Journal of Contemporary Issues in Business and Government Vol. 27, No. 3,2021
https://cibg.org.au/

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2021.27.03.208

EFFICIENT EYE BLINK COMMUNICATION ASSISTANCE FOR PARALYZED PATIENTS

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ABSTRACT: The research study presents a real time method based on some video and image processing algorithms for eye blink detection to voice conversion. The motivation of this study is to help the disabled people who cannot communicate with human. The Haar Cascade Classifier is used for face and eye recognition to gain details about the eyes and facial axes. In comparison, the same classifier is used to assess the relation among the senses like eye and axis of the face to position the eye based on haar like features. This proposes an effective eye detection system which uses the sensed face location. An efficient eye detection method is proposed which uses the position of detected face. Finally, an eye blink detection method is done based on eyelids movement whether it is open or closed and is used for controlling mobile phones. The study have designed a very low-priced device that coverts the eye blinks to voice message with more accuracy compared to existing system. The eye blinks that are detected can be helpful in applications such as health assistance, S.O.S, basic utility. Test results show that our proposed system for a distance of 35cm delivers a overall accuracy of 98% and a detection accuracy of 98%

Keywords: Open-CV, Motor Neuron Disease (MND), Image processing, Face detection, Eye detection, Eye blink, Twilio, GTTS.

1. Introduction

The paralyzed people lack the capacity to regulate muscle movement within one or more classes of muscles. Strokes, ALS, multiple sclerosis and many other diseases may affect the disease. Locked in Syndrome(LIS) is a paralysis type in which a patient has lost control of nearly all voluntary muscles. These individuals, except eye moment and blinking, cannot regulate any part of their body. These individuals are unable to speak, write, and communicate normally because of their

P-ISSN: 2204-1990; E-ISSN: 1323-6903
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illness. While cognitively conscious of people suffering from LIS[1], their emotions and ideas are trapped within them. To interact such people rely on eye blinks. They focus on the caretakers and nurses to understand and decipher their blinking. People with this form of impairment have great trouble managing this activity. Fortunately, Augmentative and Alternate Communication (AAC) innovations have facilitated the incorporation of this community of people by turning their capacities into a communicative practice[2]. So, the research study for this problem and enhancing existing methods are there would be a two-interface displayed on screen. One interface which regularly captures a real time video of the patient operated using OpenCV. Another interface is a virtual keyboard interface where the number is going to be revolving series by series in matrix format.

The growth of technology in medicine field diminish thedifficulties of patients to an immense extent. The disease name Motor Neuron Disease (MND). MND patient unable to express their feelings like talk, walk and communicate to the outside world due to the weakening of muscles. The broad review on literature of different solution or MND[3] patients is described in this paper. In MND, a motor nerve gets weakened and ultimately ceases functioning. And the nerves linked to the muscle that are weakened gradually lose their energy. There are also approaches developed to interact with the outside world for people with the motor neuron disease. Including the technique of brain wave and electro-oculography.

In the study a single-function filter series, Haar Cascade algorithm is used to classify items in the sub-regions. Eye tracking offers the new graphical user interface an almost smooth method of interaction. Although mouse, keyboard and other touch equipped technologies reigned as the main media synonymous with human computer interaction ground, advances start to raise prices and precision for eye-tracking applications that are prepared for competing the function. The study thinks if disabled people can use mobile device with a wink, asking nurses what they really need would be a great benefit. Next, we use OpenCV to try to locate an part of the body. We then establish a means of sensing eye opening and closing. We adapt the process by using capacity and using image intensity to achieve more precise tests to detect a blink [4].

The main objective of our research study is shown below

To make cost effective: The current method for coping with injured people is too expensive. Therefore, a device that is affordable to average citizens must be built that incorporates cost-effective parts for the design.

Electrode less method: To build a device in which the patient is able to speak without electrode application. As it is important to pierce these electrodes through the human body's skin that is quite distressing. Electrode utilization is only

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procedure from now on and is price-effective, yet its unpleasant so keeps sufferer nervous each time, so the method will always be inconvenient.

Fast and Accuracy: For the purpose of communication there are few algorithms which are developed. The main objective of this study is to build an algorithm which is very fast and more accurate when compared to the existing ones.

