	8.60
17:01:24.775	-18.71
17:01:24.775	-47.43
17:01:24.793	-70.55
17:01:24.806	-87.93
17:01:24.827	-103.11
17:01:24.859	-116.46
17:01:24.868	-128.20

Figure 5.8: Data captured by Coolterm software

Data analysis:

Our try route in the application accepts the data file in the text format. That text file is internally converted to csv format in the application. The csv file contains only two columns. Values in the first column represent Timestamp in seconds whereas those in the second column represent Voltage in volts. To observe the variation of voltage in different timestamps, a graph of Voltage v/s Timestamp can be plotted as shown in figure 1. Each wave in the blink pattern is considered as a blink. So, finding the number of blinks in the waveform is the same as finding the number of waves in the blink pattern. Each wave will have a crest and trough. Therefore, the number of waves in the pattern is the same as the number of crests in the pattern which is the same as the number of troughs in the waveform. Hence, to find the number of blinks made by a person, it is sufficient to find the number of crests in his Voltage v/s Timestamp plotted waveform.

Based on the values accumulated or captured, any positive voltage value greater than 90 units is considered as a peak point in that blink waveform. Here, the threshold value is considered based on the voltage values of different captured data is considered.

Figure 5.9: EOG waveform seen in Arduino IDE

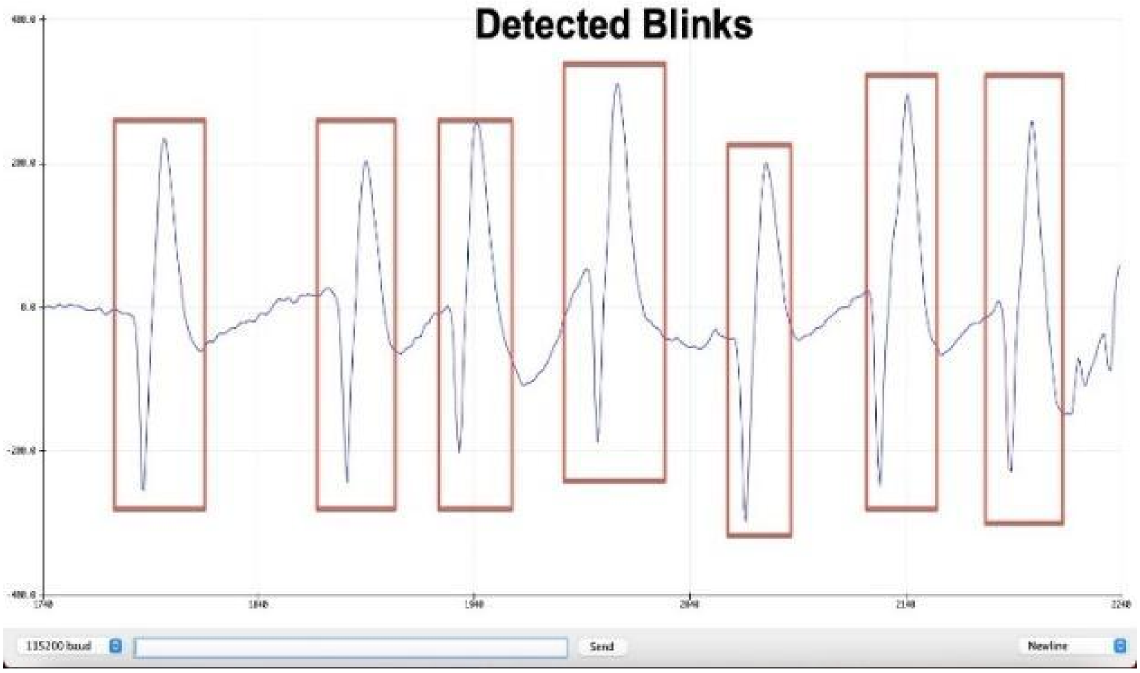


Figure 5.10: Consecutive blinks seen in blink waveform

```python
import numpy as np
import pandas as pd
from matplotlib import pyplot as plt
from sklearn.metrics import confusion_matrix
from sklearn.neighbors import KNeighborsClassifier
from sklearn.preprocessing import LabelEncoder
from sklearn.model_selection import train_test_split
import seaborn as sns
import ast
sns.set()


value = input()
response = ast.literal_eval(value)

rage = int(response["iage"])
rgender = response["igender"]
rblinkrate = int(response["iblinkrate"])
rredness = response["iredness"]
rburning_sensation = response["iburning_sensation"]
rscreen_time = int(response["iscreen_time"])
rscratchy_level = response["iscratchy_level"]
rblurred_vision = response["iblurred_vision"]
rdryness = "None"
rthready_mucus_discharge =
response["ithready_mucus_discharge"]


def formatFile(df):
    le = LabelEncoder()

    label = le.fit_transform(df['Age'])
    df["Age"] = label

    label = le.fit_transform(df['Gender'])
    df["Gender"] = label

    label = le.fit_transform(df['BlinkRate'])
    df["BlinkRate"] = label

    label = le.fit_transform(df['RednessLevel'])
    df["RednessLevel"] = label
    label = le.fit_transform(df['ScreenTime'])
    df["ScreenTime"] = label

    label = le.fit_transform(df['BurningSensation'])
    df["BurningSensation"] = label

    label = le.fit_transform(df['ScratchySensation'])
    df["ScratchySensation"] = label

    label = le.fit_transform(df['ThreadyDischarge'])
    df["ThreadyDischarge"] = label

    label = le.fit_transform(df['BlurredVision'])
    df["BlurredVision"] = label

    label = le.fit_transform(df['Dryness'])
    df["Dryness"] = label
    return df

def predictDisease(df,input):
  formattedInput = pd.DataFrame.from_dict([input])
  df = df.append(formattedInput, ignore_index = True)
  df = formatFile(df)

  X = df.iloc[:-1, :-1]
  y = df.iloc[:-1,-1]
  input = df.iloc[[-1],:-1]

  knn = KNeighborsClassifier(n_neighbors=3)
  knn.fit(X, y)
  output = knn.predict(input)
  return output


df = pd.read_csv("./Data/Data.csv")

input =
{"Age":rage,"Gender":rgender,"BlinkRate":rblinkrate,"Redness
Level":rredness , "ScreenTime":
rscreen_time,"BurningSensation":rburning_sensation,"Scratchy
Sensation": rscratchy_level,
"ThreadyDischarge":rthready_mucus_discharge,"BlurredVision":
rblurred_vision,"Dryness":rdryness}
output = predictDisease(df,input)
result = ["Mild","Low","Medium","High"]
result = result[output[0]]
```

Figure 5.11: Applying KNN Algorithm

```
void setup() {
  // Serial connection begin
  Serial.begin(BAUD_RATE);
}

void loop() {
  // Calculate elapsed time
  static unsigned long past = 0;
  unsigned long present = micros();
  unsigned long interval = present - past;
  past = present;

  // Run timer
  static long timer = 0;
  timer -= interval;

  // Sample
  if(timer < 0){
    timer += 1000000 / SAMPLE_RATE;
    float sensor_value = analogRead(INPUT_PIN);
    float signal = EOGFilter(sensor_value);
    Serial.println(signal);
  }
}
```

```
float EOGFilter(float input)
{
  float output = input;
  {
    static float z1, z2; // filter section state
    float x = output - 0.02977423*z1 - 0.04296318*z2;
    output = 0.09797471*x + 0.19594942*z1 + 0.09797471*z2;
    z2 = z1;
    z1 = x;
  }
  {
    static float z1, z2; // filter section state
    float x = output - 0.08383952*z1 - 0.46067709*z2;
    output = 1.00000000*x + 2.00000000*z1 + 1.00000000*z2;
    z2 = z1;
    z1 = x;
  }
  {
    static float z1, z2; // filter section state
    float x = output - -1.92167271*z1 - 0.92347975*z2;
    output = 1.00000000*x + -2.00000000*z1 + 1.00000000*z2;
    z2 = z1;
    z1 = x;
  }
  {
    static float z1, z2; // filter section state
    float x = output - -1.96758891*z1 - 0.96933514*z2;
    output = 1.00000000*x + -2.00000000*z1 + 1.00000000*z2;
    z2 = z1;
    z1 = x;
  }
  return output;
}
```

Figure 5.12: Applying Filter for EOG Blink waveform

```
import numpy as np
import pandas as pd
import os
import shutil
import matplotlib.pyplot as plt
import plotly.graph_objects as go
import plotly.graph_objects as go
import re
from scipy.signal import find_peaks


filename = os.listdir("./files")[0]
receivedFilepath = "./files/"+filename
os.rename(receivedFilepath,"./files/data.txt")

temp = pd.read_csv("./files/data.txt",delimiter="\t")
headerList = ['Timestamp', 'Voltage']
temp.to_csv("./files/data.csv",header= headerList,index=None);

data = pd.read_csv("./files/data.csv")

x = data['Timestamp']
y = data['Voltage']



fig = go.Figure(data=go.Scatter(
    x = x,
    y = y,
    mode = 'lines'
))
```

```
voltage = y

indices = find_peaks(voltage,threshold=0,distance = 50)[0]
peaks = list(i for i in indices if voltage[i]>90)

fig = go.Figure()
fig.add_trace(go.Scatter(
    y=voltage,
    mode='lines',
    name='Original Plot'
))


fig.add_trace(go.Scatter(
    x=peaks,
    y=[voltage[j] for j in peaks],
    mode='markers',
    marker=dict(
        size=8,
        color='red',
        symbol='cross'
    ),
    name='Detected Peaks'
))


fig.write_image("images/fig.svg")



os.remove("./files/data.csv")
os.remove("./files/data.txt")
```

