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Eye Blink Oriented Chat for Specially Challenged People

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***Abstract*— Among all the physical ailments that lead to Motor Neuron Disease (MND) Paralysis is treated as most hazardous. For patients with paralysis, the only way to communicateis through blinks or moving the eye muscles since their ability to control muscle movement is limited. Therefore, a Human Computer Interface system based on eye movement has been an anticipated innovation—the objective of this paper is to discuss various Eye movement communication techniques for a wholly paralyzed patient. The applications allow users to communicate using the onscreen keyboard. An eye gaze detection technique allows people with disabilities to express their needsto their caretakers when they cannot move their muscles voluntarily. A patient's eye movements and blinks can be analyzed using Dlib and OpenCV to select the desired key. The patient's Eye Gaze state selects the keyboard keys. In addition, hot phrases(images) are available to request services like food, water, natural phone calls, phone calls, ask for assistance, raise the alarm in case of an emergency, andturn on or off lights, fans, and other appliances in their homes. Our proposed Human Communication Interface (HCI) system provides automated communication for specially challenged people to increase their quality of life.**

***Keywords*: Open CV, Dlib, Eye Gaze, Eye Blink**

I. INTRODUCTION

Motor Neuron Disease (MND) is one of the ailments that causes progressive damage to the nervous system and leads to paralysis . Paralysis refers to the failure in muscle functionality of one or more group of muscles. A person with this disorder will normally have weakness in their muscles present in their hands, feet, or voice. It becomes hard for such patients to express even their needs because of their inability in performing independent movements. Paralysis is generally caused by the damage in the nerve system portions such the spinal cord .Major causes are stroke, trauma with nerve injury, poliomyelitis, amyotrophic lateral sclerosis (ALS), botulism, spina bifida, multiple sclerosis, and Guillain-Barre´ syn- drome. [2]Quadriplegia also called tetraplegia .If patient's all four limbs are paralyzedit is the symbol of Quadriplegia.A person with this condition is capable of controlling upon blink and eye movement. These people can better express their needs through eye blinks. Therefore, the nurses and caretakers must be able to interpret those eye blink in order to provide a timely support. Most of their ideas are being trapped within themselves .They couldn't share with others. These diseases lock the freedom to express which lasts miserable pain to them. As technology has advanced rapidly in recent years, there has been a great demand for human-computer interaction. The HCI systems have been proven to work well in establishing communication

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communication between the computer and humans. This communication can bebuilt based on several human behavioral patterns. Application of blink detection can be found in many domains like HCI, mobile communications, Medicare, and safe driving. In case of blind and paralyzed people, the natural eye-movement is captured to create a confluence to improve the quality of life. It is not only paralyzed people who can benefit from eye blink detection, as there are numerous other applications such as Driver drowsiness detection, Iris tracking system etc.

II. RELATED WORK

Different communication models presented by the literature are broadly classified intothe following categories

- Electro-oculography (EOG)
- Video-oculography (VOG)
- Brain wave technique

A. Electro-oculography

As a part of EOG ,electrodes are placed all around the user's eye they measure any movement or blinking by measuring electrical impulses generated while performing the test .[12] Two electrodes were positioned above and adjacent to the primary eye as shown in the figure 2 to measure horizontal and vertical electro-oculograms. The two detectedchannel signals were logically combined based on threshold settings customized to each individual to produce eight directional cursor movements .In these procedure patient might feel a bit stressed and uncomfortable due to electrodes.

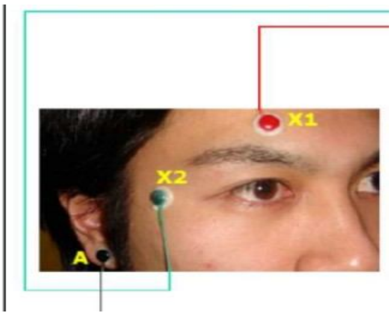


Fig-1 Electro-oculography

B. Video-oculography (VOG)

Patients who have difficulty communicating can benefit from Video Oculography, a method that converts eye blinks into meaningful sentences.[11]Blink patterns are associated with numeric values transmitted over Bluetooth to the handheld device. Upon receiving this value, the mp3 player plays the associated audio file through its speaker as shown in the figure