2. Literature Survey

Verification and Validation of an Electrode Array for a Blink Prosthesis for Facial Paralysis Patients was suggested by Daniel McDonnell, Robert Askin, Christopher Smith, and K. Shane Guillory Ripple[5]. This study establishes FES device for inducing blink operation of eye for unilateral paralysis sufferers. The insert able device would monitor wink through neuronal stability, contralateral eyeshield used for timing wave to activate paretic eyeshield. New, conductive series of polymer electrodes was developed through research by placing platinum stupefied ink with insulating chemical substratum Testing this system's automated reliability, we performed invitro analysis for stretching testing system above bent range when tracking the resistivity of the electrodes more than 25 million rounds until now. Scale for instrument tests was done by inserting instrument into corpse eyeshield for answering concerned regarding medical control. Additionally, to verify this research approach, it performed overture invivo experiments taking mammalian subjects. The dreadful research confirmed the array's resilience for surviving mechanical medical implantation rigours.

Eye Blinking Detection To Perform Selection For An Eye Tracking System Used In Assistive Technology was anticipated by Alex and ruPasarica, Radu Gabriel Bozomitu, Vlad Cehan, Cristian Rotariu[6]. The study describes the review of strategies used by people with neuro-motor disorders to incorporate eye movement collection in an eye monitoring device used in assistive technologies. The program uses keyword technologies or ideograms displayed on the device screen for choosing. Approach utilized to detect blinking is based on segmentation of the image utilizing local threshold calculated either by basic image sum or process of Bradley. Found results demonstrate the approach applied for wink identification which could be utilized successfully for assistive technology applications in existent time tracking device for eye.

Novel Method for Eye Tracking and Blink Detection in video frames was proposed by Leo Pauly, Deepa Sankar [7]. This study introduces a new approach to track eye as well as identify blink from frames in video collected through web cameras that consists weak resolution customer grade. This utilizes a system using a Haar centred eye tracking cascade process along with mixture consisting functionality of HOG and an eye twitch recognition classifier for SVM. The approach presented is non-intrusive and therefore offers comfortable contact

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between users. The eye monitoring system accurateness is 92.3% whereas wink recognition system accurateness is 92.5% which was validated utilizing regular databanks as well as cumulative accurateness is 86% as measured in a typical environment in real world conditions.

Design Of a switch controller For Paralytic Patients Using EEG was suggested by Arunsrinivas.P, Deepak.N, Ganeshkumar.K, Navathej.G, Mrs.B.Geethanjali, Dr.V.Mahesh [8]. This study explains the EEG centred alteration method utilizing volunteer eye flicks derived through EEG Enablement signals. For the motive of collecting EEG wave from the patient, 2 electrodes on the surface are mounted atop the skull's frontal area and past the auricular
portion area to compare. It has been observed that the EEG wave produced through volunteer blink of eye generates stronger waves with greater magnitude, frequentness that varies normal EEG. CPU ARMwas designed successfully for eye twitch identification. The two modes of device control– audio method that sufferer utilizes for communicating their needs whereas control methods that lets sufferer turn in/out of separate computer. Such methods aid in significantly raising the stress of the paralytic subject.

Assistance For The Paralyzed Using Eye Blink Detection was proposed by Atish Udayashankar, Amit R Kowshik, Chandramouli S, H S Prashanth [9]. The research describes Paralysis as the total lack of muscle control in any part of the body. It happens when the flow of signals between the muscles and the brain converts into issue. Any individuals who are paralyzed cannot lift common body component than eye of theirs. Primary objective of study develops an immersive actual time plan, which will support disabled in manipulating equipment like lighting/ replaying previously recorded voice signals via previously defined count of blinks of eye. Recognition of image methods were introduced to detect blinks in the pupils.

Eye Monitored Device for disable People was anticipated by AsfandAteem, Mairaj Ali, Zeeshan Ali Akbar, Muhammad AsadBashir [10]. The Software discussed in the study was helping humanity. Turning people techneeded when period clicks. Technologists want to crack barriers; it's what they do to make homo sapiens simple. Besides, we have also lodged with technologies with blueprint for engineering modish stuff. Statistics suggest several instances of disabled individuals identified worldwide, particularly individuals with syndrome locked up; is a therapeutic style in which most muscles of the body are paralyzed except eye control. The research aims to transform the lives of these people effortless, painless and achievable to restore these people's joy, fulfillment, cheerfulness and self-possession. The research supported the implementation of affordable assistance for people with disabilities and the manufacture of eye-controlled systems that control the handling of all electrical equipment / loads dependent on eye movement.

