

Real-time Eye blink detection & counting Computer Vision Digital Library

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering Degree in
Electronics and Communication Engineering

by

ASODI KISHORE KUMAR REDDY (39130043)

ATTE RUSHI VARDHAN (39130045)



**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS**

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

(Established under Section 3 of UGC Act, 1956)
Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai -600119
www.sathyabama.ac.in



DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Professional Training Report is the bonafide work of **ASODI KISHORE KUMAR REDDY (39130043)** and **ATTE RUSHI VARDHAN (39130045)** who carried out project entitled " Real-time Eye blink detection & counting Computer Vision Digital Library " under my supervision from NOVEMBER 2022 to APRIL 2023 .

Internal Guide

Mr. V. KALIST M.E

Head of the Department

Dr. T. RAVI, M.E., Ph.D.

Submitted for Viva voice Examination held on 24.04.2023

Internal Examiner

External Examiner

DECLARATION

I, **ATTE RUSHI VARDHAN** and **ASODI KISHORE KUMAR REDDY** hereby declare that the Professional Training Report on " **Real-time Eye blink detection & counting Computer Vision Digital Library** " done by me under the guidance of **Mr. KALIST** at Sathyabama Institute of Science and Technology is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

A. Rushi Vardhan



DATE:24.04.2023

PLACE: CHENNAI

SIGNATURE OF THE CANDIDATE

1. ATTE RUSHI VARDHAN
2. ASODI KISHORE KUMAR REDDY

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ABSTRACT

Nowadays, eye tracking and blink detection are increasingly popular among researchers and have the potential to become a more important component of future perceptual user interfaces. The real-time eye tracking and eye blink detection system has been a fundamental and challenging problem for many. Input and output of the system Input are usually obtained via webcam and output results are obtained in real-time as the count of no. of blinks. We will be using Deep Learning and Computer Vision algorithms. The existing models for eye blink detection are based on CNN and are very complex. The state-of-the-art methods are less effective and less accurate. We propose an automated, real-time eye blink detection system that can be used for various applications with the lowest cost. It will monitor the number of times we blink using eye contours. An aspect ratio method is used to implement a robust and low-cost embedded eye blink detection system. This method is exact resourceful, fast, and easy to perform. It will monitor the number of times we blink using eye contours. It would analyze the x, y coordinates and examine them with precision. Computer vision is used for analyzing the landmark points of the eye accurately. The proposed application would also analyze the width and height of the eye region and monitor clockwise. The Advantages of the proposed system are Secured, Interpretability, High accuracy, Lightweight model & fast processing. It could be used in Face recognition apps, Video surveillance systems, eye-tracking applications, and healthcare where the number of time a person blinks is often associated with dryness or an allergy of the eye.

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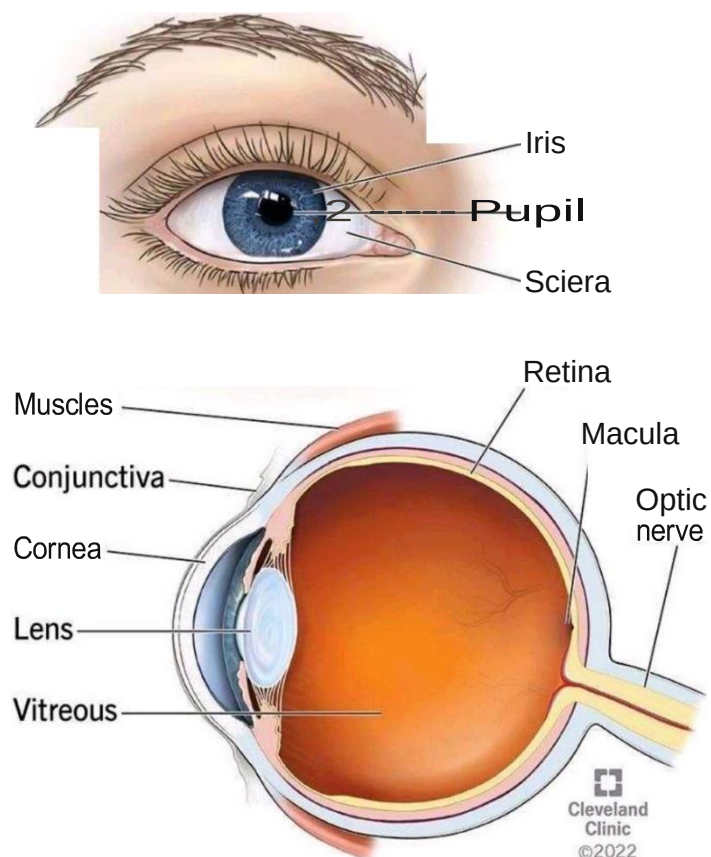
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CHAPTER 1

1.1 Introduction

The eye is a visual sense in humans. A critical organ of vision it plays a very important part not only in life but also the human body. The human eye is the system that provides us with vision, which offers us access to more details about our environment compared to any of the other four organs. By processing the light that things reflect or emit, the eye enables us to see and understand the shapes, colors, and dimensions of items in the world. The eye can see in both high and low light, but it is unable to discern objects in complete darkness.

Eye anatomy



Visible Eye Parts :

Eyelid: Your eyelid shields your eye from debris, sweat, and other contaminants that could harm it. It promotes blinking to maintain the eye well-lubricated and nourished by opening and closing both intentionally and involuntarily.

Pupil: The area of a eye via that we can see, or the pupil, varies in size according on the amount of light. The pupil shrinks to let less light in if the surroundings is exceptionally bright, whereas it expands to let more light in when the atmosphere is dimmer. This ensures that the proper quantity of light reaches the retina at the rear of the eye and helps us see clearly in a variety of lighting conditions.

Sciera: The white portion of your eye, or sclera, serves as an outer layer of defense. It protects the optic nerve and can provide an accurate assessment of overall eye health. For instance, a pale sclera may point to liver issues, while a red sclera may signal that your eyes are weary or dry.

Iris: The iris, which is the colored portion of the eye, really regulates the pupil's size. In other words, it controls how much light enters the eye. The connective tissue and muscle that surround the pupil form the iris, and just like your thumbprint, it has an unique shape, texture, and coloring.

1.2 Internal Eye Parts:

Cornea: The cornea is the transparent surface in front of your eye that allows light to enter. Your iris and pupil are directly covered, adding an additional layer of security. We do laser eye surgery on the cornea because irregularities in your cornea's curvature are what lead to an eye prescription and your requirement for spectacles. Your vision will be better if your cornea has a smooth surface.

Lens: The portion of the eye that focuses is the lens, which is situated beneath your iris. Light rays passing through the lens are focused so that they strike the retina at the proper angle, changing the focal distance of the eye. As you age, a protein development in the eye may cause the lens to become clouded. The term refers to a cataract. Fortunately, you can remove your lens and substitute it with a synthetic, transparent lens to restore your eyesight.

Aqueous humor: Your eyes continuously manufacture this watery liquid to support healthy ocular pressure and hydrate your cornea. This maintains the health of your

eyesight. It is essential for strong vision and is removed from the eye at the same rate that it is created.

Ciliary muscle: The eye's ciliary muscle is the component that genuinely modifies the lens's structure to enable the eye to concentrate on different distances. Additionally, it regulates the flow of aqueous humor inside the eye and keeps the lens in the proper place in the central layers of the human eye.

Retina: The portion of tissue known as the retina is located at the back of the eye. The retina's main function is to take in light from the lens and transmit signals to the brain so it can convert it into a mental picture. Rods and cones are the two categories of photoreceptor cells found in the retina. Cone cells are in charge of detecting colour vision, whereas rods are in charge of detecting and classifying, darkness, and brightness. Maintaining your retina's function is essential since issues with the retina can lead to the loss of eyesight.