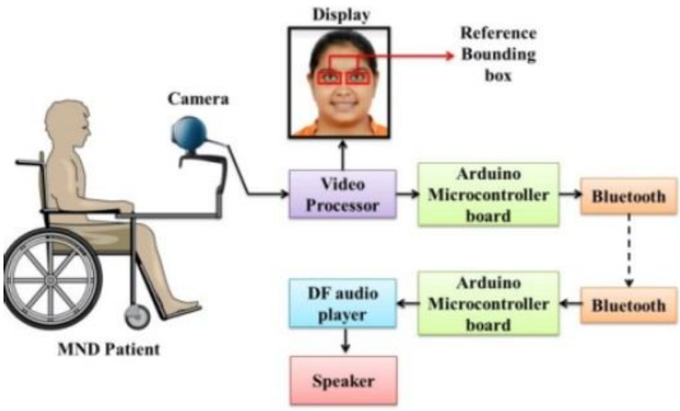


Fig-2: The setup used for VOG experiment

C. Brain wave technique

Reyes Andres F,Camacho Edgar C,Mateus Armando proposed a tool that provides communication for individuals with disabilities,particularly those who are unable to communicate verbally..Mindwave Mobile 2 headset uses electroencephalogram (EEG) signals to detectvoluntary blinks.[10] The EEG signal underwent classification into five discrete groups , encompassing No blink, One blink, Two blinks, Three blinks, and Other, employing a Long-Short Term Memory (LSTM) neural network. Bluetooth connects the cellphone application to the EEG device. Conversation can be built based on the

- predefined number of eye blinks [6]
- Iconic user Interface[7]
- An eye gaze controlled virtual keyboard [3]

Assistance for Paralyzed Patient Using Eye Motion Detection [7] proposes a human computer interface based on eye motion and eye blink detection for a totally paralyzedpatient In this the Input is taken from a simple webcam through a non-intrusive communication interface which was developed and runs on consumer grade computers. An open source software called OpenCV is used to process the video frame. Through the utilization of multiple image processing techniques, the video frames are meticulously analyzed, yielding the desired output.. Upon face detection and eye detection, EAR ratio is calculated and based on that eye direction is determined, so the user navigates to the required Icon and in order to click that particular Icon he/she needs to blink. In this the user Interface includes somespecial gestures like Emergency call, Medical Assistance, Entertainment and Essential service. In the above methods users are provided with predefined functionalities but there is no typingor chatting environment .A human being feel trapped if he is not able to express his ideas,opinions,views to the others .Introduction of virtual keyboard aids the problem.
Kashish Kathpal, Shweta Negi and Shilpi Sharma proposed iChat: Interactive Eyesfor Specially Challenged People Using OpenCV Python :[3]They focused on Providinga typing and chatting environment without using hands and fingers i.e., with the help of eye blinks. For that they use 68 facial points, which must be present on every face.[2]Firstly, eye detection can be done using Dlib and then by extracting eye co- ordinates, and then calculation of eye ratio and blinking ratio can be done. After that, according to the blinks actions are performed. Virtual keyboards are created using Python dictionaries containing 40 keys, including the delete key.This virtual keyboard pointer moves forward and backward based on user Eye Gaze and selects the desired key on blink. The typed letter will be displayed on a whiteboard developed in Python .It act as an excellent assistance for quadriplegics.

III. MATERIALS & METHODS

A. Dataset

The dataset comprises data used to train the blink and gaze detection models. In the case of gaze detection, the data is divided into three classes: left gaze, right gaze, and center gaze, based on the position of the eyeball. For blink detection, the data is categorized into two classes: class ‘0’ represents a completely closed eye, and class ‘1’ represents an open eye, using a dataset collected previously. The dataset comprises a total of 4453 images, with 1468 images labeled as center gaze, 1497 images labeled as left gaze, and 1173 images labeled as right gaze. These labeled images are used for both training and testing the models.

