2015 1st International Conference on Next Generation Computing Technologies (NGCT-2015)
Dehradun, India, 4-5 September 2015

# Language for people suffering from complete paralysis based on Eye Gestures

Rajesh Kannan Megalingam*, Malavika Karath*, Vaishnavi Valluri*, Aparna Shreedhar*, Meghana Katti*, Sapna Gurjar*and Aiswarya Nair*

* AVVU, Kollam, India, rajeshkannan@ieee.org, malavikakarath@gmail.com,aparna.195@gmail.com,vaishnavi888@yahoo.co.in, mmk1894@yahoo.com, sapnagrjr@gmail.com, aiswaryavnair@gmail.com

***Abstract*—The main aim of this research work is to develop means of communication for people with complete paralysis. This is done by making use of the eye movements of the patients as these patients cannot move any other body part. In this paper we discuss about two schemes a YES/NO scheme and a regular scheme. In YES or NO scheme the patient is provided with a list of amenities. One option is displayed at a time wherein the patient can choose either YES or NO through the eye movements. In the regular scheme the patient will be able to form sentences using the eye movements. The eye movements are captured using via camera and tracked using image processing algorithms. The particular eye movement captured is recognized as either YES or NO. On achieving this stage the communicating options are expanded by augmenting more options by implementing the second scheme. The schemes, the image processing algorithms, their implementation, tests and results are provided in detail in the paper.**

**Keywords: eye movements, iris detection, adaboost, Viola Jones algorithm.**

## I. INTRODUCTION

Paralysis is the loss of muscle function for one or more muscles. Quadriplegia is a type of paralysis where all the muscles stop functioning. The patient looses mobility and above all looses the ability to communicate through speech. Primary goal of our research work is to develop a communication language using eye gestures so that the patient suffering from complete paralysis can easily communicate to the rest of the world. Many works have been developed by using eye gestures such as The Eye Cursor [5,7] and The Eye based Wheel chair [2] that have used various techniques to detect eye movements like Electrooculogram (EOG) [4] and IR Sensor Techniques [1, 3]. In our work we use a camera to capture the images of eyes, used the Viola Jones algorithm to extract the eyes from the image and edge detection techniques to extract the pupil.

## II. MOTIVATION

If most disabled persons undergo various physiological problems, family members too suffer great emotional and physical hardship to care a loved one that is disabled. Fortunately, technology has developed so much that there are many things that the caregivers can do to ensure the best care for their loved ones and also attend to their own needs. Our research work mainly aims to apply the technology to compensate and make the lives of people suffering from certain disabilities to lead an easier and smoother life. People suffering from quadriplegia can voluntarily move their eyes. This has led us to devise a language where patients can effectively communicate with others using their eye gestures that would be converted to English sentences. This way they would no longer feel isolated.

## III. RELATED WORKS

In [1] Mukeherjee et al proposed the idea of converting the Eye Blinks to a universally accepted code-The Morse Code, which would enable people suffering from paralysis to communicate. The eye blinking is detected using IR techniques which measure the reflectivity between closed and open eyes. The reflection is relatively more when the eyes are closed. The pattern of Eye Blinking is recorded by the IR sensor module and fed to an Arduino UNO board which converts the pattern to English alphabets and display on the LCD display.

In [2] Challagundla et al proposed a technique to drive a wheel chair based on Eye Gestures recorded using IR module to enable people suffering from Tetraplegia to navigate. In the technique proposed the user needs to wear optical device on which the IR module is mounted. The system also makes use of Arduino UNO board and ultrasonic sensors. When both the eyes are open the Arduino makes both the motors to run in the forward direction, when both the eyes are closed the motors run in the backward direction. Similarly when only the right eye is closed the wheels move right and when only left eye is closed the wheels move left.

In [3] Bronte et al presented a nonintrusive approach to detect a drivers drowsiness by detecting the eye features. The face and eye is extracted using Viola Jones Algorithm and Kalman Filter and the pupil extraction is done using Integral Projection Techniques and Gaussian Model. Once the iris is detected Iris Centre Algorithm is executed. In this approach Perclos is used as the drowsiness parameter. An IR stereo camera is used to obtain the perclos. The perclos is calculated in the two images given by the stereo camera and the mean of both is calculated.