Fovea: The macula portion of the retina's fovea is where it is placed. Sharp central vision, necessary for reading, driving, and other activities requiring attention to visual detail, is controlled by this little region.

Macula: The macula is the retina's central region. We can read and see fine details because of the heavy proportion of light-sensitive cells (photoreceptors) in this incredibly small space. Our central vision entails a more detailed vision. Our peripheral, or side, vision is produced by the retina's bigger remaining region.

Choroid: Between the retina and the sclera is the choroid. It is made up of layers of blood vessels that bring nourishment to the eye's inner regions.

Function of Eyes

One of the most significant eye-related behaviors may be an eye blink. The cranial nerve VII innervates the orbicularis oculi muscle (the facial nerve). The palpebral orbicularis, the muscle responsible for an instinctive blink and a voluntary wink, contracts the palpebral region of the eyelid, gently closing it. The levator muscle then relaxes. 23 Spontaneous involuntary blinking replenishes the precomeal tear coating.

A loud noise, corneal, conjunctival, or cilial contact, a quick approach of an object, or any combination of these stimuli may cause a reflex blink, which serves as protection. The tissues around the eyelids-the forehead, temple, and cheek are contracted when the orbicularis orbitalis contracts, which causes the eyelid to shut firmly

Eye blinking has potential uses in a wide range of industries, such as human-computer interface, driver awareness indicator, psychology analysis, and more.

The importance of eye-blink detection is as follows:

1. Driver Drowsiness Detection

Nowadays, the transportation system is a crucial component of daily life. Everyone who is driving has the potential to become asleep or sleepy. Particularly after a brief sleep, in poor health condition, or following lengthy travels, sleepiness may occur.

The perception of sleep lowers a driver's level of alertness, creating a hazardous situation and raising the likelihood of a traffic collision. The primary cause of road fatalities is discovered to be operators' loss of concentration while driving. And so by keeping drivers awake while operating a vehicle, the risk of accidents can be decreased.

To lower the crash rate, the auto driver must undergo onboard surveillance. To ascertain if someone is paying attention to an issue or not, there are numerous procedures. On the other hand, a disproportionate number of traffic accidents happen as a result of the transient condition of the driving force.

Thus creating a system to gauge a driver's level of attentiveness is becoming a serious problem in the field of active safety analysis (Wang et al. 2006). There are numerous methods for determining a driver's level of awareness.

The driver's face must be continuously captured by a lens for this process to work. The state of awareness can be determined using several facial features. Popular techniques include examining eye blink rates, eye aspect ratios, eye closure times, etc. If the observed result deviates from the expected value, this type of system can issue a warning.

2. Human-Computer Interactions

An incurable medical disorder known as motor neuron disease (MND) causes the patient's motor neurons to become disabled. Additionally, it causes the muscles of the hands, feet, and voice to become weak. As a result, the patient is unable to perform voluntary acts, and communicating their wants is extremely challenging. One such ailment where people are unable to move their lower extremities is tetraplegia. Solutions for people with the aforementioned disorders are now available thanks to innovations like the one offered and described throughout.

The point of interaction between a human user and a computer is known as the human-computer interface (HCI). Keyboards, computer mice, trackballs, touchpads, and touch screens are a few examples of commonly used inputs. All of these gadgets need to be manually operated, thus those with movement disabilities cannot use them.

Therefore, it is necessary to create alternate means of human-computer communication process that are appropriate for people with neuromuscular disorders that would enable them to participate in the information society. Researchers from all over the world have recently become interested in the creation of alternative interacting components.

A user-friendly interface should meet a number of requirements for people with significant mobility impairments, including being non-contact and avoiding specialist equipment, having any real effectiveness, and operating on a consumer-grade computer.

3. Virtual Gaming Reality

The construction sector, biology, aviation, military training, and video games are just a few of the fields where virtual reality systems are finding utility due to the rapid advancement in technology. Consoles and hand-worn data gloves were the traditional ways of interacting in a virtual reality (VR) environment.

Despite having the ability to operate video games, these gadgets lack natural user interfaces. The entire VR experience is hampered by the usage of external physical input devices because the user is immersed in a virtual environment.

With the development of BCI (brain computer interface) research, researchers have made some strides in human machine/computer interaction, aiming for complete intuitive control of distant virtual environments, a think-and-play type of user interface.

With the help of this realistic interface, gamers may have a more thrilling gaming experience as their digital surroundings react to their eye blinking movements.

Background

In order to improve human-computer interaction (HCI), the first attempt to track eye blinking was made in 2001. However, the investigation was only partially PC-based. Their techniques are necessary to locate eyes and monitor their specific position.

Mahalanobis's distance of different picture blobs dictate where the eyes are located. After that, they calculate the relationship between the tracked eye and the template. The system categorizes the state of the eyes as "open" if the outcome is less than a specific threshold and "closed" thereafter.

Post-research can be divided into two groups as a result of this study. The very first group starts by detecting the eyes and then registers it. To be even more precise, the group makes template out of the eyes that have been identified.

Then they compare the template to the actual eyes to determine where they are. The above approach annoys users since it must repeatedly initialize sight detection if the recorded eye location is found to be incorrect. It employs the scatter plot on the x, y axes of multiple photos and applies the percentage between their height and width.

The second category, in contrast to the first, conducts face and eye detection first, followed by eye

- blink detection. The second group locates the area around the eyes on the face it initially detects. The procedures are then used to determine where the identified eyes are located.

The eye's blinking state can be represented by a variety of feature detection techniques, including Boosted LBP, Gabor wavelet, and picture flow. There is also the feature extraction template matching.

Each of these groups' approaches have drawbacks for HCI on connected phones, which calls for real-time usability and functionality.

Eye tracking as a tool is now more accessible than ever, and is growing in popularity amongst researchers from a whole host of different disciplines and has the potential to become an even more important component in future perceptual user interfaces. The technique is used in cognitive science, psychology, human-computer interaction, advertising, medical research, and other areas. Today, human eye-gaze, blinking and eye movement can be recorded with relatively high reliability by unobtrusive techniques. Though, there are relatively few techniques proposed for the active scene where the head and the camera move independently and the eye moves freely in all directions independently of the face. Though care must be taken, eye-gaze tracking data is used in a sensible way since the nature of human eye movements is a combination of several voluntary and involuntary cognitive processes. Normally, eye tracking is performed on two dimensions to measure the horizontal and vertical motions of the eye. Horizontal and vertical eye (2D) positions can be determined from pupil center coordinates, which can be computed using the center of mass algorithm. The development of technologies for detecting or preventing drowsiness at the wheel is a major challenge in the field of accident-avoidance systems. Because of the hazard that drowsiness presents on the road, methods need to be developed for counteracting its effects. The aim of this paper is to develop a prototype drowsiness detection system. The focus will be placed on designing a system that will accurately monitor the open or closed state of the driver's eyes in real-time. By monitoring the eyes, it is believed that the symptoms of driver fatigue can be detected early enough to avoid a car accident. Detection of fatigue involves a sequence of images of eyes, and the observation of eye movements and blink patterns. This paper is focused on the localization of the eyes, which involves searching for the entire image of the eyes, and determining the position of the eyes, by a self-developed image-processing algorithm. Once the position of the eyes is located, the system is designed to determine whether the eyes are opened or closed, and detect fatigue.

Nowadays, eye tracking and blink detection are increasingly popular among researchers and have the potential to become a more important component of future perceptual user interfaces. The real-time eye-tracking and eye blink detection system has been a

for many. Input and output of the system. Input is usually obtained via webcam and output results are obtained in real-time as the count of the number of blinks. We will be using Deep Learning and Computer Vision algorithms. The existing models for eye blink detection are based on CNN and are very complex. The state-of-the-art methods are less effective and less accurate.