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Assistance for Paralyzed Patient Using Eye Motion Detection was suggested by Milan Pandey, Anoop Shinde, Kushal Chaudhari, DivyanshuTotla, Rajnish Kumar, Prof. N.D. Mali[11].The analysis purpose introduces real device system of eye contact and visual blink recognition to a fully paralyzed patient. The power to paralysis regulates muscle activity restrictions to brawns in body, otherwise patient's individual means of connection happens through blink. Intrusive interfaces in such communication requires distinct hardware otherwise focus on Infrared measuring device. Technology that wontintruse was built on a consumer-friendly basis is device that extracts feedback from an affordable webcam by video frame type with no special lighting conditions. The system senses voluntary eye blinks and then interprets pupil activity by means of control instructions. Orientation of eye observed could be supportive by programs for instance emergency aid, simple usefulness, S.O.S. OpenCV library manages the video frame and is an open source program.

3. Design and Implementation

The design part includes the system architecture. It explains the workflow of the system proposed. The architecture mainly explains how the data is being modified. How it is being used. and how the results vary with it. Capturing the frame from the video using the system's camera initializes the execution of the proposed system. The frames are converted into gray scale image and we are making zero and ones combination of white and black pixels. We are considering 68 point pixel for face and 6 point pixel for eye lids. 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. The output from Face Detection Algorithm then gets processed to detect face. Eye detected will be sent to check whether the eye is closed or open. When the eyes are open the virtual keyboard numbers are being played sequence until the eyes are closed. Once eye is closed then the particular need of the patient in that number is given as a output for care takers. The outputs are in the form of image display, text alerting, audio played and message sent to the concerned person.

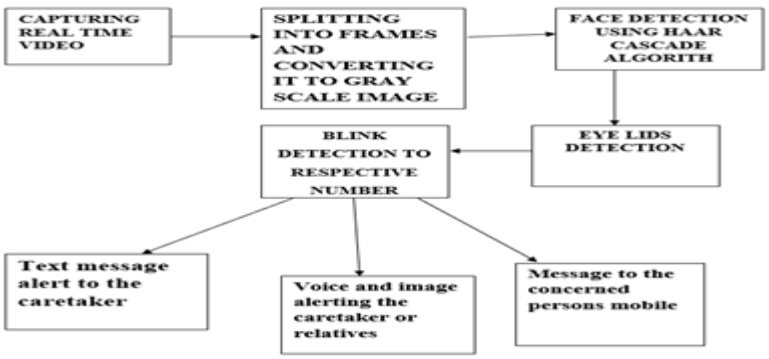

Figure 1: System Architecture

P-ISSN: 2204-1990; E-ISSN: 1323-6903
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The research study consists of three modules

3.1 Face Detection

Study's first step is initialisation. Using the laptop's front camera or any external camera attached to the device, a brief picture of the participant's face is taken. A process frame technique is used to construct frames from the recorded footage. The colored frames are produced from this process. Afterwards, only the luminance portion would be removed to turn these colored frames into gray scale frames. We use the luminosity approach to transform the colored frames to gray-scale prints. The formula for luminosity is L=0.21R + 0.72G + 0.07B

Figure 2: Gray Scale Conversion

Face detection is done using facial landmark algorithm, which results in locating the face in a frame. Only facial based structures are observed, and the use of this algorithm excludes every other categories of objects such as houses, plants, and branches. It can be achieved fundamentally utilizing the libraries that are NumPy and Dlib. Package called NumPy in python used in rapid, complex calculated computation. Other package called Dlib, a distinctive kit that includes algorithms for machine learning. Using these collections, we will find and reflect prominent features of the face. Within dlib, the facial land mark mark detector put produces 68 xy points on the forehead. These 68 points marked were obtained by shape predictor algorithm. Using these points, region of eye can be detected. The face which is marked with 68 points as shown in the figure below. As a result of that 68 points around the face, a rectangle box is computed around the eyes which is later used in the next module for detecting the eye.

