Perspectives in Communication, Embedded-Systems and Signal-Processing (PiCES) – An International Journal
ISSN: 2566-932X, Vol. 2, Issue 2, May 2018

Human Eye Blink Detection System

Sumana C, Amulya Meda N, Prithvi H, Sahana V, Sindhura S
Computer Science, Jyothy Institute Of Technology, Bengaluru, India

Abstract: One of the major problems faced by Motor Neuron Disease (MND) patients is that they cannot communicate, as there speaking ability gets affected. Thus, the aim of the project would be to design and develop a communication unit for MND patients using real time video processing. The objective of our project would be to develop a blink to speech conversion system, where the patient is supposed to perform series of blinks or winks that represent a particular sentence and the corresponding message is converted into the speech. The proposed system help the patients to fulfil their basic needs efficiently and the designed algorithm should differentiate between the intention blinks and normal blinks and convert the same into the speech. MATLAB is the platform used to develop the system. Since, MATLAB has many built-in functions and libraries that is helpful in image processing and also creating GUI.

Keywords: Image Processing; Blink; MND

I. INTRODUCTION

Establishing proper communication or interaction is one of the main challenges faced by patients affected by MND. The inability to communicate effectively leads to various problems which might also result in not receiving the basic needs in time. The loss of speech could be frightening and hard to adjust to. This was both in practical terms, for example not being able to make people understand what you wanted (especially during hospital stays), and in emotional terms, for example losing the ability to express your personality, make jokes and take part in normal conversation.

Advances in technology have given people many opportunities to communicate in different ways, including texting, email, internet forums and voice software. These do not suit everyone - people with hand and arm weakness sometimes find it difficult to use a mouse or keyboard, for example, although computer adaptations are available to help people with limited hand use. Those who are not used to typing could find it too slow to use a computer. Some preferred to use handwriting, and some used letter frames, picture charts or sign language. In many cases, people used a combination of strategies. One person also used a battery-powered voice amplifier but none of these techniques could be used for patients who suffer from complete paralysis, the only contributing factor for communication would be their eyes. The blink patterns can be used to symbolize certain conversation phrases which help them get the required basic needs from time to time.

The Human Eye Blink detection system has played a major role in establishing a source of communication for patients affected by various types of MND (Motor Neuron Disease) and paralysis. Several methods have been established over the years that enhanced interaction facilities through the use of some external agents. This project proposed a visual approach keeping blinks as the key to support interaction of the affected.

The Blink System initiates the interaction by capturing a series of pictures of the completely paralyzed individual under a given timeframe. The next step emphasizes only on the eyes of the individual by cropping the rest of picture. Later the blinks generated are captured and the equivalent message is converted into speech.

II. LITERATURE SURVEY

A. A Device Controlled Using Eye Movement

The major disadvantage of disabled people is that they cannot move anything except their eyes. For these people eye movement and blinks are the only way to communicate with outside world through computer. Here eyes are taken as the input, the movement of user's eyes can provide a convenient, natural and high- bandwidth source of input. Though there isn't a universal method to track the eye movement, this experiment uses eye tracking is technique for measuring the gaze or movement of an eye and this helps us to identify where the user is looking. There are 3 sections in this project ie the first step is the capturing of image which uses a Webcam and Infrared LED followed by processing of the captured image using MATLAB also shape detection using Hough Transform and lastly the cursor control which points to the exact location.

- Eye Tracking Techniques:

An eye tracker is a device for measuring eye positions and eye movement. The selection of technique depends in the application. During the analysis phase of this research, three techniques were analyzed; the Limbus tracking, Pupil tracking, and third technology is Electrooculography.

a) Limbus Tracking uses the limbus for tracking of the eyes. The limbus is the boundary between the white sclera of the eye and the darker iris.The sclera is white part whereas the iris is darker part, so the boundary can be easily traced. This technique is based on the position and shape of the limbus relative to the head, so either the head must be held quite still or the apparatus must be fixed to the user's head.

b) Pupil tracking uses gaze detection and is commonly used with the other technique. The main Advantage of Pupil tracking is the notion of the "bright spot" and the border of the pupil is sharper than the limbus, also a higher resolution is achievable. Also, as the pupil is never really covered by the eyelid, therefore the x-y tracking is more easy and feasible as compared to Limbus tracking.