We propose an real-time eye blink detection system that can be used. It will monitor the number of times we blink using eye contours. An aspect ratio method is used to implement a robust and low-cost embedded eye blink detection system. This method is exact, resourceful, fast, and easy to perform. It will monitor the number of times we blink using eye contours. It would analyze the x, and y coordinates and examine them with precision. Computer vision is used for analyzing the landmark points of the eye accurately.

The proposed application would also analyze the width and height of the eye region and monitor clockwise. The Advantages of the proposed system are Secured, Interpretability, High accuracy, Lightweight model & fast processing. It could be used in Face recognition apps, Video surveillance systems, eye-tracking applications, and healthcare where the number of times a person blinks is often associated with dryness or an allergy to the eye.

1.3 Problem Statement

Blinking is indicative of various human behaviors and states including drowsiness. This is particularly critical to DMS where driver attention monitoring is a key functionality. Analyzing the details of blinking patterns, other than blink frequency, is difficult for most conventional cameras. We propose an automated, real-time eye blink detection system that can be used for various applications at the lowest cost.

1.4 Objectives

This method facilitates the extraction of drowsiness related features (i.e. blink duration etc.) and utilises the higher temporal resolution offered by event cameras. This prevents accidents and saves lives of people. Thereby, reducing road accident cases in the country.

CHAPTER2

Literature Survey

[1] Bishar R. Ibrahim, Farhad M. Khalifa, Subhi R. M. Zeebaree, Nashwan A. Othman, Ahmed Alkhayyat, Rizgar R. Zebari, Mohammed A. M. Sadeeq, "Embedded System for Eye Blink Detection Using Machine Learning Technique", 1st Babylon International Conference on Information Technology and Science (BICITS), 2021

Bishar R. Ibrahim proposed a method for detecting blinks in real-time using machine learning and computer vision libraries. The proposed method is divided into four stages: (1) taking frames with a raspberry pi camera attached to the raspberry pi 3 platform, (2) using the haar cascade algorithm to identify faces in the captured frames, (3) detecting facial landmarks with the facial landmark detector algorithm, and (4) calculating the eye aspect ratio. The proposed method achieved high accuracy in detecting eye closure or opening. An aspect ratio method was used in this study to implement a reliable and low-cost embedded eye blink detection system on the Raspberry Pi platform. This method is precise, quick, and simple to use for detecting eye blinks.

[2] Shogo Matsuno, Minoru Ohyama, Hironobu Sato, Kiyohiko Abe, "Classification of Intentional Eye-blinks using Integration Values of Eye-blink Waveform", IEEE International Conference on Systems, Man, and Cybernetics (SMC), 2020

The proposed method detects intentional blinks automatically by determining the blink type threshold based on the waveform integration value as a new feature parameter. In addition, a blink measurement system was built to evaluate the proposed method, and the proposed method was tested by experiment. The system divides the interlaced image field into distinct fields in order to measure blinks with sufficient temporal resolution. It then extracts the waveform feature parameters and classifies the eye-blink types automatically. The experimental results show that the proposed method successfully classified intentional eye-blinks with 86% average accuracy,

demonstrating its superiority over conventional methods based on eye-blink duration.

[3] Rahul Dasharath Gavas, Somnath Karmakar, Debatri Chatterjee, Ramesh Kumar Ramakrishnan, Arpan Pal, "Cost Effective Real-time System for cognitive computing using Personalized Eye Blink Detection from Camera", 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), 2021

Rahul Dasharath Gavas proposes an eye blink detector system based on personalized vision. The proposed method is ubiquitous and unobtrusive, and it can be implemented with standard webcams/mobile cameras, making it deployable in real-world scenarios. This method has been validated using data from the researchers' lab as well as an open data set. The results show that this system performs well in both cases for a variety of conditions such as natural/artificial light, with or without spectacles. They outperformed state-of-the-art approaches with an F score of 0.98 for their collected data and 0.91 for an open dataset.

[4] P. Ran, H. Wang, "Real-Time Eye Blink Detection Based on Python", The 8th International Symposium on Test Automation & Instrumentation (ISTAI), 2021

P. Ran studies the use of face recognition and detection technology to detect the closed state of drivers' eyes, and the results of the detection provide timely status warnings, reducing the likelihood of traffic accidents. Python, OpenCV, Dlib, and other third-party libraries are used in this article to obtain the driver's face video via the mobile phone camera and detect changes in eye aspect ratio (EAR) and mouth aspect ratio (MAR) to determine the driver's state. Finally, this test outputs the relationship between EAR and MAR over time.

[5] Nageshwar Nath Pandey, Naresh Babu Muppalaneni, "Real-Time Drowsiness Identification based on Eye State Analysis", International Conference on Artificial Intelligence and Smart Systems (ICAIS), 2021

Based on the duration of eye blinks, this proposed work has established drowsy detection as well as an accident avoidance system. First, the open and closed states of the eye are determined using the eye aspect ratio (EAR). Furthermore, the blink duration or count during the transition from open to closed eye state is examined. Then, when the blink duration exceeds a certain threshold, it detects drowsiness and sends an alert message to the driver via the alarm. On the yawning dataset, the developed system achieved an approximate accuracy of 92.5%. (YawDD).

[6] Sree Haran A, Siyam Adit G, Vignesh N, Vimal Athitha S G, Subash Sakthivel S, Rath G, Anuradha R, "Brain Computing Interface based Auto Calling Using Eye Blink Detection Algorithm", Fifth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2021

This study attempted to assist patients through the use of a Brain-Computer Interface. Brain• Computer Interface (BCI) is a cutting-edge communication system that connects the brain to external electronic devices. BCI achieves this communication by capturing signals from the brain with electrodes. This study created a mobile application that allows users to call their favourite number using electrooculogram signals to assist physically challenged people in times of emergency.

[7] Oana Ursulescu, Betina Ilie, Georgiana Simion, "Driver Drowsiness Detection Based on Eye Analysis", International Symposium on Electronics and Telecommunications (ISETC), 2018

The main reason for developing a real-time system that monitors the condition of the driver's eyes is to reduce car accidents, which will benefit millions of people worldwide. This work proposes a method for detecting and monitoring the driver's eyes, specifically analyzing the eyes and determining whether they are closed or open. The number of frames in which the eyes are closed. When this number of frames exceeds a certain threshold, the driver receives a visual alert on the navigation display indicating that he is drowsy.

[8] Adriana Revelo, Robin Alvarez, Felipe Grijalva, "Human Drowsiness Detection In Real Time, Using Computer Vision", IEEE Fourth Ecuador Technical Chapters Meeting (ETCM), 2020

The algorithm presented in this paper uses an infrared camera to obtain frontal images of the driver and then uses the Viola-Jones algorithm to perform automatic face detection. Following that, the eye portion is extracted, and the classification between open and closed eyes is performed using one of two methods: a) a method based on the extraction of maximums and minimums of the eye's horizontal and vertical edges, and b) a multilayer perceptron (MLP) neural network. Finally, it detects drowsiness during the time interval in which the eyes were closed. The first method achieves 84% accuracy for open and close eye classification, while the second method achieves 97% accuracy, including test images in low-light conditions.

[9] Wissarut Kongcharoen, Siranee Nuchitprasitchai, Yuenyong Nilsiam, Joshua M. Pearce, "Real-Time Eye State Detection System for Driver Drowsiness Using Convolutional Neural Network", 17th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), 2020

This study compared three eye recognition algorithms for drivers that could be integrated into an open source solution to wake drivers as they begin to doze off: 1) CNN with Haar Cascade, 2) 68 landmark points on the face, and 3) gaze detection in 3 distinct face positions for both day and night driving conditions, as well as with and without glasses. Each of those variables is tested 100 times. The best algorithm is selected based on the number of correct detections, and it is then tested again based on light (day and night), angle of face (left, right, and center), angle of the camera (left and right), and glasses (on and off) to detect both blinking and closed eyes.