In [4] Spentanto et al proposed a cost effective embedded system for tracking eye to support disabled to do basic interaction with Bluetooth enabled electronic devices. The eye tracking is done using EOG using three pair of Hypodermic

Electrodes. The EOG signals are processed using differential amplifiers and A/D converters. The amplified EOG signals are converted to digital by the ADC available in the microcontroller. The microcontroller also samples the signal and also to communicate with other devises over Personal Area Network (PAN). In [5] Norris et al proposed a cursor like device controlled by eye movements and eye winks which allows a disabled person to use the computer. Here a one channel EOG is used to track the eye movements. The device outputs four different intensions left glance, right glance, glance to up and glance to down which are used to move the cursor and voluntary wink-left wink for Enter and right wink for Menu to select. A classifier Algorithm is used to differentiate and classify the different eye gestures. In [6] John described the basics of eye-movement technology and eye tracking in Human- Computer Interaction(HCI) research. It also examines the various ways of measuring eye movements systematically to examine interface usability. Eye tracking is a technique whereby an individuals eye movements are measured so that the researcher knows where a person is looking at any given time and the sequence in which their eyes are shifting from one location to another. The advantages of a range of different eye movements are also presented in this paper.

## IV. DESIGN AND IMPLEMENTATION

The setup is shown in a simple diagram in Figure 1 which consists of two screens; one that would act as an interface for the patient i.e. the tablet and the other screen would display what the person wants to say to his/her caretakers.

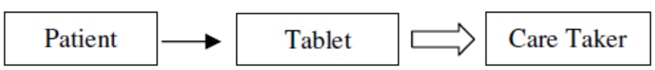


Fig. 1. System Architecture.

The patient communicates to the caretaker through the tablet. His eye movements are translated into an understandable language by the softwares present in the tablet. Various schemes can be followed using Matlab/Application to convey the patients thoughts to the caretaker. The caretaker then receives the interpreted message on the second screen. This second screen can either be a part of the setup or can be the Smartphone in the caretakers hands.

### A. Architecture

The internal processing done inside the tablet is as show in Figure 2.

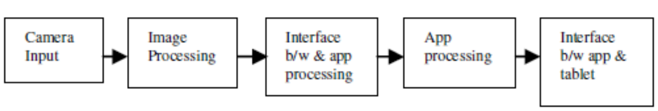


Fig. 2. Tablet Based Processing.

- Camera input: The camera takes in continuous video input of the face of the patient. This is done using the webcam in the first tablet. The patients eyes are continuously monitored and the video is sent to the image processing block.
- Image Processing: In this block, using Viola Jones Algorithm and Edge Detection algorithm, the movement of the patients eye is tracked.
- Interface between Matlab and App processing: The Matlab software and the Android application are interfaced.
- App Processing: An android Application is developed that would process the input from the Image processing block to get the accurate eye movements and outputs the decision on what the respective eye movement signifies.
- Finally, based on the output of the App, the tablet transmits a message to the screen, through a wired connection, that the caretaker can read.

The scheme implemented here can also be advanced to a stage where the message is directly transmitted to the caretakers smartphone using a wireless technology (like Bluetooth) and the phone speaks out what the patient wants to say. This can make their communication more reliable and efficient. To implement this, the caretakers device must support the features as shown in the block diagram in Figure 3.

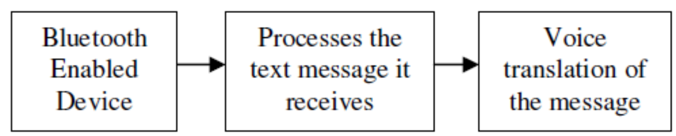


Fig. 3. Caretaker Gadget.

### B. Algorithms used

The tablet is considered to have an in-built camera. The real-time video input from the camera is given to Matlab as input for further processing. There are 2 individual processes that are involved.

- Viola Jones Algorithm: This algorithm is used to detect the eyes of the patient from the real time video. The Viola Jones Algorithm is the first ever object detection framework used to detect real time objects. It is capable of detecting a variety of object classes after proper training. The basic principle of the Viola-Jones algorithm is to scan a sub-window capable of detecting faces across a given input image. Viola-Jonesm algorithm rescales the detector and runs the detector many times through the image. The detector devised is a scale-invariant detector that requires the same number of calculations whatever the size of the detector is.

The four major stages of the algorithm are: Haar features selection, Creating integral image, Adaboost Training algorithm and Cascaded classifiers. Haar features are basically combinations of black and white rectangles. These are applied to the input image (grayscale image) for comparison. When a Haar feature Patient Tablet Care Taker Camera Input Interface b/w app processing App processing Interface b/w app tablet Image Processing Bluetooth Enabled Device Processes the text

| | | |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 1 | 1 |
| 1 | 1 | 1 |

| | | |
|---|---|---|
| 1 | 2 | 3 |
| 2 | 4 | 6 |
| 3 | 6 | 9 |

Fig. 4. Image Pixel Matrix.

message it receives Voice translation of the message is applied to a photo the rectangular patterns and the pixels in the face underneath are compared. The first step of the Viola-Jones face detection algorithm is to turn the input image into an integral image. This is done by making each pixel equal to the entire sum of all pixels above and to the left of the concerned pixel as shown in Figure 4.