Figure 5.13: Detection of peaks in the blink waveform obtained from EOG

5.3 UML diagrams

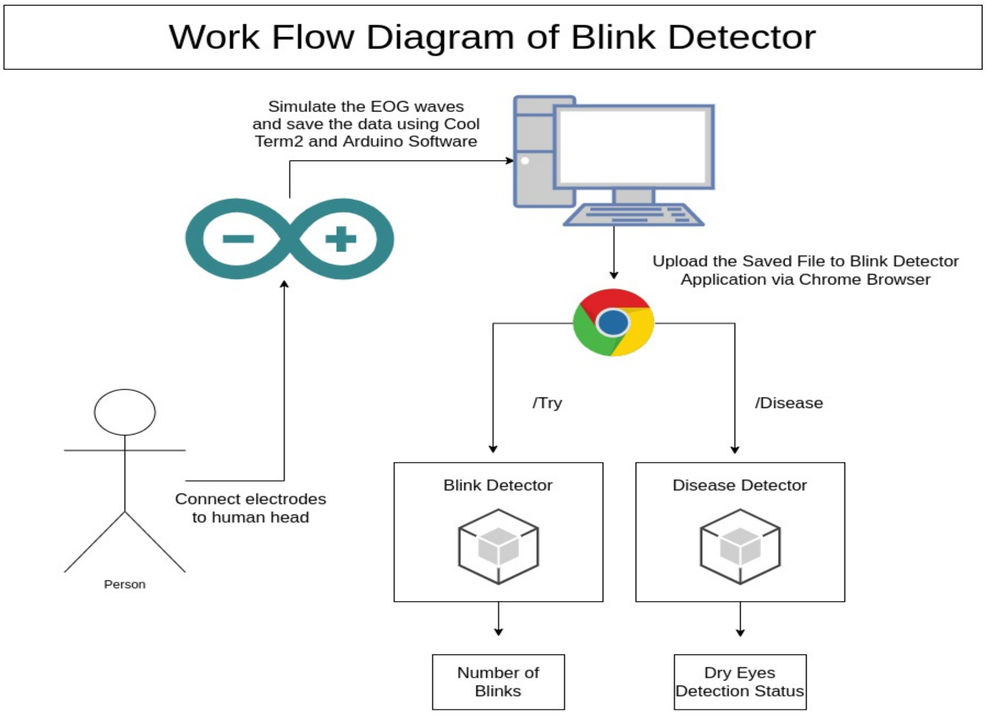


Figure 5.14: Workflow diagram of Blink Detector

EOG electrodes are connected to the patient and those electrodes are connected to the Arduino UNO through a Bio-amp EXG Pill. The Arduino UNO board is further connected to the PC/Laptop which in turn gives power for the Arduino. Arduino IDE is used to visualize the blink pattern. Code containing sampling rate, baud rate and input pin will be compiled and uploaded in the IDE. Later, digital data will be captured in required format (Timestamp and voltage) using Coolterm Software. Captured file will be in the text format and can be stored in the desired location of the system. This saved text data file need to be uploaded to the Blink detector application via Chrome Browser which will yield Blink rate as the result. Then, Dry eye disease can be predicted using Disease detector by specifying patient's necessary details.

5.3.1 Sequence Diagram

Sequence diagram for obtaining the blink pattern of a patient has been shown in Fig. 4.12. At the first, EOG electrodes has to be attached to the patient. Electrodes need to

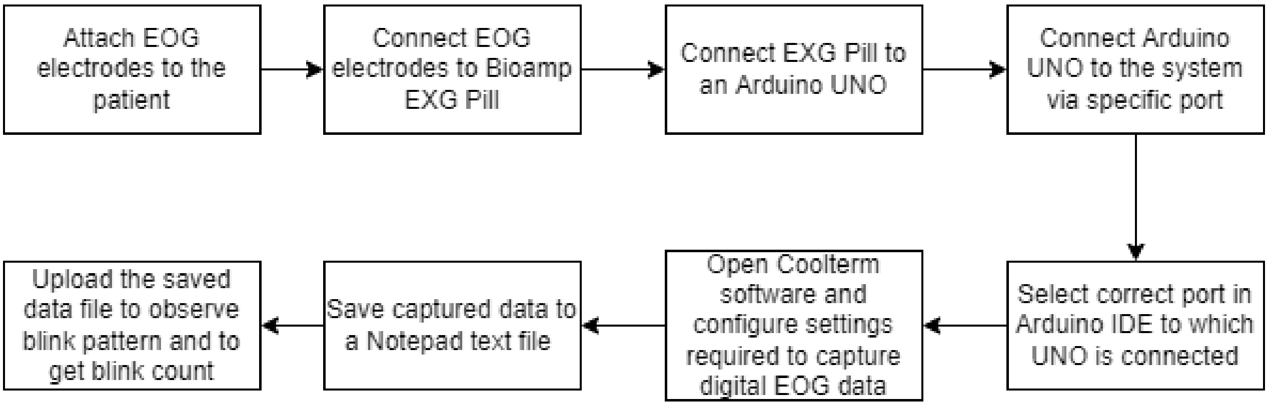


Figure 5.15: Sequence diagram to obtain Blink pattern of a patient

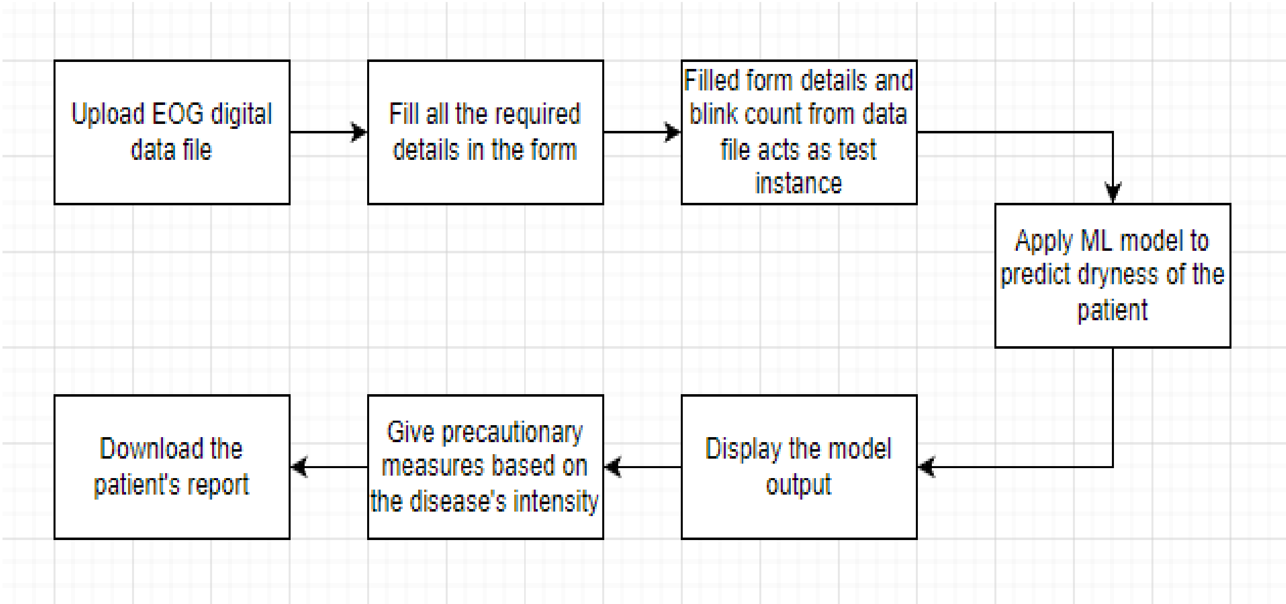


Figure 5.16: Sequence diagram for disease prediction

be connected to an Arduino UNO to see the blink pattern via a Bioamp EXG Pill which can record biopotential signals, in this case the EOG signals. Arduino UNO is connected to the system via a specific port and the same port will be selected in the Arduino IDE where blink pattern can be observed. To capture digital data of blink, Coolterm software is used. Data should be stored into a notepad text file which is useful in finding blinks count and also in observing many blink parameters from the pattern obtained.

In fig 4.13, a sequence diagram for predicting the disease is shown. Captured EOG digital data file will be uploaded to the application for further analysis. Application will ask certain details about the patient which are necessary for predicting the intensity of the dry eye disease if it exists. Once all the details are filled, these filled details along with the blink count obtained from the uploaded EOG file, act as test parameters for the ML model which predicts the output based on the existing dataset. Finally, the model output i.e. dry eye disease output is displayed and precautionary measures are suggested based on it and the patient can download his report.