c) Electro-oculography is mainly based and works on the concept of electric potential. The electric potentials measured with electrodes placed around the eyes because the eyes are the origin of a steady electric potential field, which have the capabilities to be detected in total darkness and also in case the eyes are closed. It generates a dipole with cornea as the positive pole and its negative pole at the retina. Electrooculogram is the electric signal that can be derived using two pairs of contact electrodes placed on the skin around one eye. While the movement of eyes takes place from the centre to the periphery, the retina approaches one electrode while the cornea approaches the opposing one. This change in the orientation of the dipole and consequently the electric potential field results in a change in the measured EOG signal. On the other hand-eye movement can be tracked by analyzing these changes.

- Hardware

In this project, minimum hardware is incorporated ie all we require is Camera, Infrared LEDs, Laptop and a mouse.

a) Camera: For enhanced image quality in this project we use Logitech Webcam use for capture image which provides a picture quality 8MP in better light condition. But in bad light condition image quality is poor and this problem can be solved by using IR LED.

b) IR LED: Here the camera module also includes a near-infrared (NIR) LED which helps to illuminate the eye. The NIR illumination has many advantages like by using NIR illumination the iris appears lighter than under visible light which has the desirable effect of increasing the contrast between the pupil and the iris.Using infrared also enables the camera to capture video even when it is dark where visible illumination would otherwise interfere with the wearer's vision.

c) Mount: We need to create a comfortable mount for the patient. In order to create a comfortably wearable mount we can use the frame of a pair of any random glasses, for example sunglasses and attach the camera on it to detect the eye from a closer range.

d) Distance from the screen to the user: The distance needs to accurate and appropriate in order to neatly differentiate the different positions of the eye as well as precisely track the centre position. If this distance is too large then the movement of the pupil will be affected and very less for traversing the range of the screen making it very difficult to accurately track the centre position. On the other hand if the distance is too less, the eye movement will be too large due to the curvature of the eye.

- Software

This project used MATLAB version 2013a for implementation. Also the basic principles of image processing like Hough transform for shape recognition and circle detection also colour recognition has been used.

a) Hough transform: The Hough transform is one of the basic principles used in Image processing and it is the technique which can be used to isolate the features of a particular shape within an image. The classical Hough transform is most widely and commonly used for the detection of regular curves like the lines, circles, ellipses, etc.

b) Canny edge detection: The Canny method focuses and emphasizes on finding edges by looking for the local maxima of the gradient of image. The gradient is then calculated by dosing the derivative of a Gaussian filter. This method uses two thresholds, first one is to detect strong and weak edges and second includes the weak edges in the output only if they are connected to strong edges.

- Experimental Result

This experiment aimed to move cursor just by the movement of eye.

The project is divided three main section:

1. Section image
2. Capture processing
3. Mouse movement.

Also illumination here is a prerequisite. Therefore adequate illumination need to be used for capturing an image which will provide a well defined shape of the pupil and this is achieved by using IR LED which is mounted on either side of the camera lenses. It is invisible to the naked eye and hence will not cause any strain to the user. This completes the first section. The next section comprises of the selected or captured image, which is primarily in the rgb format which gets converted into grayscale for finding the centre with the corresponding row and column values. The next step here is to convert the Gray image to BW using Canny edge method and also use Hough transform for circle detection which also helps for thresholding. We need a proper threshold value to obtain a well filtered binary image of the pupil so we are converting image to binary image. By using the binary image we can find circle and center co-ordinate and can easily track exact point where the user is looking and later MATLAB use these co-ordinate to instruct a computer mouse to move to a particular location on the screen. For click action, the time period specified is 0.5 to 0.10 seconds. During this time, the cursor is to stay any folder then this folder is either open or closed. Thus this helps the user achieve complete control of the cursor movement of the mouse through eye movement.