B. Proposed Methodology

Our proposed method has been implemented as a sequential process starting with patient’s face capturing to conversion of his eye blink into a communication. The entire process is visually illustrated through a flowchart provided in Fig-3.
The initial step involves capturing video from the webcam. The captured video frames are then processed by converting them to gray scale. This conversion is performed to minimize the computational requirements for subsequent processing steps. The gray scale conversion method employed is based on the luminosity formula, which is used to transfigure the color image into gray. The formula used for the conversion is given in Eq.1

$$Gr = 0.299R + 0.587G + 0.114*B. \qquad (1)$$

Where R, G, B representing the Red, Green, and Blue channels of the color image. For the face detection, Facial landmark algorithm is used which locates the face within a frame. The algorithm exclusively focuses on facial structures, disregarding all other object categories like houses, plants, and branches. The facial landmark detector, dlib, generates 68 x,y points as shown in the Fig3 through a shape predictor algorithm. These 68 points enable the detection of the eye region and facilitate further analysis. As a result of those 68 points around the face, a rectangular box is calculated around the eyes, and this computed box is subsequently employed in the subsequent module for the purpose of eye detection. The two eyes are detected from the face using cropping. The left eye is isolated from the face by utilizing the landmark points 37, 38, 39, 40, 41, and 42, while the right eye is extracted from the face using landmark points 43, 44, 45, 46, 47, and 48. Most of the existing solutions use Gaze ratio in order to determine the user's gaze .The gaze direction is determined by analyzing the spatial location of the iris and pupil, with the white region in the eyes playing a significant role in determining the point of direction as given in equ. (2) and Table 1.

$$\text{Gaze ratio} = \frac{\text{Left side White}}{\text{Right side White}} \qquad (2)$$

TABLE I: GAZE DIRECTION COMPUTATION

Gaze ratio	Direction of gaze
Above the threshold of 1.7	Left
Between 1 and 1.7	Center
Less than 1	Right

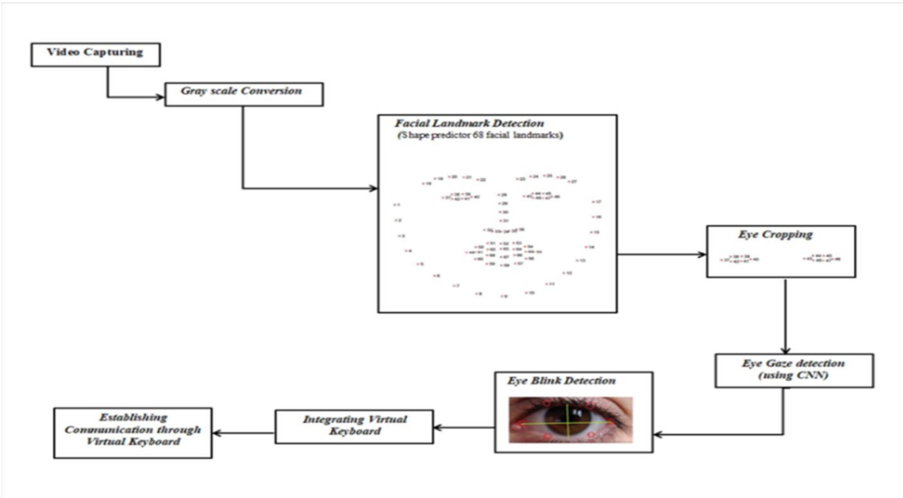


Fig-3: Flowchart of the proposed system

Eye Gaze detection using CNN

Eye gaze prediction can be effectively achieved using neural networks, specifically Convolutional Neural Networks (CNNs). By training a CNN model with predefined class labels representing directions such as left, right, and center, accurate prediction of the eye direction in the required frame can be achieved. This prediction plays a vital role in facilitating navigation in a virtual keyboard. One of the significant advantages of utilizing CNNs for eye gaze prediction is that it is a calibration-free method. This means that it does not require complex calibration procedures and can adapt to different individuals with varying eye characteristics, making it a more practical and versatile approach. The Gaze detection architecture comprises of convolutional layers with 32, 64, and 128 filters applied to the input image, followed by max-pooling operations to reduce spatial dimensions. A fully connected layer with 512 nodes is added, along with Dropout for regularization. The final classification is generated by a dense layer with ReLU activation and three output nodes, which are activated using SoftMax. The CNN architecture used for Eye Gage detection is shown in Fig-4.

Blinking is a rapid action involving the swift closing and opening of the eyelids.Conventionally, Blink detection is accomplished by calculating the ratio of the distance between the horizontal and vertical lines crossing the eye as formulated in equ. (3).

$$EAR = \frac{|P_2 - P_6| + |P_3 - P_5|}{2|P_1 - P_4|} \qquad (3)$$

In our work, we have proposed a CNN model for eye blink detection, as illustrated in Fig.5. The blink detection neural network is a specialized model designed to classify eye states as open or blinked. It is trained using labelled data containing examples of both open and blinked eyes. By leveraging the power of neural networks, the model learns to accurately identify blinks based on the patterns and features extracted from input images, providing an efficient and reliable solution for blink detection. The Blink detection architecture closely resembles the Gaze detection architecture, differing only in the output layer that comprises a singular output node. The activation function utilized for the output node is Sigmoid, which serves to transform the output into a range of values between 0 and 1.