5.3.2 Use-case Diagram

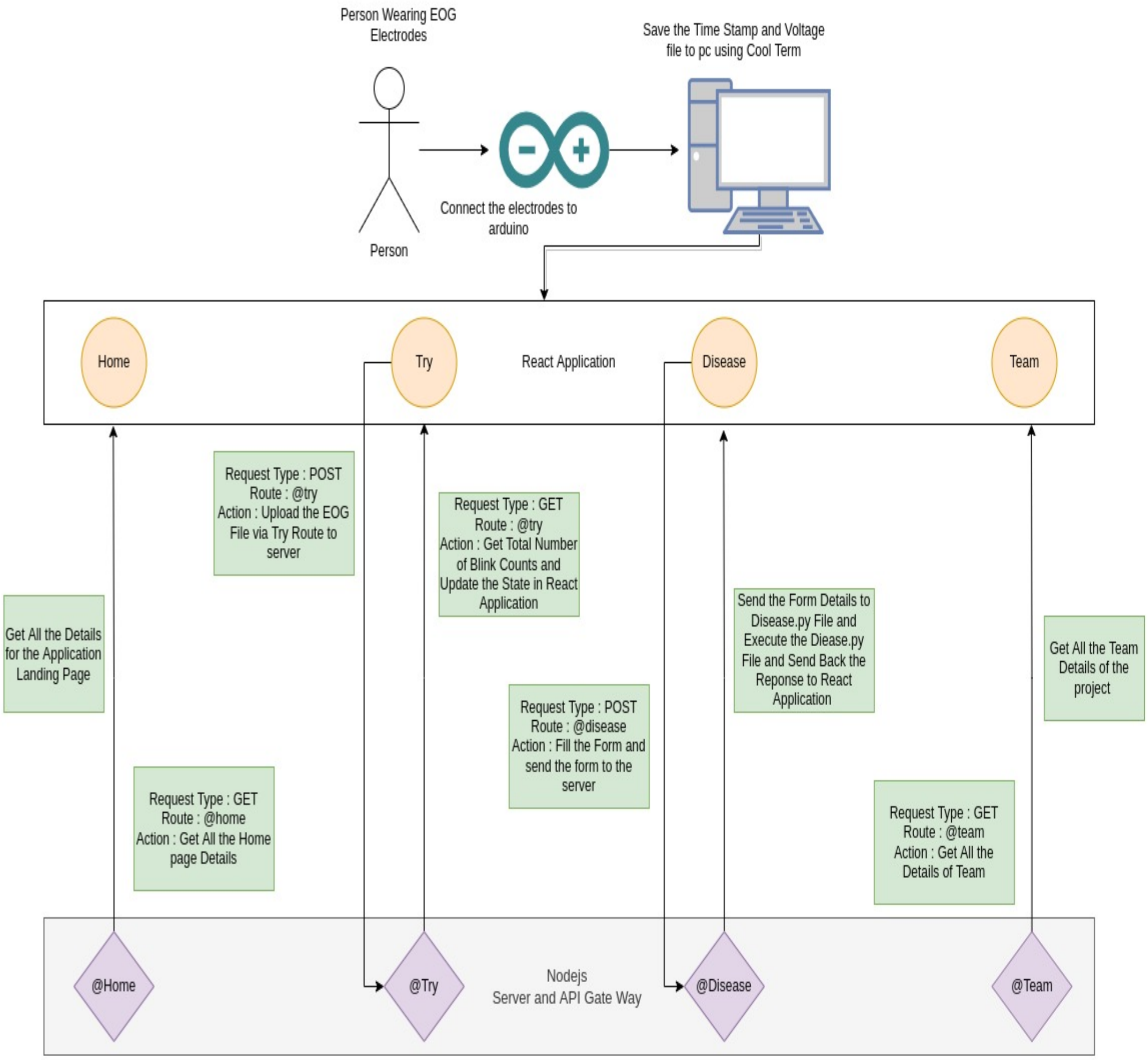


Figure 5.17: Use-case diagram

Person will be wearing the electrodes and those electrodes are connected to Arduino UNO and it is further connected to the PC where the digital data obtained from the electrodes will be stored in a notepad text file consisting of timestamp and voltage values. There are four routes in our application namely home, try, disease and team. Through GET requests, all the home page details can be obtained for the Application Landing Page. In the try route, both GET and POST requests are involved. Through GET request, total number of blinks i.e. the blink count can be obtained from the data file uploaded and the same can be updated in the React application. Through the POST request, users can upload the EOG data file and send it to the server side. In the disease route, users can send all the details required for predicting dry eye disease to the server by filling the form and sending them through the POST request. All the form details are further sent to a python file where ML code is written for prediction. This python script will be executed and the result will be sent back to the react application. In team route, team details can be accessed through the GET request.

Chapter 6

Testing

Software testing is a crucial component of the creation of a software system since it verifies first-rate certification and demonstrates a review of specificity, composition, and coding. Ultimately, any object process that was finished prior to item modification is applied to this level. Something finished a prolonged effort by running a few unit case tests. Additionally, there are several kinds of testing to consider that are necessary throughout object development, including unit testing, re-integration testing, and so on. Based on the results of these unit tests, the outline is positioned beneath the test device. If something goes wrong in that scenario, several programs and approaches are used to rectify the problems and replace them while still being reviewed. And until error-free software is finished, this process is employed repeatedly with the ultimate objective of releasing it to the market and inviting users to use it. Customers and firms occasionally leave the market after posting their products with major variances.

6.1 Test Workflow

6.1.1 Unit based Testing

Each functional and testable unit of the program is tested as part of the software development process, which also includes unit testing. We gain trust in the code we have built for the application by testing the separate components of the application. Additionally, unit tests ensure that any alterations to the code introduced by a new team member won't affect the application's functioning. Unit tests are often developed after an application's code has been written, and the application is subsequently tested using them.

6.1.2 Integration Testing

Integration testing is carried out to test the integration of small coding components as well. After that, the embed code is tried, and finally, the costs are examined. When testing the entire software system with numerous new test charges, these integrated code components are built into the main code and integrated at specific levels. We performed tests in small units and examined all integrated modules for our project. a large test unit combined with an attempt to fully explore everything.

6.1.3 Testing Procedures and environment

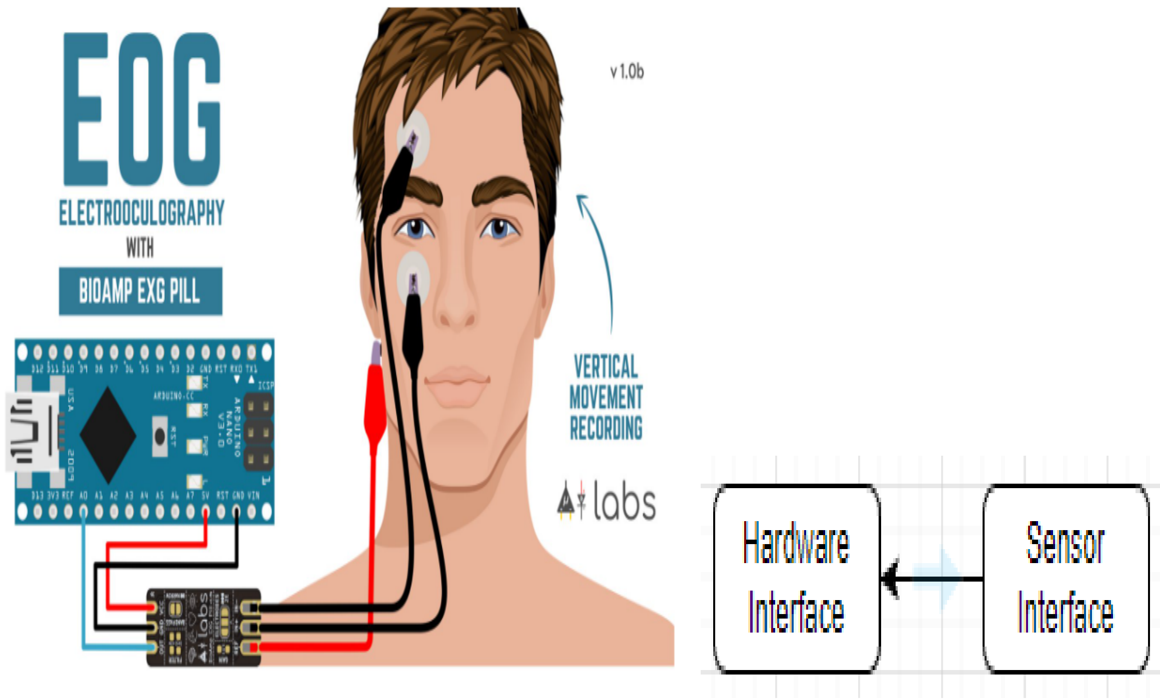


Figure 6.1: Connections between Hardware and Sensor Interface

EOG electrodes act as sensors and sense the blink action and send the same to the hardware interface that is the Arduino where it can be visualized. Here, Sensor Interface includes EOG electrodes and the Hardware interface includes Bioamp EXG Pill and Arduino UNO. Sensor Interface output is given as input to the hardware interface.