B. *Portable Video – Oculography Device For Implementation In Sideline Concussion Assessment - A Prototype*

In a variety of cases let us consider one of these cases in the NFL loss of lawsuit, it was estimated that there where over a $900 million play against a group of former players. The main job of NFL was to warn a group of players about the dangers of concussion but NFL failed to warn players about the danger and failing to implement to necessary procedure to help to prevent these injuries. There are few things about this: 1.There is no proper scientifically accepted definition about the concussion (injury to the brain caused by a blow or by falling etc. which makes unconscious).

- This is mainly thought that here will be an impact to the head that will result in the impairment of some nervous function.
- In a medical term of concussion is considered as a sub set of an mTBIs (middle Traumatic Brain Injuries).
- In recent time the injury to the brain by falling is increasingly recognized as a very serious in a public health problems and it is also been said that it has even reached that affects many people in a wide area.
- Many studies have suggested that a repeated sub-concussive head injuries suffered by the athletes who are competing in sports are the major people who contributing fact for the micro swelling of the white matter. This type of microstructural changes are mainly detected through a method called as diffusion tensor imaging and these are thought to be a caused by diffuse axonal injuries.
- These injuries are mainly undetected if an athlete with an concussion based symptoms continues or return to the completion as soon as to suffer from an concussion, and one more impact to the head can cause a permanent damage to the brain tissue. This result can also show similar symptoms of an Alzheimer's disease, Parkinson's disease and Amyotrophic Lateral Sclerosis (ALS). According to a Sports Concussion Assessment Tool 3rd edition (SCAT3) is a standard concussion test and several sporting bodies such as FIFA (Federation International de Football Association), RBI (International Rugby Board) and Olympic committee. This test basically is a medical professional and combines a various variety of concussion methods. The physical functionality of a player to give an indication of whether a player has possibly with stand a concussion or not. This mainly depends on a person who has professional in testing. Unfortunately this not feasible to have in a medical facilities and experience. According to literature eye tracking is a good indicator of a concussion. Researches have shown that ocular motion function provides a means of pathways potentially damaged by concussion. Video-Oculography (V-O) devices evaluate tracking devices are huge this requires a computer and this is restricted to hospital and universal laboratories. In an eye movement tracker this requires further investigation. This paper deals with a design of a portable V-O device that can be used as a concussion screening tool. The device must perform a significant operation before running out of power.

- Hardware

The first example used to develop can assembled with a low cost, components and 3D printed parts. A 3D system (Rapman) and 3Dprinter is used to print the entire firm protective covering. This protective covering was designed to have on all the hardware ports for accessibility. A helmet constructed for a head mount for safety. A Raspberry pi2 is used on a processor board. In a single-board processor there will have ability to perform a complex task which was possible only on computers. 1GB of RAM and 900 MHz quad core ARM Cortex-A7 CPU present in Raspberry pi2. This Raspberry pi2 will enable to perform computation for an expensive eye tracking algorithm which has good rate. Inside protective covering there will be 5inch LCD screen. The stimulation is displayed on the screen and the displaying screen is placed at a distance 170mm from eye this type of doing is mainly corresponding to 30 to 40 years old camera is used as a sensor. This camera will communicate with a Raspberry pi's directly to a CSI port.

This protocol has a low latency compared to USB protocol used in a camera. The eye visible in a camera has a big contrast between the pupil and the other part of eye if it is observed under infrared illumination but this camera doesn't have an infrared filter. Three infrared LEDs are used to make easier. An effective eye tracking algorithm is used. Camera is placed on an arm which is flexible (can be moved however we want) and stays in a position. This tight fit has a variable head attachment which ensures that camera stays in a stable position. This will have a continuous operation of 5hrs and 24sec.

- Software

This software structure has four phases all are done using a MATLAB and SIMULINK. In first phase user will be told about and given instruction, camera is placed which is attached to an adjustable arm and camera is placed such that it focuses only on eye. Camera is connected to a screen for displaying an image of eye. In second phase camera captures a video of pupil before this there will be nine point calibration grid shown on screen and user is told to look at each point of grid in order to change from white to read. The recorded video consists of data of the pupil where user eye looking at the nine calibration point and position is fixed on a screen. A circle function is used to detect the pupil. This setup consists of five parameters namely maximum area, minimum area, circularity, inertia and convexity. The used infrared will ensure that there is a good difference between the iris and the pupil. In third phase user is instructed to follow visual stimulus when it moves across a screen. A circle with red colour appears on the screen with diameter of 3pixels, eye is moved clockwise and five revolutions are completed. The video is recorded from a camera as it follows the moving target point. Last phase

system uses a reference algorithm and map it based on a simple arithmetic function in a previous phase recorded video of eye is used a circle function is used again to find the pupil position and position is displayed on screen. Calculations are performed accordingly.