Finally for integrating a virtual keyboard to the application, a virtual keyboard with alphanumeric keys has been developed. Our keyboard includes the letters A to Z, as well as the numbers 0 - 9,delete key. Users have the capability to navigate in any direction using their Eye Gaze. To access a specific column, users can indicate their selection by voluntarily blinking, which triggers the highlighting of each row key within that column for a defined duration. If the desired key is reached, users can confirm their choice by giving another voluntary blink, resulting in the display of the corresponding letter on the board. This interactive process allows users to type text by efficiently navigating the virtual keyboard through their eye movements and confirming their selections via intentional blinks. In addition to the textual communication, Hot Phrases have been added. HP (Hot Phrases) is a feature designed to assist users who may find it challenging to type due to weakness. By entering the HP key, predefined text will be displayed on the screen, with each phrase highlighted temporarily. The user can blink at their desired choice, and the corresponding text will be converted into voice output. This functionality aims to facilitate communication in situations where typing may be difficult.

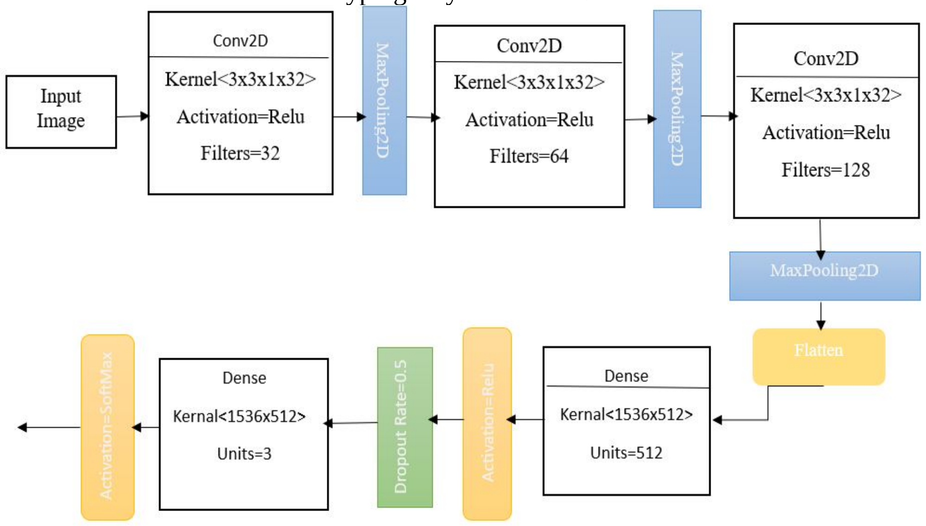


Fig-4: CNN architecture for Gaze detection

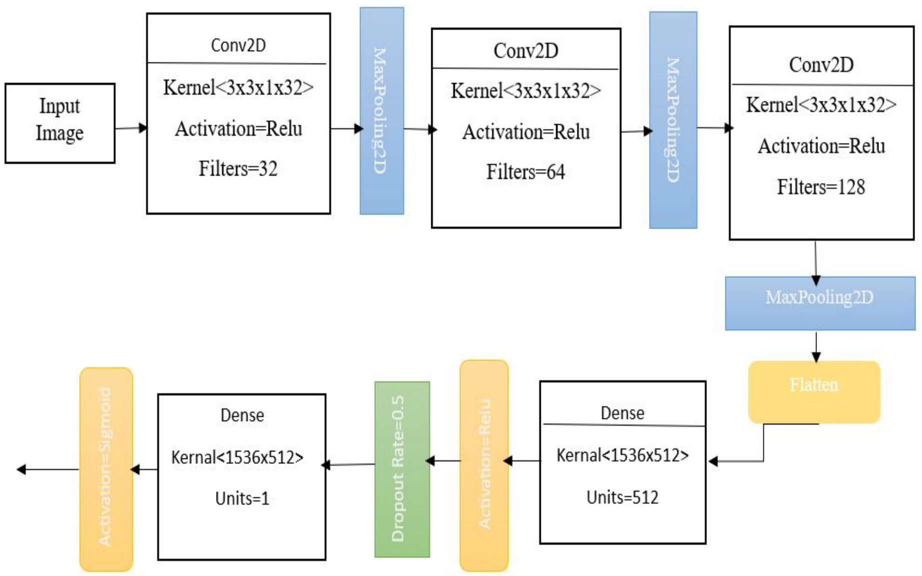


Fig-5: CNN architecture for Blink detection

IV. Results

The Eye blink oriented chat system has been implemented in Windows 10 and Python, with key libraries like OpenCV, Tensor, dlib, and imutils for image and video processing, machine learning using webcam-equipped monitor, 4GB RAM, and an I-3 processor.

A. Evaluation criteria

After implementation, the performance of our proposed method has been analyzed using the following metrics.

Character per minute (CPM)

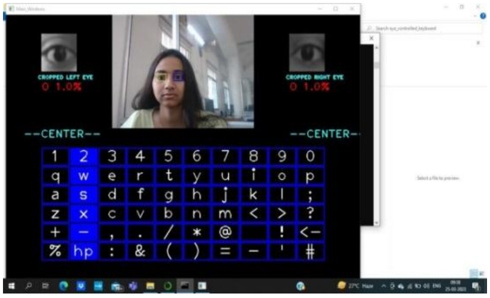