Arduino UNO is a hardware device that can be handled in the computer through Arduino IDE. Here, the Hardware interface is the Arduino UNO, and the Software interface is the

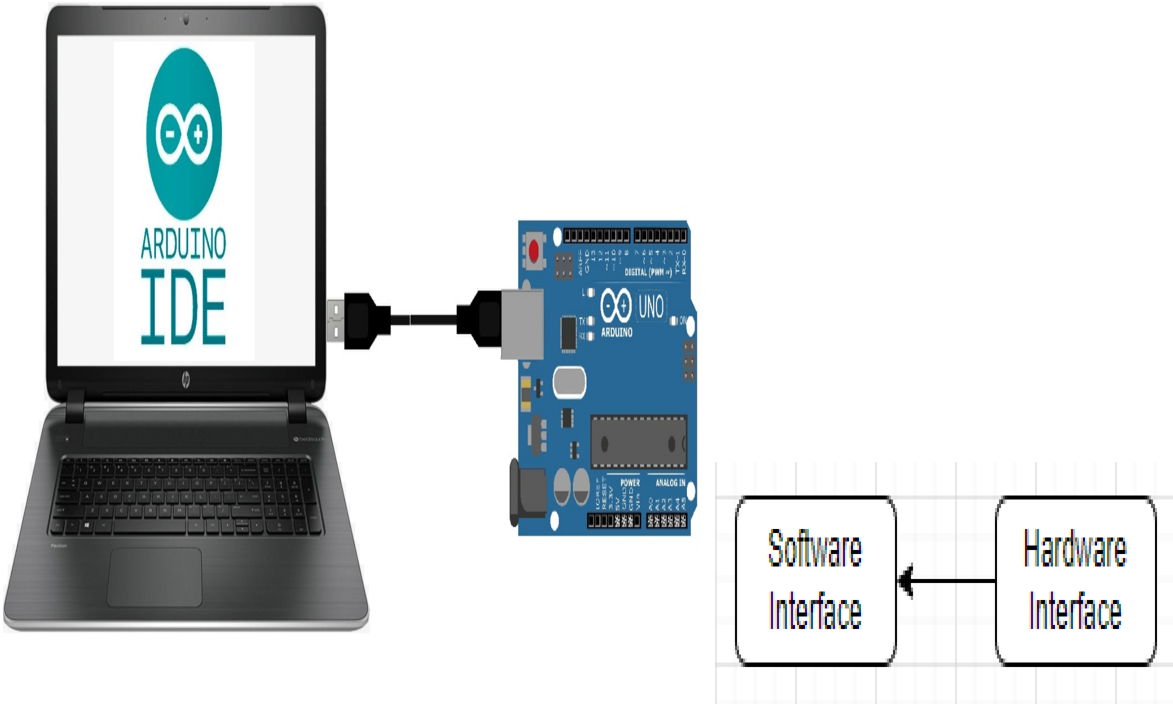


Figure 6.2: Connections between Hardware and Software Interface

Arduino IDE running on the pc. The connection between the two interfaces is wired and hence reliable. Arduino IDE is designed specifically for the interaction between Arduino hardware devices and the pc. Hardware interface output is passed to the software interface for further analysis.

6.2 Advantage and Disadvantage

6.2.1 Advantage

1. By detecting errors at an early stage, it can be corrected easily.
2. It saves money and time since errors detected at a later stage are very much difficult to correct.
3. Testing helps to alter the plan as and when needed and thereby supports smooth development of software.
4. A small bug if not identified at an earlier stage will become a big challenge during later stages especially in the maintenance stage. Hence, frequent testing solves the problem with the least effort.

6.2.2 Disadvantage

1. Testing is time consuming.

2. Testers need to think of all possible test cases which might not be possible in certain situations.

3. Separate human effort is required for testing i.e. a separate testing team is required apart from the development team.

6.3 Test case details

6.3.1 Test case id-1

Unit to test - Blink rate after uploading the file.
Assumptions - Blink rate should be displayed once the user uploads the file.
Test data - Data file that has been extracted from EOG device.
Steps to be executed - Click on select files button and select the file which has the data of user blinks that has been extracted from the device and then click on upload button and then click on 'blink' button.
Expected result - Blink rate should be displayed on the screen.
Result - Blink rate displayed successfully.
Pass/Fail - Pass
Comments - Our model can process the uploaded file successfully and be able to display blink rates to users.

6.3.2 Test case id-2

Unit to test - Chart to display the peaks that have been detected from the file uploaded.
Assumptions - Peaks are detected correctly and it is matching with the blink counts that are being displayed numerically.
Test data - Data file that has been extracted from EOG device.
Steps to be executed - Click on select files button and select the file which has the data of user blinks that has been extracted from the device and then click on upload button and then click on 'chart' button.

Expected result - Chart must be displayed with the original plots and peaks.

Result - Number of peaks detected from the chart and the number of blinks we got numerically both are matching.

Pass/Fail - Pass

Comments - Our model can process the uploaded file successfully and be able to detect peaks with accuracy and be able to plot it with original plots.

6.3.3 Test case id-3

Unit to test - Form for updating other parameters.

Assumptions - User will update all the details and he will not be able to submit the form until he enters all the details and could generate and download the report after entering all details.

Test data - Form details must be filled.

Steps to be executed - Enter all the details in the form and click the submit button and generate report button to get the report.

Expected result - Download and generate button should not work till user enters all the details.

Result - User can't download and generate a report until and unless he enters all the details.

Pass/Fail - Pass

Comments - Our model can handle empty entries efficiently.

6.3.4 Test case id-4

Unit to test - File uploading

Assumptions - When a user uploads 2 files at a time, the model has to take the recent one for the analysis.

Test data - Two files should be uploaded at a time.

Steps to be executed - First upload a file then upload another file.

Expected result - Model should analyse with the recent file that has been uploaded.

Result - Our model is considering the recent file for the analysis.

Pass/Fail - Pass

Comments - Our model can handle two files.

6.3.5 Test case id-5

Unit to test - The order of getting the data.

Assumptions - When a user clicks on the chart button before getting a blink count then our model will alert the user to get a blink count first.

Steps to be executed - Click on chart button before blink button.

Expected result - Our model will give an alert to the user by pop-up.

Result - When the chart button has been pressed without getting a blink count chart has not been displayed.

Pass/Fail - Pass

Comments - Order of the button clicked has been handled properly.

6.3.6 Test case id-6

Unit to test - Handling different types of file.

Assumptions - When a user uploads a file of different type other than .txt format then the file should not be uploaded and it should give a pop-up to the user to upload it in required format.

Steps to be executed - Upload a file other than .txt extension.

Expected result - Our model will give an alert to the user by pop-up.

Result - When the required type of file has not been uploaded, our model gives an alert by pop-up.

Pass/Fail - Pass

Comments -Different types of files have been handled efficiently.

6.4 Results

6.4.1 Blink Detection from the EOG Blink waveform

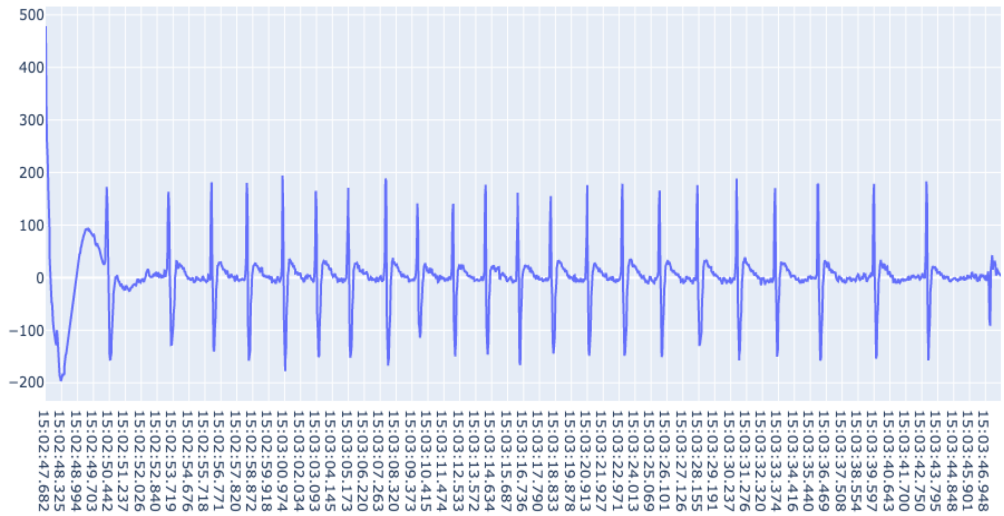


Figure 6.3: Blink waveform obtained from EOG - plot of Voltage Vs timestamp

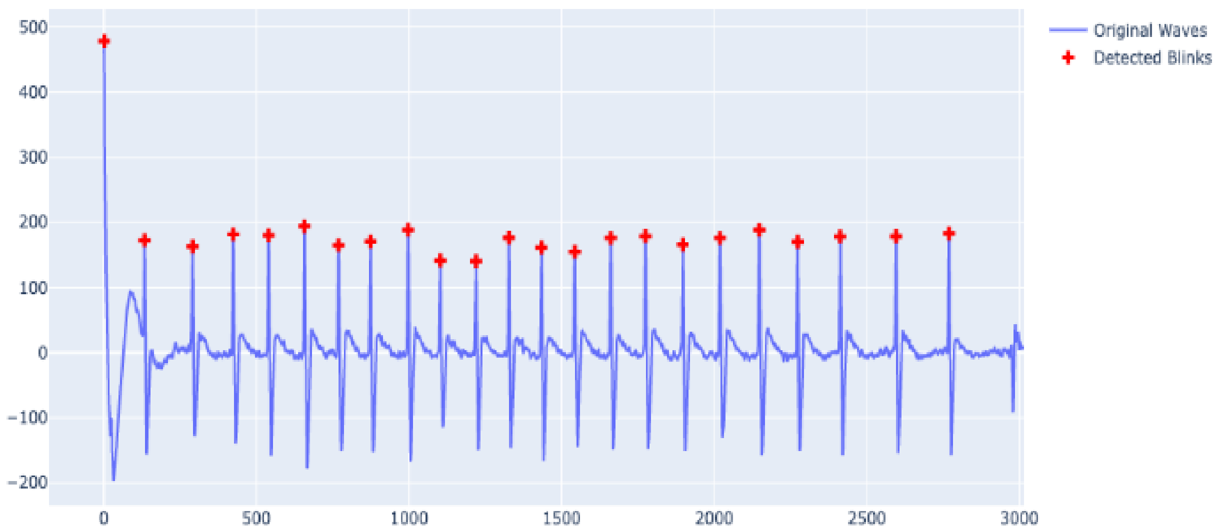


Figure 6.4: Peaks detected in the Blink waveform

To find the number of crests present in the blink pattern, a python function find_peaks which is defined in scipy.signal package has been used. It takes one mandatory parameter which is the array consisting of values out of which peaks need to be found out. This function finds all local maxima by simple comparison between neighbouring values. To pick only some peaks out of all possible local maxima, conditions need to be specified for the peak's properties. After considering a certain number of datasets, a threshold can be fixed so that it will be applicable for all future waveforms and acts as a condition for peak. Similarly, minimum distance between consecutive peaks can be specified. All these conditions can be specified by passing values to the optional parameters.