[10] Akihiro Kuwahara, Rin Hirakawa, Hideki Kawano, Kenichi Nakashi, Yoshihisa Nakatoh, "Eye Fatigue Prediction System Using Blink Detection Based on Eye Image", IEEE International Conference on Consumer Electronics (ICCE), 2021

Smartphones and other information devices have become indispensable in our daily lives. As a result of the increased use of information devices, there has been an increase in eye strain and the development of various eye diseases. Because the accumulation of eye fatigue manifests itself in a change in the number of blinks, blink detection technology is required. Face image normalization was used in this study to enhance the blink detection system by reducing the noise associated with facial movement. In all subjects, the proposed system surpassed the results of blink detection accuracy using EAR.

CHAPTER 3

3.1 Existing System

Different techniques have been reported for eye blink detection over the past few years. Although detection results achieved are promising, these traditional approaches are still far from being highly accurate and efficient. The existing systems are simple and effective but are extremely vulnerable to impact. The existing systems are based on multiple calculations and are highly complex in nature. Due to high complexity and inefficiency, the CNN-based models are inaccurate and have low precision. The existing system also leverages the Raspberry Pi Camera, found to be ineffective during low light conditions.

The inefficiency of the existing system:

- The limitations of the existing model are that the Raspberry Pi camera was used and because of this, the system could not work during the nighttime. A night-vision camera should have been used.
- Also, the dataset used was small and improper, which led to low accuracy and low precision.
- The existing model leverages CNN while the technology has now advanced towards computer vision.
- In the existing system, a fixed blink duration is assumed even though everyone's blink duration lasts differently.
- It is observed that the system's accuracy decreases in bad lighting conditions.
- The discussed limitations have been overcome to enhance the performance of the model successfully in the presented application.

3.2 Proposed System

A real-time algorithm to detect eye blinks in a video sequence from a standard camera is proposed. Recent landmark detectors, trained on in-the-wild datasets exhibit excellent robustness against a head orientation with respect to a camera, varying illumination, and facial expressions. We show that the landmarks are detected precisely enough to reliably estimate the level of the eye-opening. The proposed algorithm, therefore, estimates the landmark positions and extracts a single scalar quantity - eye aspect ratio (EAR) - characterizing the eye-opening in each frame. Unlike traditional image processing methods for computing blinks which typically involve some combination of: Eye localization. Thresholding to find the whites of the eyes. Determining if the "white" region of the eyes disappears for a period of time (indicating a blink). The eye aspect ratio is instead a much more elegant solution that involves a very simple calculation based on the ratio of distances between facial landmarks of the eyes.

3.3 Difference Between Proposed and Existing System

The existing systems are not very robust in prediction. They have not evolved according to technological advancements and time. The results are also unsatisfactory and may lead to erroneous detection of eye blink. The proposed system performs better than all previous ones in

terms of accuracy and time effectiveness.

3.4 Advantages Of Proposed System

The efficiency of the proposed system:

- This method for eye blink detection is fast, efficient, and easy to implement.
- The efficiency of the proposed eye blink detector has been compared with the state-of-the-art approaches using two video databases. The analysis of the results shows that the proposed technique's effectiveness is superior to the existing methods of eye blink detection.
- When performing classification in the trained model by applying sample test data of eye blink detection, the proposed application gives accurate results.
- The proposed model works well against train data and test data further this model

- The application is beneficial for conditions where data has to be processed in a short time and results are required instantly.

CHAPETR 4

4.1 System Methods

The organization of a computer vision system is highly application-dependent. Some systems are stand-alone applications that solve a specific measurement or detection problem, while others constitute a sub-system of a larger design which, for example, also contains sub-systems for control of mechanical actuators, planning, information databases, man-machine interfaces, etc. The specific implementation of a computer vision system also depends on whether its functionality is pre-specified or if some part of it can be learned or modified during operation. Many functions are unique to the application. There are, however, typical functions that are found in many computer vision systems.

- **Image acquisition** : A digital image is produced by one or sever imagesensors, which, besides various types of light-sensitive cameras, include rangesensors, tomography devices, radar, ultra-sonic cameras, etc. Depending on the type of sensor, the resulting image data is an ordinary 2D image, a 3D volume, or an image sequence. The pixel values typically correspond to light intensity in one or several spectral bands (gray images or colour images), but can also be related to various physical measures, such as depth, absorption orreflectance of sonic or electromagnetic waves, or nuclear magnetic resonance.
-
- **Pre-processing** : Before a computer vision method can be applied to image data in order to extract some specific piece of information, it is usually necessary to process the data in order to assure that it satisfies certain assumptions implied by the method. Examples are:
 - Re-sampling to assure that the image coordinate system is correct.
 - Noise reduction to assure that sensor noise does not introduce false information.
 - Contrast enhancement to assure that relevant information can be detected.
 - Scale space representation to enhance image structures at locally appropriate scales.

- **Feature Extraction** – Image features at various levels of complexity are extracted from the image data. Typical examples of such features are:
 - Lines, edges and ridges.
 - Localized interest points such as corners and blobs or points.

More complex features may be related to texture, shape or motion.

- **Detection/Segmentation** : At some point in the processing a decision is made about which image points or regions of the image are relevant for further processing. Examples are:
 - Selection of a specific set of interest points.
 - Segmentation of one or multiple image regions that contain a specific object of interest.
 - Segmentation of image into nested scene architecture comprising foreground, object groups, single objects or salient object parts (also referred to as spatial-taxon scene hierarchy), while the visual salience is often implemented as spatial and temporal attention.
 - Segmentation or co segmentation of one or multiple videos into a series of per-frame foreground masks, while maintaining its temporal semantic continuity.
 -
- **High-level processing** – At this step the input is typically a small set of data, for example a set of points or an image region which is assumed to contain a specific object. The remaining processing deals with, for example:
 - Verification that the data satisfy model-based and application-specific assumptions.
 - Estimation of application-specific parameters, such as object pose or object size.
 - Image Recognition – classifying a detected object into different categories.

- Image Registration – comparing and combining two different views of the same object.
- **Decision making** Making the final decision required for the application, for example:
 - Pass/fail on automatic inspection applications.
 - Match/no-match in recognition applications.
 - Flag for further human review in medical, military, security and recognition applications.

4.2 Image-understanding systems

Image-understanding systems (IUS) include three levels of abstraction as follows: low level includes image primitives such as edges, texture elements, or regions; intermediate level includes boundaries, surfaces and volumes; and high level includes objects, scenes, or events. Many of these requirements are entirely topics for further research.

The representational requirements in the designing of IUS for these levels are: representation of prototypical concepts, concept organization, spatial knowledge, temporal knowledge, scaling, and description by comparison and differentiation.