Figure 3: Face Detection

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Haar Cascade Algorithm

- Pick f (maximum acceptable false positive rate per layer) and d (minimum acceptable detection rate per layer)
- Lets F_{target} is target overall false positive rate
- Lets P is a set of positive examples
- Lets is a set of negative examples
- Lets $F_0 = 1$, $D_0 = 1$, and $i = 0$ (F_o : overall false positive rate at layer 0, D_0 : acceptable false positive rate at layer 0, and i : is the current layer)
- While $F_i > F_{target}$ (F_i : overall false positive rate at layer i):
    - i+ + (*layer increasingly by* 1)
    - $n_i = 0$; $F_i = F_{i-1}$ (n_i : negative example i):
    - While $F_i > f * F_{i+1}$-
        - n_i ++ (check a next negative example.
        - Check the result of new classifier for F_i and D_0.
        - Decrease threshold for new classifier to adjust detection rater r > = d * F_{i-1}
    - N = empty
    - If $F_i > F_{target}$, use the current classifier and false detection to set N

Facial Landmark Algorithm

The identification of landmarks in face is part of shape prediction problem. Shape Predictor aims in finding the localize Points around the structure when an input image (and normally the ROI decides the object of interest) is given. They are hence important for various facial analysis tasks. Regionalizing the face is done by using Facial Landmark Algorithm. In the sense of facial landmarks our aim is to use shape prediction methods to identify significant facial structures on the face. The dlib library is used to identify facial features using plot 68 dots on the forehead. Using these indexes, it is possible to remove the appropriate area of the face and measure a bounding box around the eyes. Steps involved in calling the Face Landmark are:

Step 1: Localize the face in the image.

Step 2: Detect the key facial structures on the face ROI

3.2 Eye Detection

In our research study eye is the deciding parameter for finding the state of the patient. After the face is detected using the facial landmark algorithm a rectangular box is created around the eyes, from this we can easily concentrate on the movement of eyes like whether the eyes are open or closed. Eye region localization is first step in this module. The eye area located from the observed face is often utilized for

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monitoring of eye and identification of blink. Region located with points is presented in the figure below

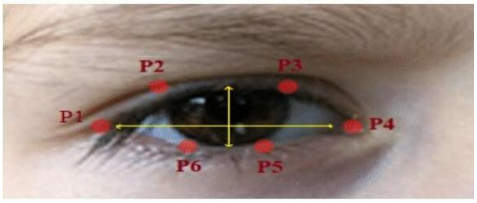

Figure 4: Eye Detection

Description of eye is done by 6 (x, y)- points, beginning from the left corner of a person's eye and then in the direction of clockwise around the remaining area.. There is a relation between the width and the height of these coordinates where p1, …, p6 are 2D facial landmark locations. Above figure shows the 6 points utilized to represent the eyes. With the aid of the time library the white area of eyes are located from the extracted area of eye. Uncertainly, it can be noticed that if eyes white area vanishes for some time that is displayed as a blink It can be determined if the white region of eye disappears for a period which is indicated as a blink. Through the assistance of EAR, blink detection may be measured.

Eye Aspect Ratio

Next step is detecting the blinks of an eye, after the eye is detected from the face. To detect the blinks of an eye we use the Eye Aspect Ratio formula. The EAR is instead a much more well-designed solution that involves a simple calculation. It is the ratio of distances between facial landmarks of the eyes. The formula for EAR is shown below.

$$EAR = \frac{\| p_2 - p_6 \| + \| p_3 - p5 \|}{2 \| p_1 - p_4 \|} \quad (1)$$

Where, in this equation above part calculates distance between landmarks of eye vertically and below part calculates distance between the landmarks of eye horizontally.

Calculating below part of equation because it just has one collection ofpoints horizontally whereas the above part of equation consists of two collection of points vertically. Aspect ratio of an eye is constant when eyes are open, so when a blink happens it will easily fall to 0. Using this basic equation, we can rely on the eye distance ratio to decide if an individual is blinking.

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Consider the below figure shown. Eye is fully open on the (top-left), the EAR here would be big and relatively same over time. Though, once the person blinks the eye aspect ratio reduces dramatically, approaching to zero as shown in the top-right in the figure. In the bottom EAR is approximately same while the eye is open, but will rapidly fall to 0 when a blink is taking place.

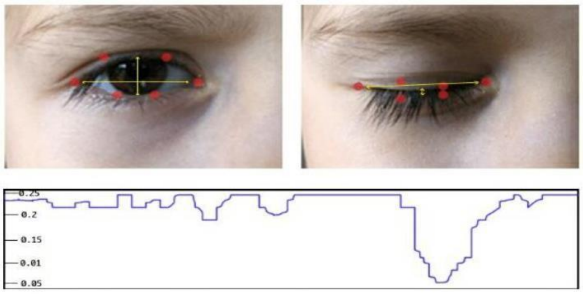

Figure 5: Eye Aspect Ratio

3.3 Eye Blink to Voice and Message Alert

This is the last module of the research study. After the eye detection from the face the eye blinks are detected using the EAR formula. Now the eye blink is to be converted to voice. For that first eye blinks are to be detected. The EAR is constant when eyes are open if the eye is going to close than it will become 0. So when eye is open it is represented using the red color and when eye is closed it is represented using green color. In this study a virtual keys represented using the numbers from 1 to 12 as shown in the figure below.