6.4.2 Appplication built for early detection of Dry Eye disease

The figure 6.5 shows the landing page of the application and this page is also obtained as a result of clicking the Home button. On clicking the Try button in the navigation bar the user gets a new page where the user can upload the EOG files which are in 2 columns consisting of time and voltage values. Once the file is uploaded the user can click on the Upload button which gives the number of blinks as shown in fig 6.7. By clicking on the chart button the graph for the uploaded file will be displayed on the screen as shown in figure 6.9.

On clicking the Disease button in the navigation bar, the user gets the choice to fill out the form. This form requires few details to be filled from the user. This data is considered to detect the level of dryness in the eyes. And the fields added in the form are few of the important parameters required to detect Dry eyes disease.

Once the user fills the form and clicks on the submit button the result will be generated. The results tell the user the status of dry eye disease and also gives a list of precautions that the user can follow to protect their eyes from the increase in dryness in their eyes.And then the user can get the complete report by clicking on the Generate Report button.This report consists of all the parameters considered to detect the level of dry eyes , the result, and the precautions to be taken.

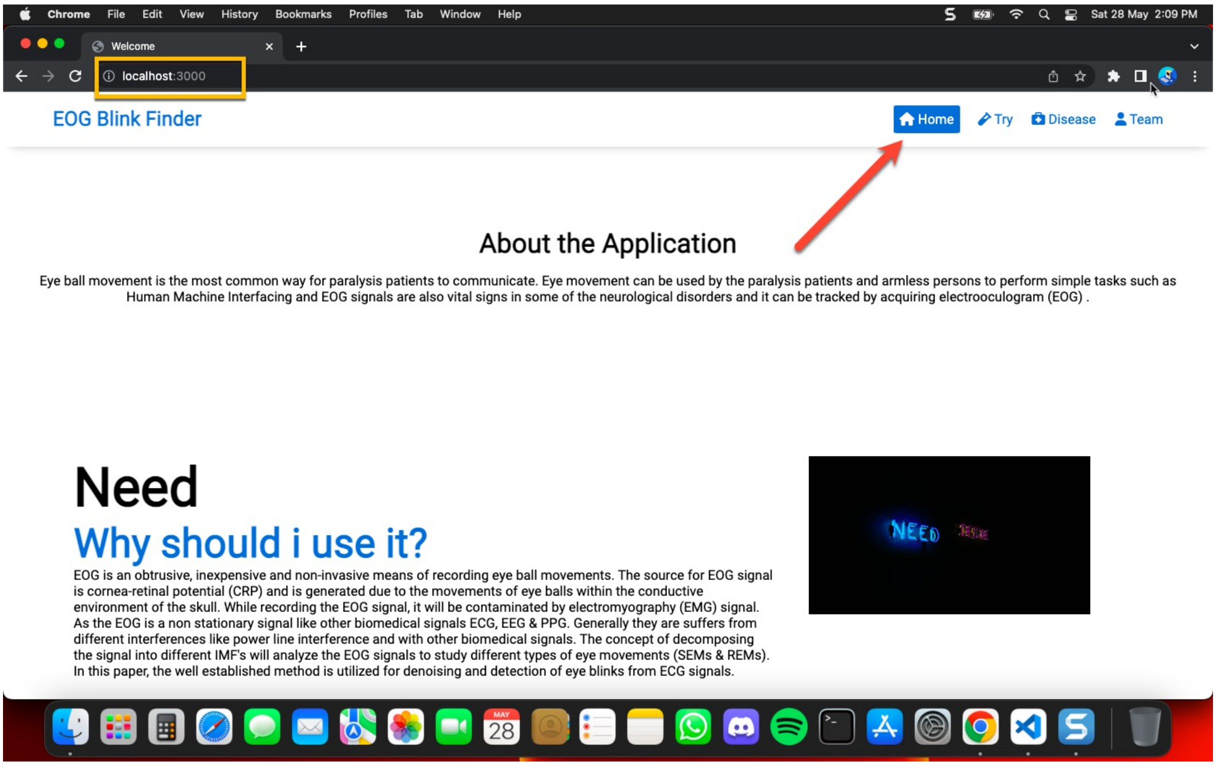


Figure 6.5: Application's Home page

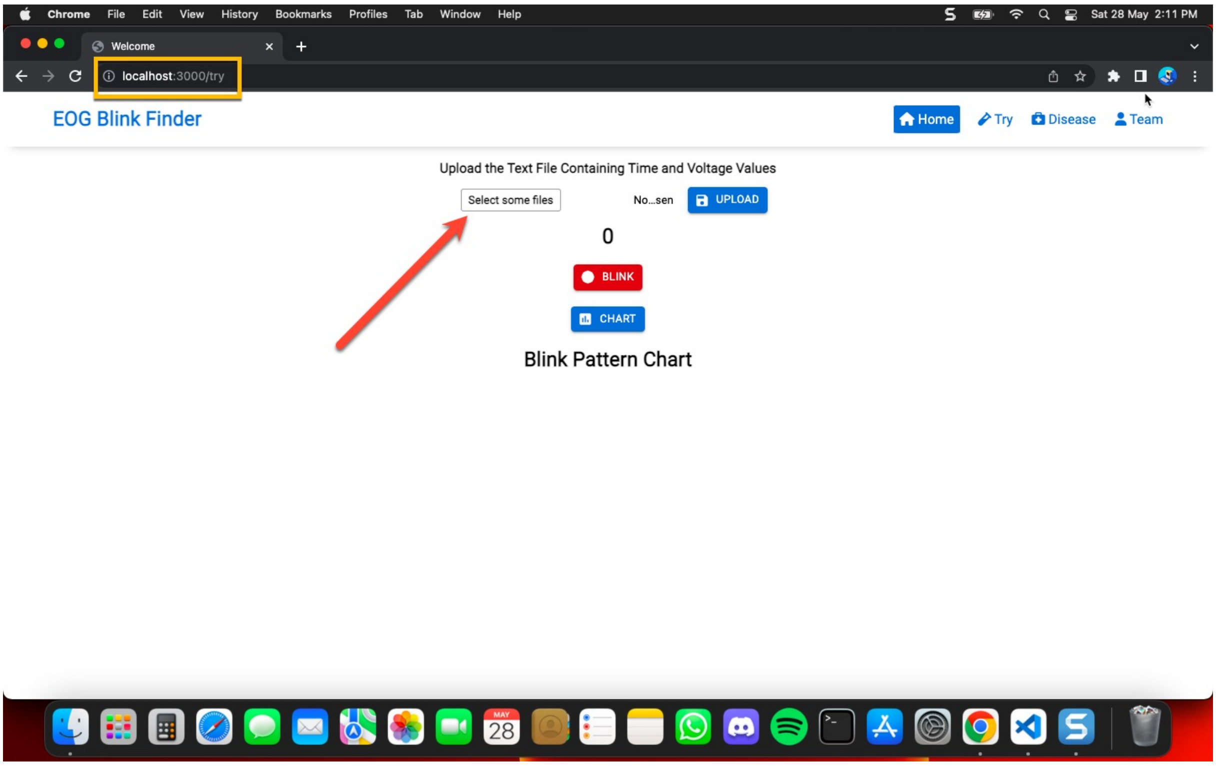


Figure 6.6: Uploading EOG digital file captured by Coolterm

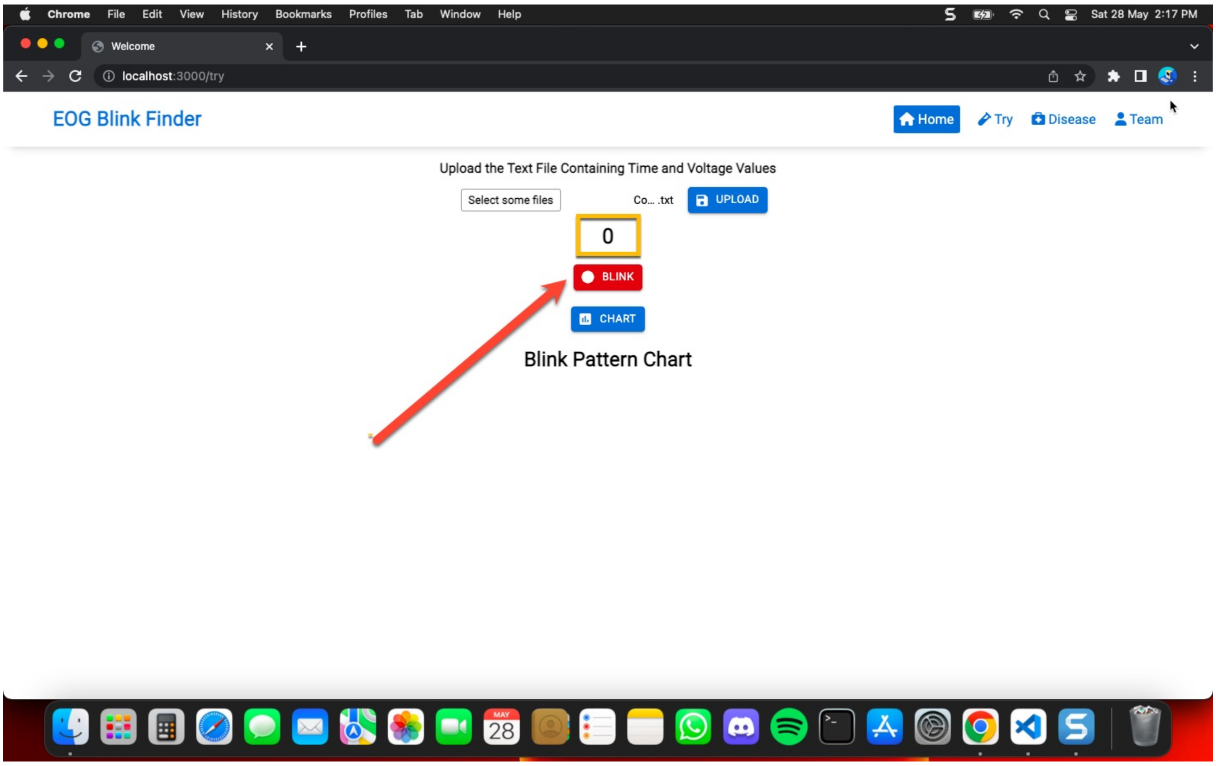


Figure 6.7: Counting number of blinks after uploading data file

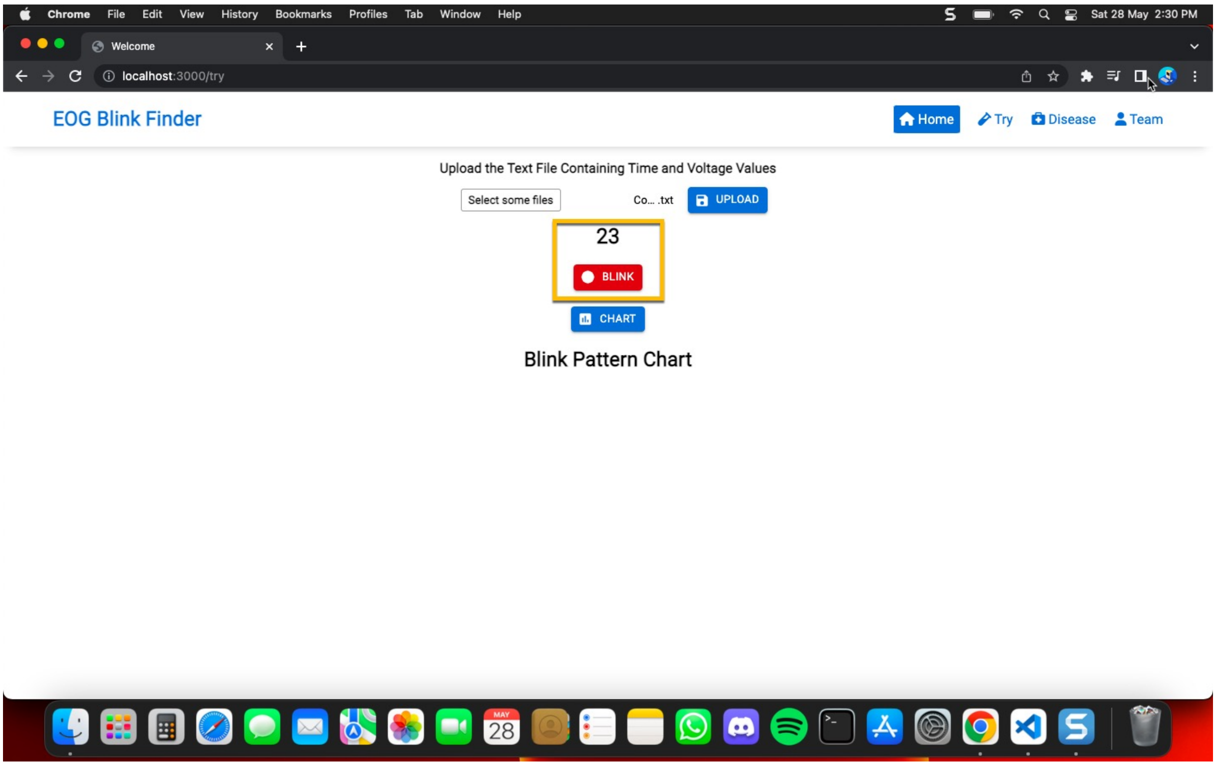