While inference refers to the process of deriving new, not explicitly represented facts from currently known facts, control refers to the process that selects which of the many inference, search, and matching techniques should be applied at a particular stage of processing. Inference and control requirements for IUS are: search and hypothesis activation, matching and hypothesis testing, generation and use of expectations, change and focus of attention, certainty and strength of belief, inference and goal satisfaction.^[41]

CHAPTER 5

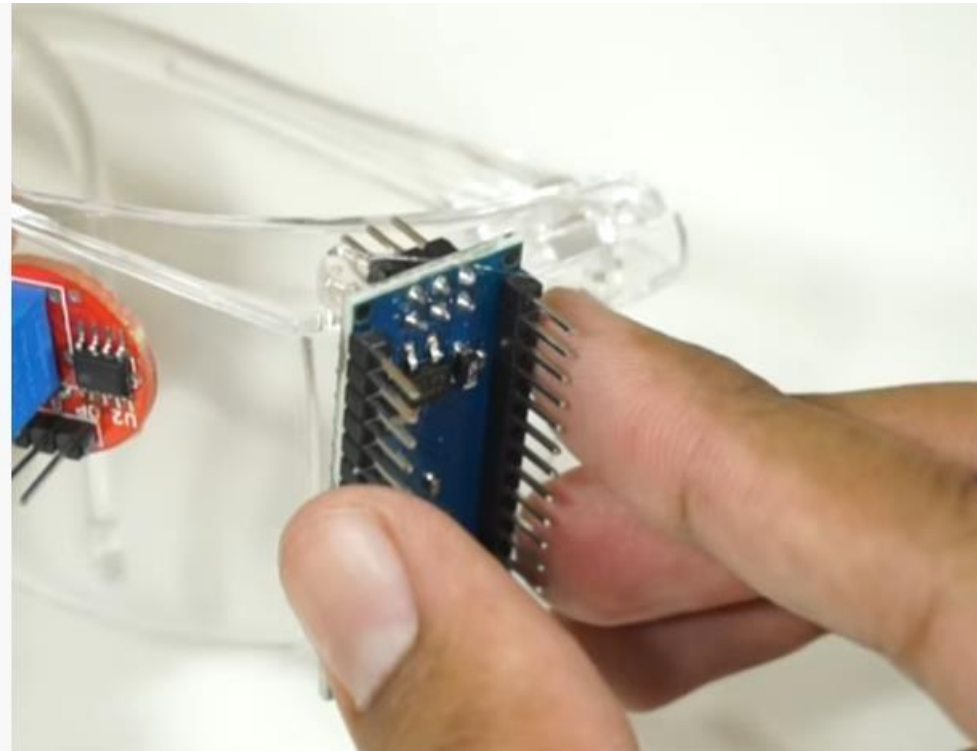
5.1 SOFTWARE REQUIRED



- The eye blink sensor is an infrared sensor. It contains two parts. A transmitter and a receiver. The transmitter continuously emits infrared waves onto the eye. While the receiver continuously looks for variations in the reflected waves which indicates that the eye has blinked.
- If the eye is closed that means it will give high output. If the eye is open then it will give a low output.
- This sensor can be used in a very different variety of robotics and mechatronics projects as it provides excellent results and is very economical.
-

Assembly of Glasses

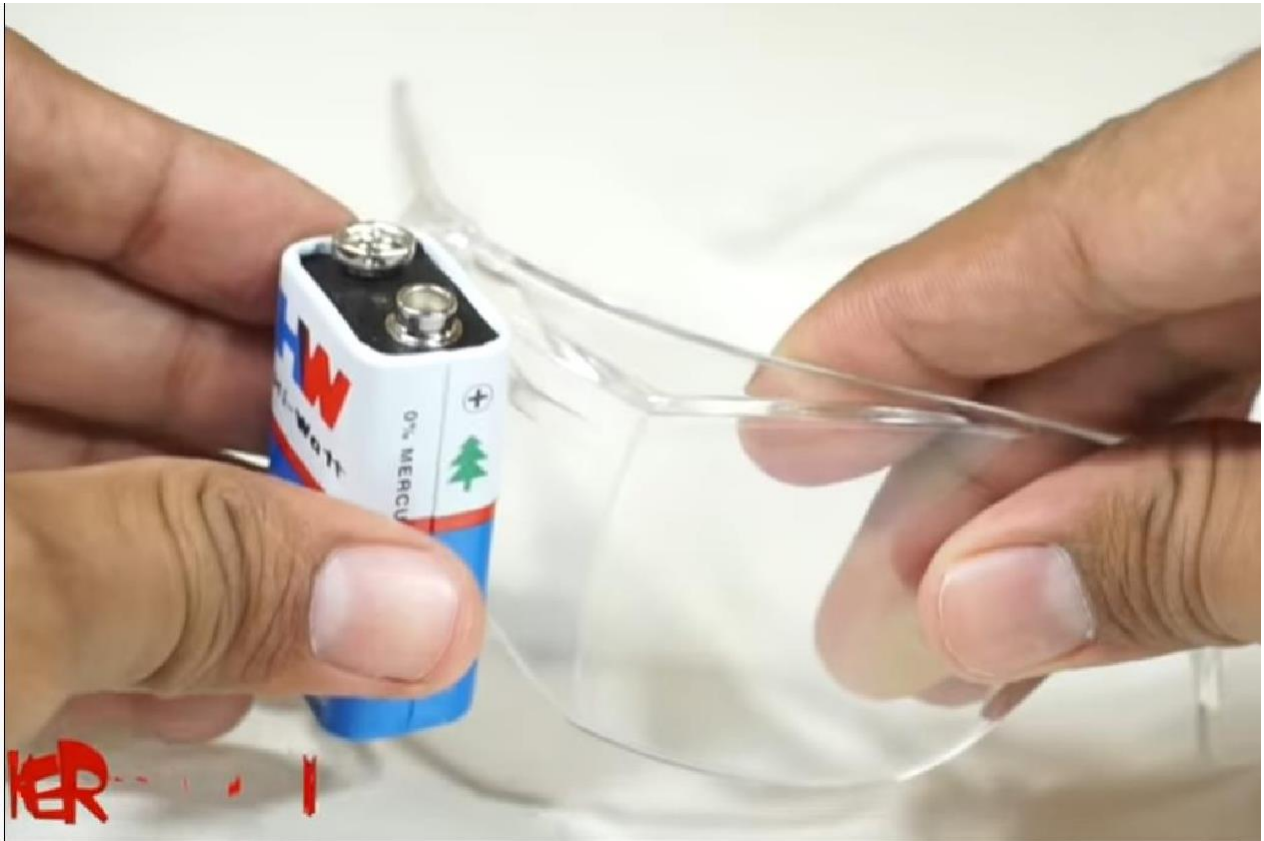
Firstly, stick the Aurdino nano onto the glasses with the help of the glue gun.



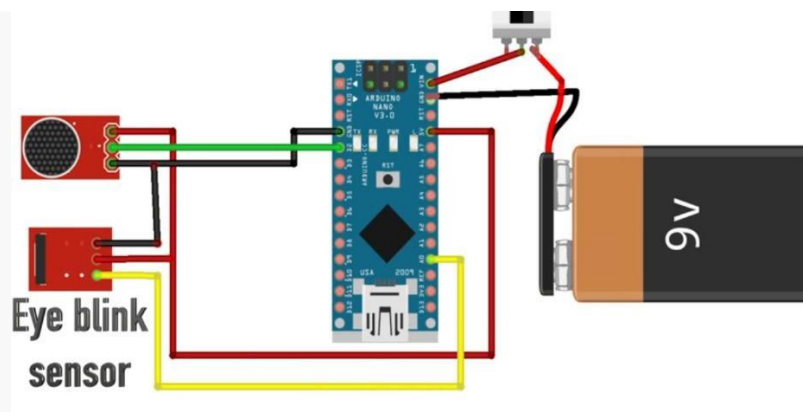
- Stick the buzzer onto the glasses.
- Connect the VCC to the Arduino Nano 5V pin.
- Connect the GND pin to the GND pin on Arduino.
- Connect the signal pin of the buzzer to the Arduino digital pin 2.



- Stick the 9V battery to the other side of the glasses.
- Connect the negative terminal of the battery to the GND pin on Arduino.
- Connect the positive terminal of the battery to the VCC pin on Arduino.
- Add a switch between the power supply and Arduino.