- Methodology

In this test accuracy is performed, a red dot is displayed in a random position on the screen and user is instructed to look a fixed point so that pupil position is recorded for a fixed amount of seconds. Pupil position is taken and calculated and this value is compared to know about a target point. Error is calculated for each target point. This test is done for about 30times. Entire process run and repeats for 30times.

- Result

System accuracy is calculated and the duration of a screening this is done until the smooth pursuit target is reached and this was recorded as a minimum of 4:31:11 and a maximum of 5:41:04 (m: s: ms).

III. PROPOSED TECHNIQUE

An image may be defined as a two-dimensional function f (x, y), where x and y are spatial (plane) coordinates, and the amplitude off at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point. When x, y, and the amplitude values off are all finite, discrete quantities, we call the image a digital image. The field of digital image processing refers to processing digital images by means of a digital computer.

There are five basic steps in image processing:

A. Image aquisition

The first stage of any vision system is the image acquisition stage. After the image has been obtained, various methods of processing can be applied to the image to perform the many different vision tasks required today. However, if the image has not been acquired satisfactorily then the intended tasks may not be achievable, even with the aid of some form of image enhancement.

Image Acquisition Toolbox provides functions and blocks that enable you to connect industrial and scientific cameras to MATLAB and Simulink. It includes a MATLAB app that lets you interactively detect and configure hardware properties. The toolbox enables acquisition modes such as processing in-the-loop, hardware triggering, background acquisition, and synchronizing acquisition across multiple devices.

B. Pre-Processing

Pre-processing is a common name for operations with images at the lowest level of abstraction -- both input and output are intensity images. The aim of pre-processing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing.

Four categories of image pre-processing methods according to size of the pixel neighborhood that is used for the calculation of new pixel brightness:

1. Pixel brightness transformation,
2. Geometric transformation,
3. Pre-Processing methods that use a local neighborhood of the processed pixel,
4. Image restoration that requires knowledge about the entire image.

C. Image Segmentation

Image segmentation is the process of partitioning an image into parts or regions. This division into parts is often based on the characteristics of the pixels in the image. For example, one way to find regions in an image is to look for abrupt discontinuities in pixel values, which typically indicate edges. These edges can define regions. Other methods divide the image into regions based on color values or texture. An effective approach to performing image segmentation includes using algorithms, tools, and a comprehensive environment for data analysis, visualization, and algorithm development. In segmentation we convert the given image into a different color models and then choose the appropriate one for the segmentation, we then differentiate it with each individual image.

D. Dilation or Erosion

These are the two fundamental morphological operations. Morphological operations is a collection of non-linear operations related to the shape or morphology of features in an image. Dilation adds pixels to the boundaries of objects in an image. It is typically applied to binary images, but there are versions that work on grayscale images. The basic effect of the operator on a binary image is to gradually enlarge the boundaries of regions of foreground pixels. Thus areas of foreground pixels grow in size while holes within those regions become smaller. The dilation operation usually uses a structuring element for probing and expanding the shapes contained in the input image. Dilation is a type of transformation that changes the size of the image. The scalar factor, sometimes called the scalar factor, measures how much longer or smaller the image is.

Erosion removes pixels on objects boundaries. Erosion is one of the basic operators in the area of morphology. It is typically applied to binary images, but there are versions that work on grayscale images. The basic effect of the operator on a binary image is to erode area the boundaries of regions of foreground pixels. Thus areas of foreground pixels shrink in size, and holes within those areas become larger. In erosion operator takes two pieces of data as inputs. The first is the image which is to be eroded. The second is a set of coordinate points know as a structuring element. It is this structuring element that determines the precise effects of the erosion on the input image.