Figure 6.8: Total number of blinks present in the data

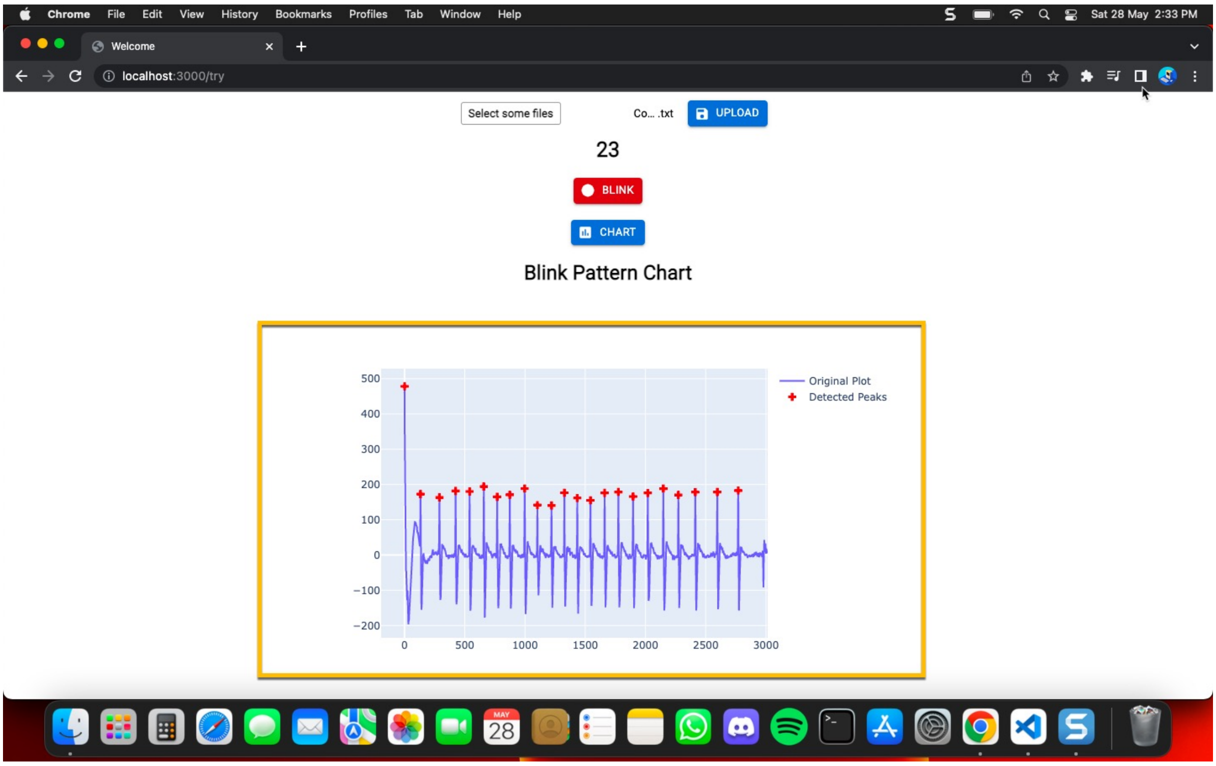


Figure 6.9: Blink pattern chart with peaks detected

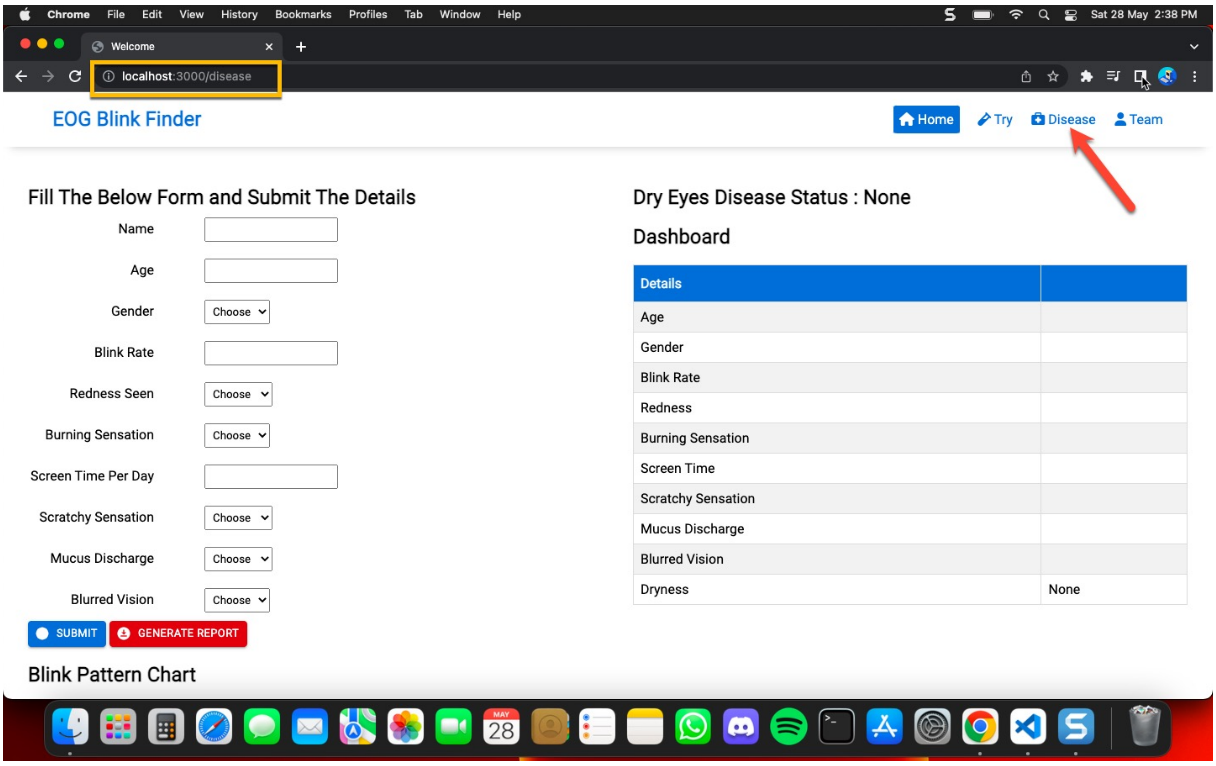


Figure 6.10: Form and dashboard in disease route

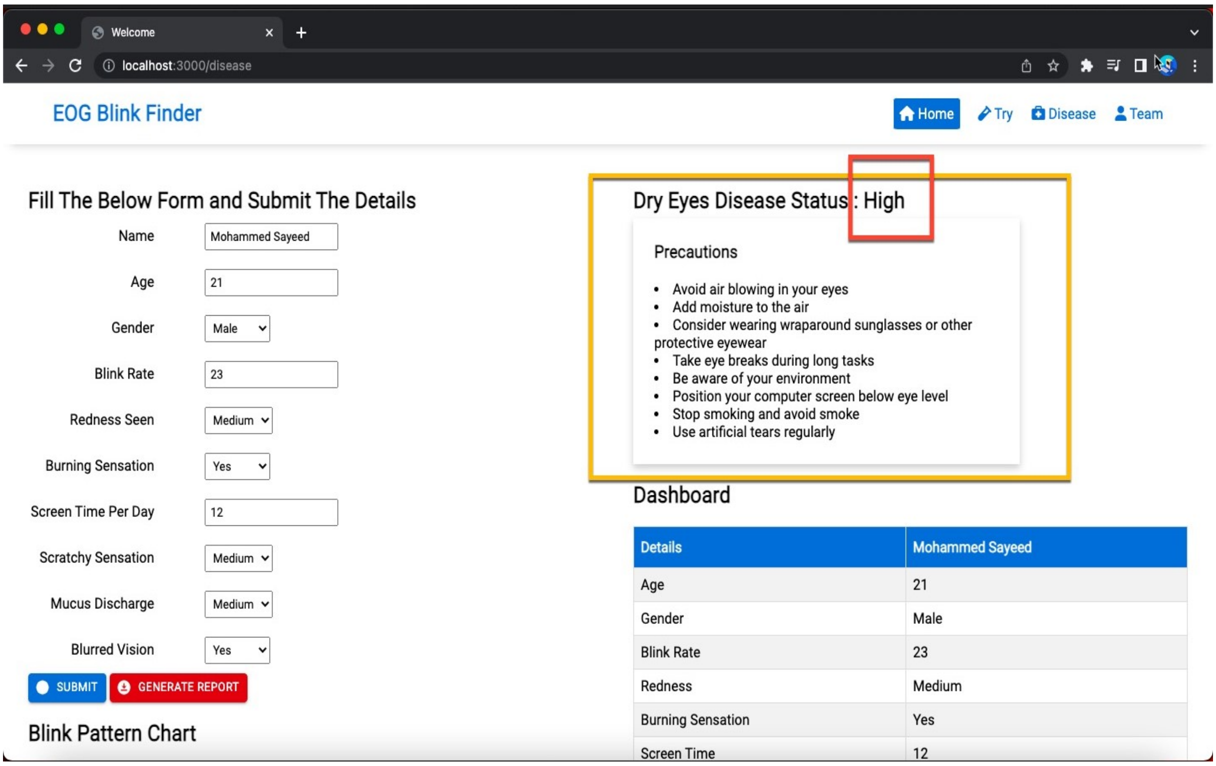


Figure 6.11: Dashboard after filling the form with dry eye disease status as High

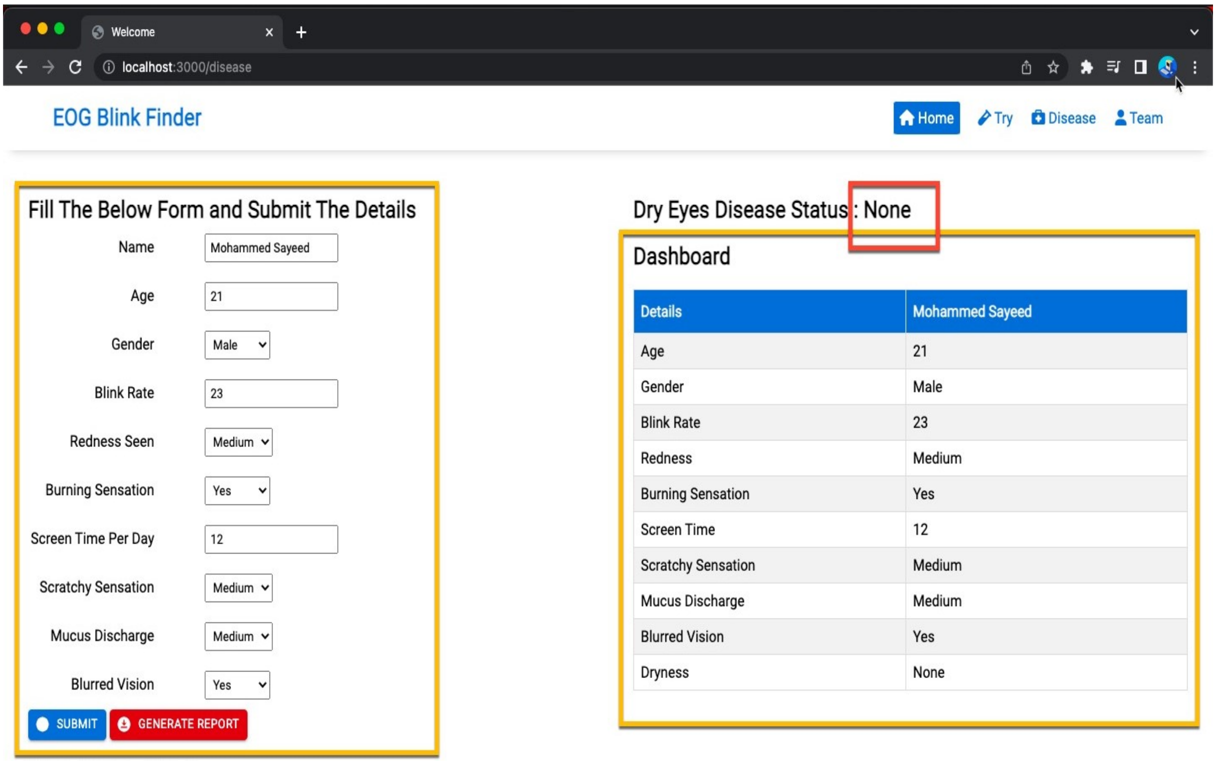


Figure 6.12: Dashboard after filling the form with dry eye disease status as None

Report

Name	Mohammed Sayeed
Age	21
Gender	Male
Blink Rate	23
Redness	Medium
Burning Sensation	Yes
Screentime	12
Scratchy Sensation	Medium
Thready Dischard	Medium
Blurred Vision	Yes
Dryness Level	High
Disease Status	High

Precautions

1.Avoid air blowing in your eyes
2.Add moisture to the air
3.Consider wearing wraparound sunglasses or other protective eyewear
4.Take eye breaks during long tasks
5.Be aware of your environment
6.Position your computer screen below eye level
7.Stop smoking and avoid smoke
8.Use artificial tears regularly

Figure 6.13: Report downloaded in PDF format

Chapter 7

Conclusion and Future Scope

7.1 Conclusion

Blinks can be identified using Electroencephalography (EEG) by analysing collected brainwaves using an EEG headset, but the log data obtained from the headset is difficult to interpret. In addition, the gadget communicates with the system's software through Bluetooth. As a result, due to the lag of a few seconds, certain blinks may be missed. Another issue is that the output from the headset's amplifier is digital, making it impossible to extract analogue signals straight from the headset. Also, the patient will be conscious about the test being conducted since he will feel the presence of the headset on his head. Blinks can be identified with some precision