5.2 Circuit Diagram

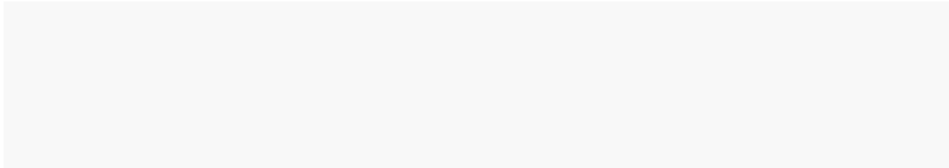


Pins on eye blink sensor	Pins on Aurdino Nano
VCC	5V
GND	GND
OUTPUT PIN	V0

5.3 Working principle of the eye blink sensing system

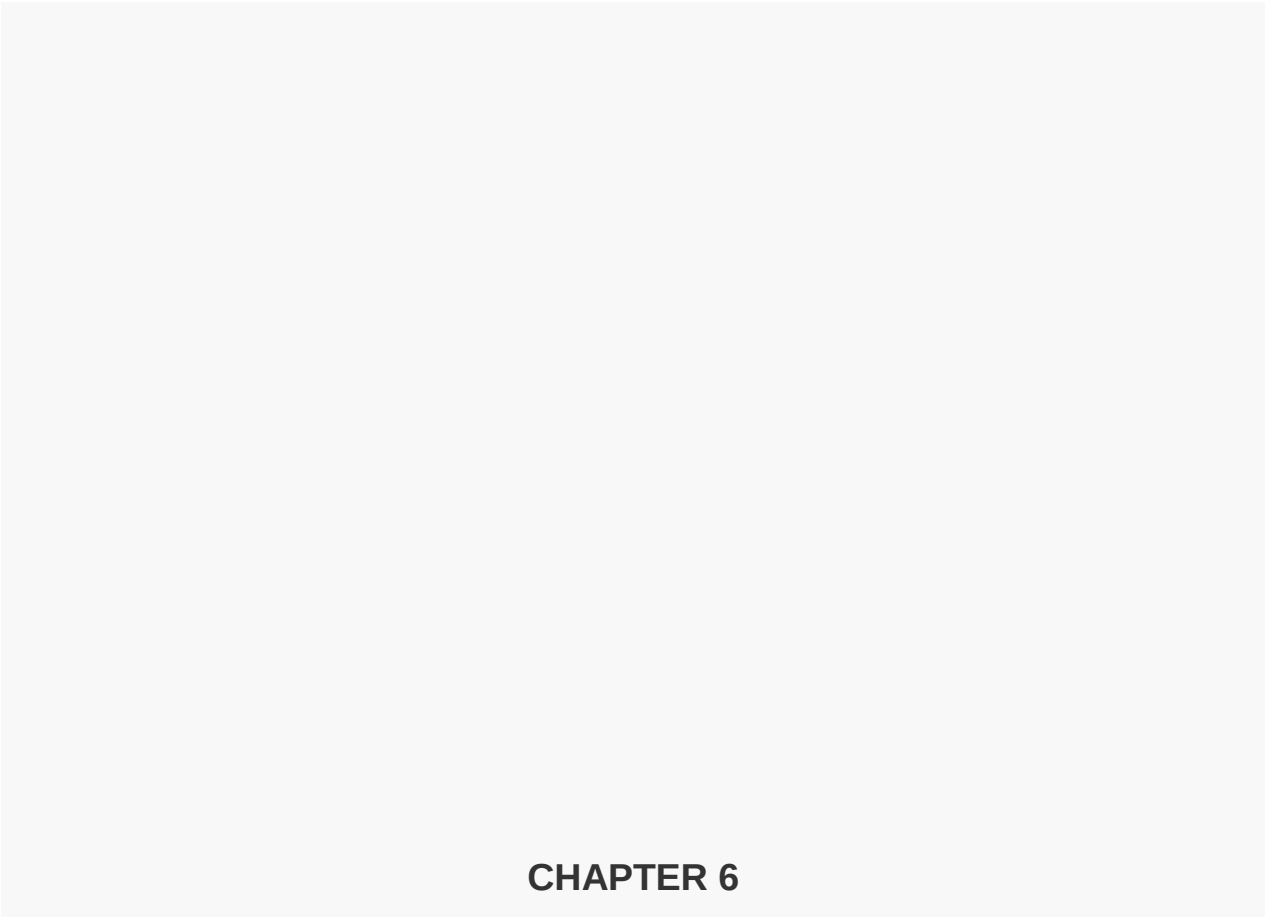
- The eye blinking system can be used for different purposes. First, let's look at the blink sensing system.
- The eye blink sensor constantly sends infrared waves which are reflected and detected by the receiver. As soon as the eye blinks, the output of the sensor goes high. This output is sent to the Arduino board.
- The Arduino sends the signal to the buzzer to make the noise. In this way, a blink is detected.
- Another purpose for which this system can be used is called the driver drowsiness system. This system can be used to check if the driver might sleep during driving. This can be done with some minor changes in the Arduino code.
- Instead of detecting blinks, the Arduino should give the command to buzz when the eyes of the driver are closed for more than 2-3 seconds depending upon your preference.
- This system can be used with all modes of transports be it trains, ships, planes, cars, etc. This can be very useful to avoid accidents.
- Another purpose of this system, it can be used in hospitals to check when patients gain consciousness. A patient when unconscious, has the eyes closed. So whenever they open their eyes, the buzzing sound can inform the nurse that the patient is awake.
- This can also be done with the help of some minor tweaks in the Arduino code.

- The output of the sensor has to be constantly high in this case as the patient is unconscious. When the output goes low i.e. when the eyes of the patient open, that is when the Arduino should command the buzzer to ring.
- This works best for patients who are in a coma. The nurses can be easily informed with the help of this system.



5.4 Applications of eye blink sensor

- It can be used to count the blinking of a person.
- It can be used to keep a check on the driver and make sure he/she is not drowsy. This can help avoid a lot of accidents.
- It can be used to know when a patient is awake or conscious.



CHAPTER 6

SYSTEM ARCHITECTURE

6.1 OBJECTIVES

1. Allow paralysis victims to communicate independently.

Many paralysis victims already use eye blinks as a form of communication. It is common for nurses and caretakers to read a patients eye blinks and decode the pattern. The ALS association even offers a communication guide that relies on eye blinks. Blink To Speak automates this task. The software reads a persons eye blinks and converts them into text. A key feature of the software is that it can be started, paused, and operated entirely with eye blinks. This allows patients to record their thoughts with complete independence. No nurses or caretakers are required to help patients express themselves. Not only does this reduce the financial burden on paralysis patients, but this form of independence can be morally uplifting as well.

2. Be accessible to people with financial constraints.

Many companies are developing technologies that are controlled by eye movement. These technologies rely on expensive hardware to track a user's eyes. While these devices can absolutely help LIS victims, they are only available to people

1. Capturing the frame from the video using the systems camera initializes the execution of the proposed system.
2. The frames are converted into gray scale image and we are making zero and ones combination of white and black pixels.
3. We are considering 68 point pixel for face and 6 point pixel for eye lids.
4. The Face Detection is done using haar cascade Algorithm processes on the captured video frames which is converted as gray scale image to give out the rectangular boxed face.

5. The output from Face Detection Algorithm then gets processed using AdaBoost Classifier to detect the eye region in their face.
6. Eye detected will be sent to check whether the eye is closed or open.
7. When the eyes are open the virtual keyboard numbers are being played sequence until the eyes are closed.
8. Once eye is closed then the particular need of the patient in that number is given as a output for care takers.
9. The outputs are in the form of image display, text alerting, audio played and message sent to the concerned person.

6.2 Gray Scale Image

1. Camera and frame capturing
2. Face Detection
3. Eye detection
4. Eyetracking
5. Eye blinking

1. Camera and frame capturing

The first step of the proposed system is the initialization. After taking a short video of the participants face using the front camera of the device used which is more likely a laptop. A process Frame method will be used to create the frames from the captured video. Afterwards the coloured frames will be converted to gray scale frames by extracting only the luminance component.

The luminosity method is a more sophisticated version of the average method. It also averages the values, but it forms a weighted average to account for

human perception. Were more sensitive to green than other colours, so green is weighted most heavily. The formula for luminosity is $0.21 R +$

$0.72 G + 0.07 B$. The luminosity method works best overall.