A CPM is a measure of the number of characters typed per minute

$$CPM = \frac{\text{No. of character}}{\text{Time taken}} \times 60$$

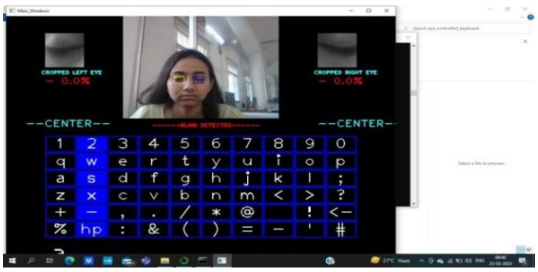
Word per minute (WPM)

A WPM is a measure of the number of words typed per minute

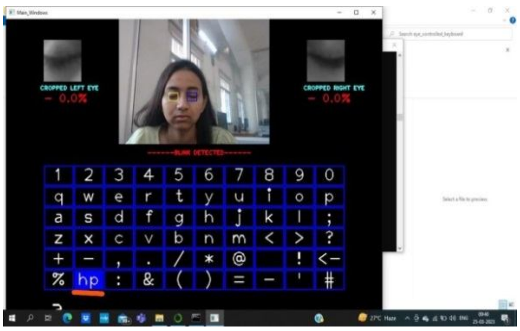
$$WPM = \frac{\text{No of word}}{\text{Time taken}} \times 60$$



a) Virtual Keyboard



b) Eye Blink detection



c) Selection of desired key

TABLE II: COMPARISON OF EYE BLINK COMMUNICATION TECHNIQUES

Method name	WPM	Total Error	CPM
Virtual Keyboard [2]	2.09	20	9.50
EyeAssist[4]	8.9	6.6	30.6
EyeBoard [8]	5.02	13.15	NA
Eye typing [5]	12.3	11.8	NA
Multimodal Gaze [1]	NA	NA	9.30
Eye-S [9]	7.99	NA	NA

V. CONCLUSION

Supporting paralyzed people has been challenging due to their inability to communicate with their caretakers. The movement of eyes/ eye blinks or have been the unique way of communication for such people. Existing systems such as Electro-oculography works by placing of electrodes around eyes causing strain upon them. They even do not work well in poor lighting conditions. The present study has proposed HCI system based on eye-blinks. The patient's picture is captured using the web-cam. The picture is further processed to detect the face and eyes. The eyes are then analyzed to recognize the eye blink. A virtual keyboard integrated to the system. The eye-blink oriented chat can then be accomplished by driving the typing on virtual keyboard through eye blinks. The inclusion of hot phrases in to the virtual keyboard helps the patient's communicate even in their helpless condition. Despite providing an invasive communication channel, our system's performance is limited in poor lighting conditions and when the patient's wear glasses. Therefore our future work fosters towards developing a system which can better recognize the eye blinks when present inside glasses and in poor lightening conditions.

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