in OpenCV based on the camera's resolution; however, high resolution cameras with high frame rates are necessary to detect blinks. In EM and IR, sensors are fixed to the eye glasses itself so that the patient need not wear any extra equipment. Found blink rate is used in Dry eye disease prediction.

In EOG, efficiently blinks can be detected. Blink wave pattern can be seen using Arduino UNO and IDE. Digital data can be captured using Coolterm software. Captured digital data consists of two columns. First column represents the timestamps and the second column depicts voltage at that particular timestamp. Many blink parameters like blink amplitude, eye opening velocity, eye closing velocity, blink frequency, blink interval etc can be found using EOG blink waveform. Also, captured EOG data is accurate when compared to OpenCV and is reliable since connections are wired and there is no involvement of bluetooth. But, the thing is the patient feels conscious about the data capturing. Hence, we may not get the actual data we were supposed to capture and also capturing cannot be continued for longer duration.

In all the discussed methods, the patient will be conscious about the sensor or device being worn. This will reduce the accuracy of the analysis made on the captured data. But as discussed in future scope, to get accurate results in real-time, the sensor or the application should be built in such a way that the patient will not be aware about the test being conducted on him so that the test can be conducted considerably for a longer duration and also patient's data can be captured at different intervals where patient will be involved in different activities. In this case, analysis made on the captured data would be more accurate compared to the proposed one.