Figure 2: Original Image

2. Face Detection

The Haar classifier is used in algorithm for face detection. . Haar classifier rapidly detects any object, based on detected feature in not pixels, like facial feature. However, the area of the image being analysed for a facial feature needs to be regionalized to the location with the highest probability of containing the feature. By regionalizing the detection area, false positives are eliminated. As the result face is detected and marked with rectangle box and will be used later to approximate an axis of the eyes for eye detection step.

3. Eye Detection

To detect the eye, first, the Haar cascade classifier should be trained, in order to train the classifiers, the AdaBoost algorithm and Haar feature algorithms must be implemented, two set of images are needed. One set contains an image or scene that does not contain the object. The EBCM used all detected elements of Haar Cascade Classifier, and the result show the detected eye in rectangle box.

AdaBoost algorithm is used to train node classifiers on a Haar-like feature set to improve the generalization ability of the node classifier. Consequently, the face detection performance of the face detector is improved. Experimental results have proved that the proposed algorithm can significantly reduce the number of weak classifiers, increase the detection speed, and slightly raise the detection accuracy as well.

4. Eye Tracking

Figure 5: Parts of Eye

The corneal-reflection and pupil-centre are the two eyes parts that are the most important parts to extract the features that will be used in EBCM method. These features help us in tracking the eyes movement. By identifying the center of the pupil and the location of the corneal reflection, the vector between them is measured. Besides, with further trigonometric calculations, point-of-regard can be found. The EBCM method succeeded in making the face and the eye's pupil moved together in the same direction synchronously and with the same direction. Let suppose that X is the human face which has been detected, $P1$ and $P2$ are two points related to the left eye, and they are moving synchronously with the movement of X .

5. Eye Blinking

Eye blinking and movement can be detected with relatively high reliability by unobtrusive techniques. Though, there are few techniques discovered for the active scene where the face and the camera device move independently, and the eye moves freely in every direction independently of the face. Although care must be taken, that eye- gaze tracking data is used in a sensible way, since the nature of human eye movements is a combination of several voluntary and involuntary cognitive processes.

6.3 EYE ASPECT RATIO (EAR)

We can apply facial landmark detection to localize important regions of the face, including eyes, eyebrows, nose, ears, and mouth. This also implies that we can extract specific facial structures by knowing the indexes of the particular face parts

In terms of blink detection, we are only interested in two sets of facial structures the eyes. Each eye is represented by 6 (x, y)-coordinates, starting at the left- corner of the eye (as if you were looking at the person), and then working clockwise around the remainder of the region. Based on this image, we should take away on key point. There is a relation between the width and the height of these coordinates Where $p1$, , $p6$ are 2D facial landmark locations.

$$EAR = || p_2 - p_6 || + || p_3 p || / 2 || p_1 - p_4 ||$$

6.4 Eye Aspect Ratio

System Implementation uses the structure created during architectural design and the results of system analysis to construct system elements that meet the stakeholder requirements and system requirements developed in the early life cycle phases. These system elements are then integrated to form intermediate aggregates and finally the complete system of-interest. Implementation is the process that actually yields the lowest-level system elements in the system hierarchy (system breakdown structure). System elements are made, bought, or reused. Production involves the hardware fabrication processes of forming, removing, joining, and finishing, the software realization processes of coding and testing, or the operational procedures development processes for operators' roles. If implementation involves a production process, a manufacturing system which uses the established technical and management processes may be required. The purpose of the implementation process is to design and create (or fabricate) a system element conforming to that elements design properties and/or requirements. The element is constructed employing appropriate

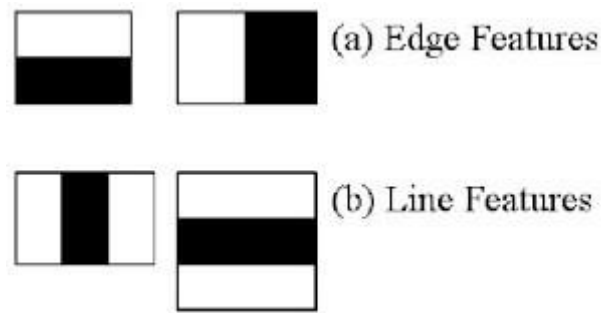
technologies and industry practices. This process bridges the system definition processes and the integration process.

CHAPTER 7

SOFTWARE EXPLANATION

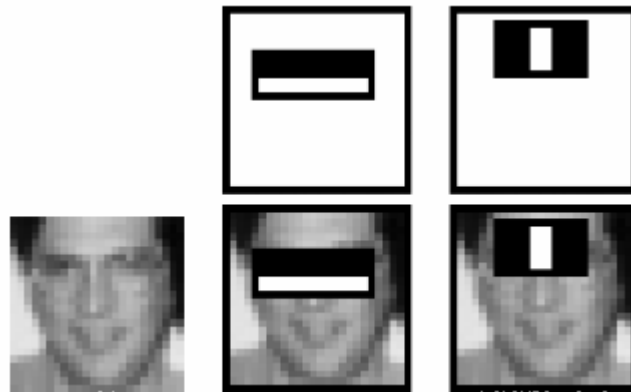
7.1 About Haar Cascades:

Haar feature-based cascade classifiers is an effective object detection method proposed by Paul Viola and Michael Jones in their paper, “Rapid Object Detection using a Boosted Cascade of Simple Features” in 2001. It is a machine learning-based approach where a cascade function is trained from a lot of positive and negative images. Here positive images are the samples which contain the target object and negative are the ones which don't. It takes a lot of positive and negative samples to train the classifier.



Haar features , source – OpenCV docs

Now, we extract the features from the given input image with the haar features shown in the above image. They are just like convolutional kernels. Each feature is a single value obtained by subtracting the sum of pixels under the white rectangle from the sum of pixels under the black rectangle.



Application of haarcascades, source – OpenCV Docs

The Excessive calculation:

With all the possible sizes of the classifiers the features are calculated, but the amount of computation it takes to calculate the features, a 24×24 window results over 160000 features. Also for each feature calculation, the sum of the pixels is also needed. To make it computationally less expensive the creators of haar cascades introduced the integral image, which means however large your image, it reduces the calculations for a given pixel to an operation involving just four pixels.

The false features

Now among the features that are calculated, most of the features are false and irrelevant. Now the window which is applied to a region of the image may see a different region which seems with the same features to the window but is not in reality. So, there is a need to remove the false features which were done by the **AdaBoost** which helped select the best features out of 160000+ features. Adaboost short form of Adaptive Boosting is a Machine learning algorithm which was used for this sole task.

7.2 Algorithm

The frame is captured and converted to grayscale.

Bilateral Filtering is applied to remove impurities.

Face is detected with the haar cascade.

The ROI (Region Of Image) of Face is fed to eye detection part of algorithm.

Eyes are detected and resulting list is passed to if-else construct.

If the length of list is more than two, means that the eyes are there.

Else the program is marked to be eye blinked and restarted.