Figure 6: Virtual Keyboard

Each numbers in the virtual keys consists of a particular needs of the paralyzed patients.The keys will be in rotation from number 1 to 12.The patient is trained with the numbers of the particular taken place. After the blink is detected the voice need. When ever the patient need something, he canblink his eyes for that particular number when the movement of the cursor points to that need. Let us take an example if a patient wants food, let the number for food be 6. Now the patient should blink his eyes when the cursor points on the number 6 in the keys. The patient have to keep his eyes closed for and time range between 1 to 5 sec. so the blink detection can be taken place. After the blink is detected the voice message is sent to the care takers via speaker and a image is displayed on the screen of the particular need and also a SMS is sent to the mobile about the need

P-ISSN: 2204-1990; E-ISSN: 1323-6903
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of the patient so the caretakers can come and help the patient regarding the particular need. After the voice message and sms sent, again the cursors keeps its rotation continued. To convert the blink to voice a gtts module imported from the dlib library that converts the texts message in to speech in a MP3 form. To convert the blink to message a twilio module imported from the dlib library is used.

4. RESULTS AND DISCUSSIONS

The study aims to offer a form of independence to paralyzed people to communicate with outside world. Developing a video processing system in real time that detects the eye blinks and converts to voice. Based on the blink for corresponding number irrespective of the movements of the head either day or night, the MND patients will be assisted by care takers. It is a modest and stress-free approach with high precision and hasty reaction compared to previous systems.

Performance Parameter

The key parameters affecting the analysis talks about light and distance factors. If the eyes of the user and the webcam distance is long, then the detection process is difficult. The lighting is another key parameter affecting based on using an ordinary light or an artificial light.

The accuracy of system is found out using following formulae as follows:

$$\text{Overall Accuracy} = \frac{(TN+ TP)}{(TP + FN + FP + TN)} * 100 \quad (2)$$

$$\text{Detection Accuracy} = \frac{TP}{(FP+ TP)} * 100 \quad (3)$$

TP = True Positive TN = True Negative

FP = False Positive FN = False Negative

Where,

- TP is the number of correctly detected eye blinks.
- FN is the number of shown eye blinks but the program is not detected.
- FP is the number of reported eye blinks but they are not.
- TN is the number of eye blinks correctly reported as no blinks.

Ordinary light condition

Table 1 below denotes the test results when ordinary light is applied without filter. The table consist of distances between the camera and person and overall accuracy and detection accuracy of the each distance.

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TABLE 1 : STATISTICAL VALUE OF ACCURACY MEASURE OF ORDINARY LIGHT

Distance (cm)	Total No of Blinks	TP	FP	FN	TN	Overall %	Detection %
15	10	3	2	3	2	50	60
20	10	4	1	3	2	60	80
25	10	3	3	4	0	30	50
30	10	6	1	1	2	80	85.71
35	10	8	0	1	1	90	98
40	10	7	2	0	1	80	77.8

Artificial Light Condition

Table 2 shows the test outcomes of overall accuracy and detection accuracy and distances between the camera and person when artificial light is applied without filter.

TABLE 2 : STATISTICAL VALUE OF ACCURACY MEASURE OF ARTIFICIAL LIGHT

Distance (cm)	Total No of Blinks	TP	FP	FN	TN	Overall %	Detection %
15	10	7	1	0	2	90	87.5
20	10	6	1	2	1	70	85.7
25	10	7	0	1	2	90	100
30	10	8	1	1	0	80	88.8
35	10	9	0	0	1	98	100
40	10	8	1	0	1	90	100

When we see the values represented in the table 1 and 2 the overall and detection accuracy from the distance of 35cm is more accurate in both the light situation. So the distance of 35cm is considered and a graph is plotted for this distance against accuracy values. The Graph below in the figure 7 shows the accuracy representation of both artificial light and ordinary light When ordinary light is

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used the overall and detection accuracy will be 90% and 98% for a 35cm distance. When an artificial light is used the overall and detection accuracy are 98% and 100% respectively for a distance equal to 35 cm.So at last it is better to use artificial light conditions instead of ordinary light with a distance of 35cm as a best parameter suitable for this study.