7.2 Future Scope

In the built-in OpenCV application, blinks can be detected by capturing eye images using a web camera attached to the laptop or using an external web camera connected to the system and processing the same using Image Processing Algorithms. Here, the person need to look at the web camera constantly until the application runs. In EEG technology, blinks can be detected by using an EEG Headset. Person needs to wear the headset and the blink pattern can be seen through the software associated with that headset. In the proposed EOG technology, a person needs to wear EOG sensors until blink recording ends. In all the existing and proposed methods and also in present blink detecting sensors, the person or the patient will be conscious about the test being conducted. He might not be too comfortable with the sensors or the headset being worn. In other words, patient may not feel normal during the test. Hence, we may not get accurate results. Also, the test may not be conducted for a longtime. So, in future, sensors or the application must be designed in such a way that the patient should not be aware about the test being conducted on him. Sensors should not affect his comfort. He must feel normal, as though he is not at all wearing them. Also, an application can be built, which will run in background all the time and capture eye images at different intervals, so that we will have access to patient's images at different situations which is essential to accurately analyse the person's blink pattern and come to correct conclusions.

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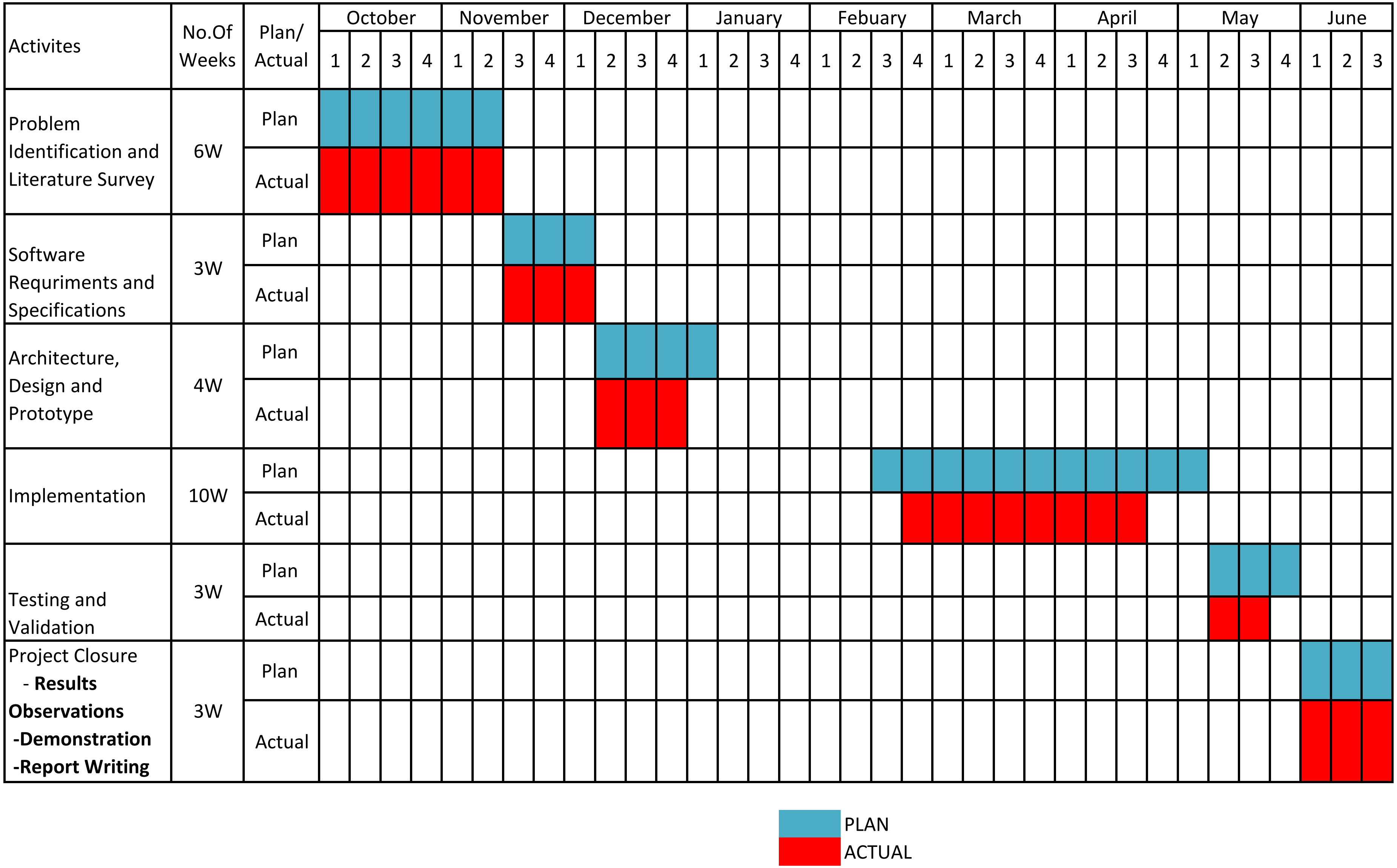
Project Plan



Cost estimation

Project cost estimation is the process of predicting the quantity, cost, and price of the resources required by the scope of a project. Since cost estimation is about the prediction of costs rather than counting the actual cost, a certain degree of uncertainty is involved. The cost estimate is used to determine the size of the required investment to create or modify assets. It is also during the early phases that alternative plans are considered that need to be priced. It covers activities such as resource planning, cost estimating, budgeting and cost control. These activities are repeated in a closed loop and take place during the whole project life cycle.

Following aspects are involved in the cost:

- Human resources
    - 1 guide: 9 months [9 * 2 meetings (30 minutes approx. each)] = 9 man-hours
    - 4 developers: 6 months [24 hours (6 days a month) * 6] = 576 man-hours each
- Component costs
    - Wearable EEG Brainsense Headset device : Rs. 10,000
    - EOG electrodes : Rs. 2500
    - Arduino UNO : Rs. 2300
    - Bioamp EXG Pill : Rs. 5536
    - Attaching wires : Rs. 200
- Internet Charges
    - The internet charges for reading online articles, conducting meetings and downloading open source software is 6,500 rupees.
- Miscellaneous charges
    - Printout of preliminary report with soft binding : Rs 100
    - Printout of main report with soft binding (6 copies) : 6 * 500 = Rs. 3000
    - Travelling charges : Rs.1500

Detailed cost values are tabulated as below :

Project Task	Man-hours	Hardware/software	Total cost
Human Resources	576		576 hrs
Component cost		Rs. 20,536	Rs.20,536
Internet charges			Rs.6500
Miscellaneous			Rs.4,600
Total	576 hrs	Rs. 20,536	Rs.31,636

PO ATTAINMENT

Programme Outcomes (POs):		Task Performed	Attainment				
			Excellent 5	Very Good 4	Good 3	Fair 2	Poor 1
PO1	Engineering knowledge	1. Applied the knowledge of Programming and Software Engineering and Machine learning.		✓			
PO2	Problem analysis	1. Literature Survey done on "Blinks and dry eye disease" 2. Different types of sensors helpful in blink detection were studied and analysed. 3. The objectives of the project were set. 4. Knowledge of Programming, ML and Software Engineering was found to be useful in implementing the project	✓				
PO3	Design/development of solutions	Solutions are developed for the following: 1. Extracting blink count from the blink waveform obtained from EOG electrodes. 2. Predicting dry eye disease with blink count and other necessary parameters. 3. Giving suitable precautionary measures for the patient based on their dry eye disease’s status.		✓			
PO4	Conduct investigations of complex problems	1. Causes for reduced blink and factors contributing to dry eye disease are gathered through Literature Survey. 2. Blink patterns of various patients indulged in various day-to-day activities are also studied. 3. Suitable solutions to meet the requirements are developed to certain accuracy.		✓			
PO5	Modern tool usage	Visual studio code, Node JS, React JS, Python is used		✓			

Programme Outcomes (POs):		Task Performed	Attainment				
			Excellent 5	Very Good 4	Good 3	Fair 2	Poor 1
PO6	The engineer and society	This project helps in early detection of dry eye disease and thereby protects human eyes.		✓			
PO7	Environment and sustainability	1. This project aims at reducing dry eye disease in patients through its early detection. 2. This project is upgradable with predicting other diseases like Parkinson and red eye disease.		✓			
PO8	Ethics	1. This project is useful in detecting dry eye disease at an early stage. 2. It is also useful in giving precautionary measures for those patients who are having dry eye disease. 3. References are quoted. 4. Report is prepared by students and plagiarism checks are made with turnitin software.		✓			
PO9	Individual and team work	1. Each student took up the responsibility of executing one module of the project. 2. The report content was contributed by each of the team members. 3. Integration of the modules was done as a team work. 4. Incorporating the suggested changes was done as a team with necessary discussions. 5. As a team presentations and demo of the project was given	✓				

Programme Outcomes (POs):		Task Performed	Attainment				
			Excellent 5	Very Good 4	Good 3	Fair 2	Poor 1
PO10	Communication	1. Phase-wise presentation and Demo of progress of project work before the panel. 2. Presentation and Demonstration of project before Industry Experts. 3. Preparation of the Report spread across the entire Semester. 4. Regular interaction with Guide and Panel members to incorporate the suggestions given during evaluations 5. Answering queries during presentations and Demos.	✓				
PO11	Project management and finance	1. Project Scheduling using Gantt Chart. 2. Maintaining Project Diary. 3. Estimating Man Hour Requirement		✓			
PO12	Life-long learning	1. Working on Node JS, React JS and Python Technology. 2. Reading papers and articles on different blink detection methodologies		✓			

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