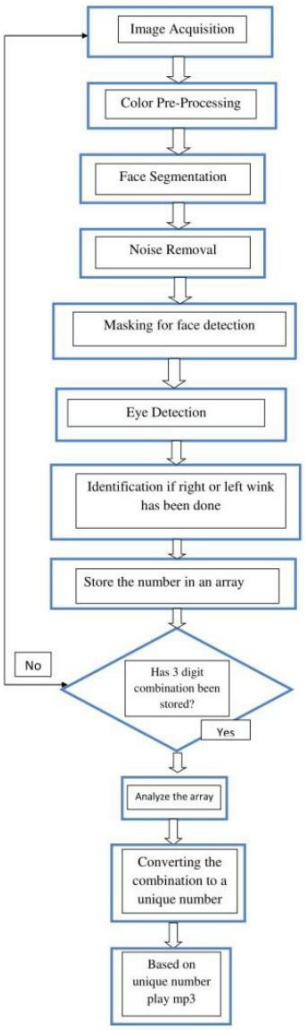


Fig 1. Flowchart

IV. RESULTS

The original image is captured from the web cam. The original image is an RGB image where R is Red, G is Green and B is Blue. It is also converted to YCbCr and HSV. Once the appropriate image is obtained where the eyes of the patient is clearly visible, that image is taken and dilation is performed on the image to remove the noise and the it is cropped to the size of the eye as the pattern is generated only by the blinks of the eyes of the patient.

V. CONCLUSION

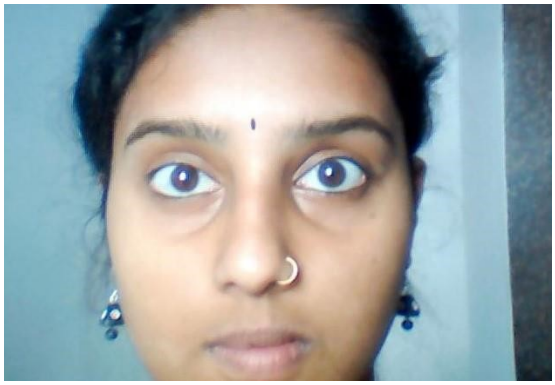
The need of the Human Eye Blink Detection System is that to help the completely paralyzed patients to communicate through the series of blinks or winks.

The proposed blink detection system helps the MND patients to communicate through the series of winks or blink to fulfill their basic needs efficiently, where the series of blink are not only converted into speech but also displayed as equivalent message.

In this project work, existing research of blink detection system is surveyed and all the limitations of the existing methods are reviewed.

The future enhancement of the project is that it can be future improvised so that it will be implemented even on the mobile based applications to receive e-mails and notifications immediately when the patient needs any help.

Further, this can also be implemented for the military applications to maintain the confidentiality during wars, this system can also be useful when the aircrafts have been high jacked and thus becomes an important medium for communication.



(a)

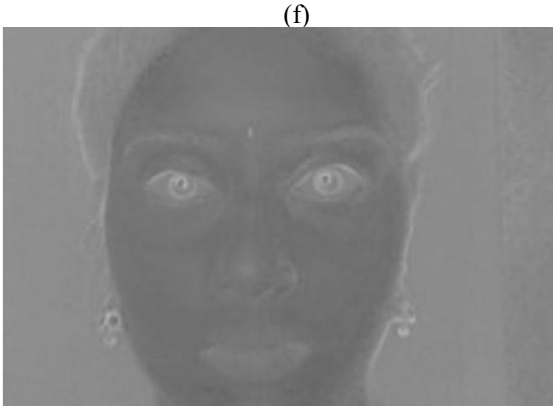
(b)

(c)

(d)

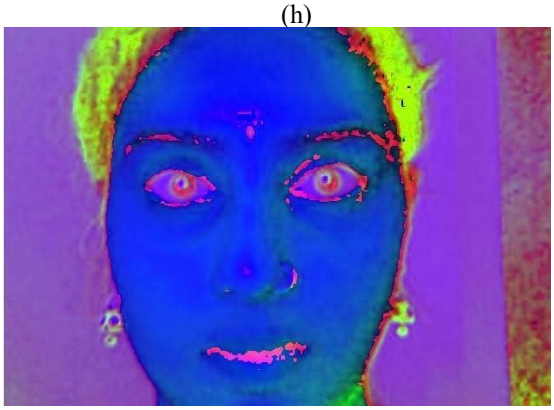
(e)