7.3 Code

The *haarcascade_frontalface_default.xml* and *haarcascade_eye_tree_eyeglasses.xml* are the xml files stored in the same directory as the python script.

```
#All the imports go here
import numpy as np
import cv2

#Initializing the face and eye cascade classifiers from xml files
face_cascade = cv2.CascadeClassifier('haarcascade_frontalface_default.xml')
eye_cascade = cv2.CascadeClassifier('haarcascade_eye_tree_eyeglasses.xml')

#Variable store execution state
first_read = True

#Starting the video capture
cap = cv2.VideoCapture(0)
ret,img = cap.read()

while(ret):
    ret,img = cap.read()
    #Converting the recorded image to grayscale
    gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    #Applying filter to remove impurities
    gray = cv2.bilateralFilter(gray,5,1,1)

    #Detecting the face for region of image to be fed to eye classifier
    faces = face_cascade.detectMultiScale(gray, 1.3, 5,minSize=(200,200))
    if(len(faces)>0):
        for (x,y,w,h) in faces:
            img = cv2.rectangle(img,(x,y),(x+w,y+h),(0,255,0),2)

            #roi_face is face which is input to eye classifier
            roi_face = gray[y:y+h,x:x+w]
            roi_face_clr = img[v:v+h,x:x+w]
```

```

#Examining the length of eyes object for eyes
if(len(eyes)>=2):
    #Check if program is running for detection
    if(first_read):
        cv2.putText(img,
            "Eye detected press s to begin",
            (70,70),
            cv2.FONT_HERSHEY_PLAIN, 3,
            (0,255,0),2)
    else:
        cv2.putText(img,
            "Eyes open!", (70,70),
            cv2.FONT_HERSHEY_PLAIN, 2,
            (255,255,255),2)
else:
    if(first_read):
        #To ensure if the eyes are present before starting
        cv2.putText(img,
            "No eyes detected", (70,70),
            cv2.FONT_HERSHEY_PLAIN, 3,
            (0,0,255),2)
    else:
        #This will print on console and restart the algorithm
        print("Blink detected-----")
        cv2.waitKey(3000)
        first_read=True

else:
    cv2.putText(img,
        "No face detected",(100,100),
        cv2.FONT_HERSHEY_PLAIN, 3,
        (0,255,0),2)

```

```

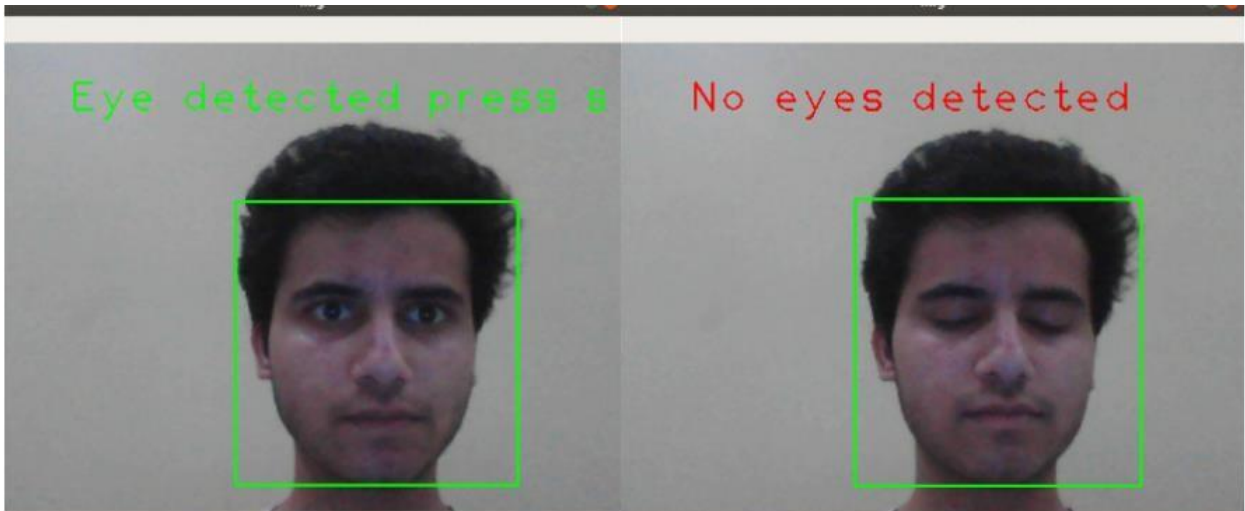
else:
    cv2.putText(img,
        "No face detected",(100,100),
        cv2.FONT_HERSHEY_PLAIN, 3,
        (0,255,0),2)

#Controlling the algorithm with keys
cv2.imshow('img',img)
a = cv2.waitKey(1)
if(a==ord('q')):
    break
elif(a==ord('s') and first_read):
    #This will start the detection
    first_read = False

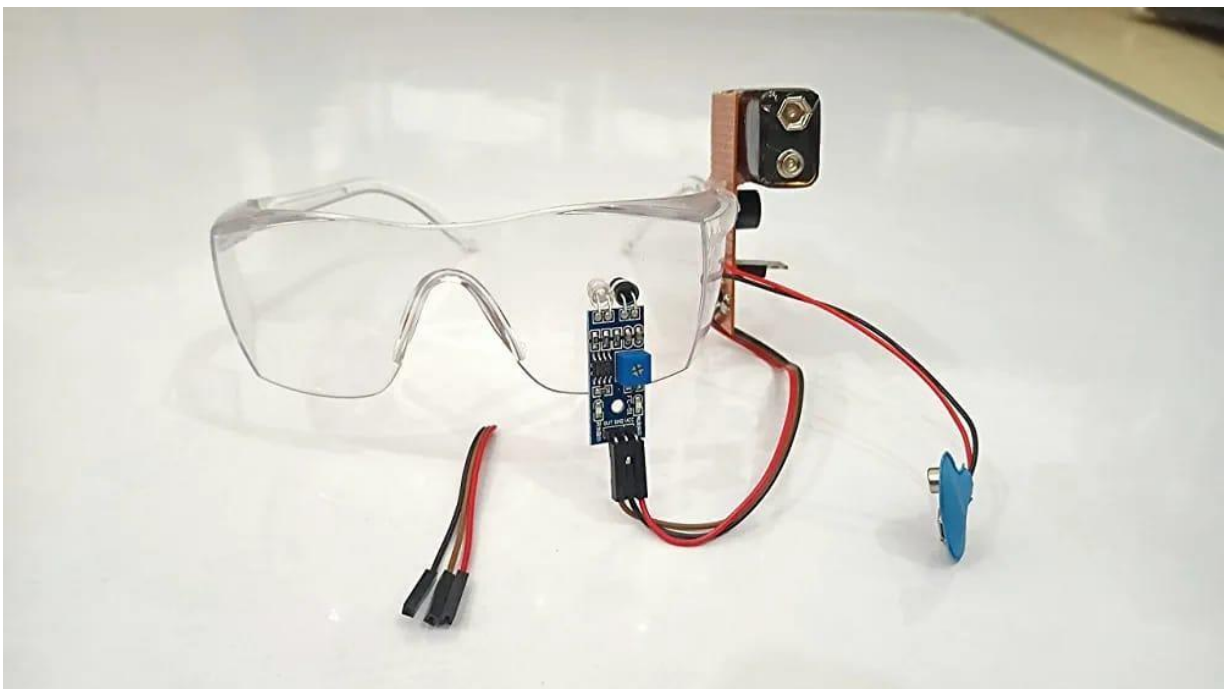
cap.release()
cv2.destroyAllWindows()

```

RESULT



If you're using a different video or if you're using a webcam you're FPS is going to be different, so might want trying changing the values of the variables we defined, although they work fine in most case.



CONCLUSION

There has been an increased interest in eye blink detection algorithms for different purposes, such as driver fatigue detection and cognitive load. Most eye blink systems are limited to infrared light systems that work with special hardware and give very accurate results but at a high cost. So, the main goal of our proposed system is trying to solve this problem.

The proposed system starts by detecting the human face. Then the eye region is extracted from the detected face. Finally, eye blink is detected using shape measurement and other different steps are used to determine eye state. The proposed system can work under different illumination conditions.

In our future research, we intend to test the proposed method in more varied environments, conduct more analyses using other digital filters or a combination of them to reduce signal noise to a minimum, and consider additional parameters that describe eye state during blinking.

The future work also entails that the system is trained on a much larger dataset and tested with different algorithms to improve accuracy and precision.

The given model can be applied to a lot of practical world applications such as driver drowsiness detection, online teaching, and many more.

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