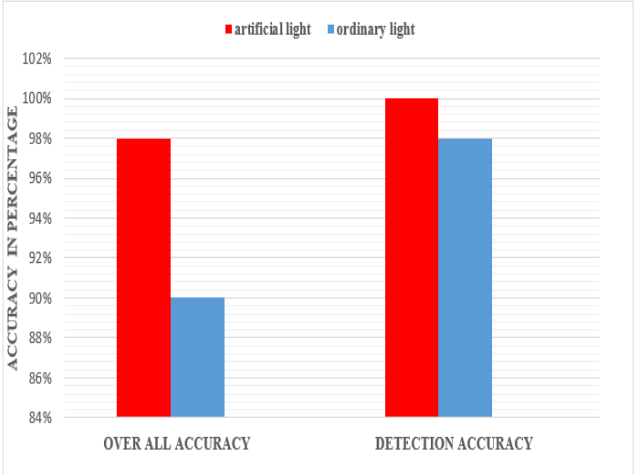

Figure 7: Accuracy Representation

The below Table 3 shows the comparison between existing system and our research study.

TABLE 3: COMPARISON TABLE

Performance Parameters	**Existing System**	**Over Research study**	**Improvement**
Overall Accuracy	94.8%	98%	3.3%
Detection Accuracy	90.7%	100%	9.3%

4.1 Face and Eye Detection

In the fig 9 after the camera is started, it starts recording the video of a person and from that video coloured frames are created. This coloured frames gets converted to a gray scale frame. The face is detected from the frames and from the face the eye is detected and its shown is red colour as in the figure.

Figure 9: Face and Eye Detection

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4.2 Eye Blink Detection

After the eye detection is done, next step is the eye blink detection. Eye blink is detected from the face when the eyes is closed for a time of range of 1 to 5 sec and then it is considered as a single blink and eye is represented in green color when it is closed as shown in the figure 10.

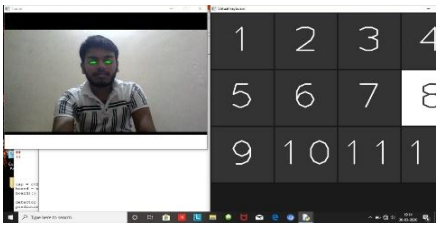

Figure 10: Eye Blink Detection

4.3 Eye Blink to alert messages

- In this step the eye blinks which is detected is converted into voice message and outputted with the help of speaker for the care takers as shown in the figure 11 with the help of GTTS code used in the program.

Figure 11: eye blink to voice

- Eye blink is converted into image as shown in the figure 12. When eye is blinked to the number 5 in the virtual keys the image of a fan is displayed on the screen as it is programmed as fan on in the coding for the number 5 in the system.

Figure 12: Eye blink to image

- In this step the eye blink is converted into SMS with the help of twilio code as shown in fig 13.As shown in the figure below the SMS is sent to the caretakers like fan on, light on etc.

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Figure 13: Eye Blink to Alert Message

5. Conclusion and Future Work

This research study main aim is to seek out away for disabled individuals to interact with the people without any harm to their body externally or internally. It overbalances the previously developed projects in this field because not even one of the components are in direct contact with the patient's body. Henceforth it definitely proves that it is more safer to the patients. As the systems that are available already in the market uses the hardware to develop a application which are very costly. So our objective was to develop a system which is cost effective, by this developed system our objective as met as it is very low priced system which is affordable. This helps the paralyzed people communicate independently without anyone's help. The existing studies were more complicated as it consists of both voluntary and involuntary blinks. Our study is simple and very easy as it makes the patients blink his eyes only for a single time for their particular need and gives a alert SMS to the care takers to provide the patient particular need with any difficulty occurring to the patients. Through our study the safety of the patient is taken cared. The result obtained from this study gives a maximum accuracy of 99% when compared to existing system.

Future Enhancement

In our research, we have demonstrated in the laptop perspective which can be equipped in compact manner. Which will help the normal users to use the proposed system. Without any human intervention the system should work according to the requirement. This analysis does not work in dark, hence it can be enhanced in the system Further it can be automated the things to which are in the form of audio and message in our study.

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P-ISSN: 2204-1990; E-ISSN: 1323-6903
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