(f)



(g)

(h)



(i)

(j)

(k)

(l)

Fig 2. (a) Original Image (b) Red Image (c) Green Image (d) Blue Image (e) YCbCr Image (f) Y (Brightness) Image (g) Cb (Chroma Blue) Image (h) Cr (Chroma Red) Image (i) HSV Colour Model (j) H (Hue) Colour (k) Saturation Component (l) Intensity Component

Fig 3. Cropped Image of Eye

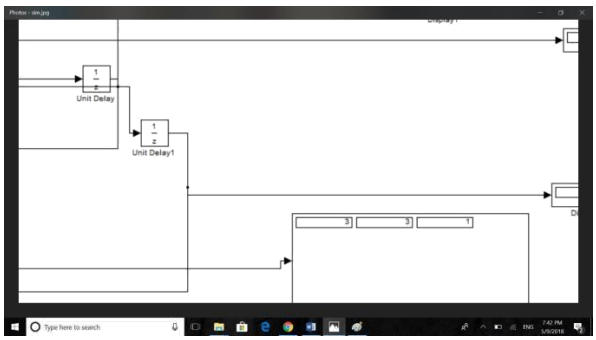


Fig 4. Pattern Generated is 331 indicating "I am Hungry"

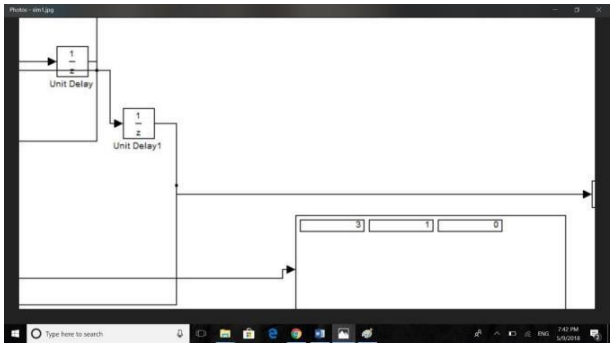


Fig 5. Pattern generated is 310 which corresponds to "I want Water"

REFERENCES

[1] E.M. Davenport, C.T. Whitlow, J.E. Urban. Abnormal White Matter Integrity Related To Head Impact Exposure in a Season of High School Varsity Football. J Neurotrauma, Edition 31, 17 Sep 2014, p1617-1624.

[2] T.M. Talavage, E.A Nauman, E.L Breedlove, U. Yoruk, A.E Dye, K.E Morigaki, H. Feuer, L.J Leverenz. Functionally – Detected Cognitive Impairement in High School Football Players without Clinically – Diagnosed Concussion. Journal of Neurotrauma. Edition 31, Feb 2014, p327-338.

[3] Gilat, Amos (2004). MATLAB: An Introduction with Applications 2nd Edition. John Wiley & Sons. ISBN 978-0-471-69420-5.

[4] Quarteroni, Alfio; Saleri, Fausto (2006). Scientific Computing with MATLAB and Octave. Springer. ISBN 978-3-540-32612-0.

[5] Ferreira, A.J.M. (2009). MATLAB Codes for Finite Element Analysis. Springer. ISBN 978-1-4020-9199-5.

[6] Lynch, Stephen (2004). Dynamical Systems with Applications using MATLAB. Birkhäuser. ISBN 978-0-8176-4321-8.

[7] https://en.wikipedia.org/wiki/MATLAB

[8] https://en.wikipedia.org/wiki/Simulink.

[9] Digital image processing by Gonzales.

[10] D. M Dobink, The rf in RFID: uhf RFID in practice. Newnes, 2012.

[11] F. Xia, L. T. Yang, L. Wang, and A. Vinel, "Internet of Things", International journal of communication system, vol. 25, no. 9. p. 1101, 2012