There are a large number of features. Of these some of them give consistent high values. Each feature presented is considered as a potential weak classifier. AdaBoost is a machine learning boosting algorithm that constructs a strong classifier through a weighted combination of weak classifiers. The AdaBoost algorithm is modified to select only the best features. The next part of the algorithm is the cascading of the classifiers. The cascaded classifier is composed of stages each containing a strong classifier where each stage determines whether the sub-window is a face or a non-face. If the sub-window is resulted to be a nonface it is discarded, else it is passed onto the next stage wherein the similar procedure follows. Say the sub-window has entered Stage 1, if it passes this stage it will enter into Stage 2, which is more detailed as shown in Figure 5. Discard i/p Discard i/p

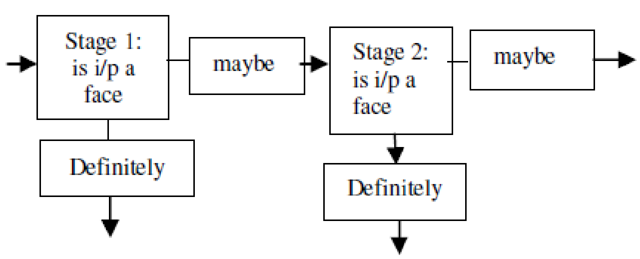


Fig. 5. Cascading Classifiers.

As we move into higher stages of cascades, they get increasingly larger and complex where additional Haar features are included. In the advanced stages it takes more time to compute. By the time we reach the last stage it will be close to a face. Thus using this algorithm, the eye from the video is extracted.

- Canny Edge Detection Technique: The Canny edge detector is an edge detection operator that uses a multistage algorithm to detect a wide range of edges in images. It is used to locate sharp intensity changes and to find object boundaries in an image. The Canny edge detector classifies a pixel as an edge if the gradient magnitude of the pixel is larger than those of pixels at both its sides in the direction of maximum intensity change. This technique is used to detect the iris from the pupil. After the Viola Jones Algorithm, the eye section of the patients face has been detected. Now to track its movement, the iris needs to be identified. This is done using Canny Edge Detection Technique. A typical implementation of the Canny edge detector follows the steps below: 1. Smooth the image with an appropriate Gaussian filter to reduce desired image details.
  2. Determine gradient magnitude and gradient direction at each pixel.
  3. If the gradient magnitude at a pixel is larger than those at its two neighbors in the gradient direction, mark the pixel as an edge. Otherwise, mark the pixel as the back ground.
  4. Remove the weak edges by hysteresis thresholding.

### *C. Language Schemes*

- YES or NO scheme : This forms the preliminary scheme. Here the patient is provided with a predetermined list of the most basic necessities. This list is displayed on tablet. According to his need the patient responds with either a YES or NO.
  Suppose the patients response is NO for a particular item in the list the next item in the list is automatically displayed for which the above procedure is repeated. For the response YES from the patient for a particular item in the list, the caretaker is immediately informed and necessary action will be taken. An example of the list provided to the patient may include: Food, water, pain, medicine, doctor, nurse, move left, move right, entertainment, bathroom, caretaker/family, light, etc., as shown in Figure 6.

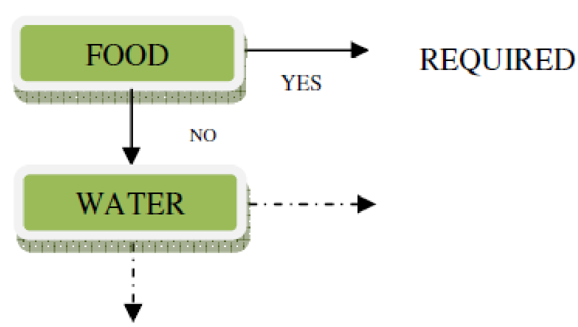


Fig. 6. Tablet Based Processing.

  The options are displayed one at a time. The next option is displayed only after receiving a response(Yes/No) to the previous option from the patient.

- Using Morse Code Format : This is another language scheme where a chart(as shown below) is displayed on the patients tablet and he can choose what he wishes by moving through the chart using his eye movements i.e. a right eye movement to move in the right direction and a left eye movement to move in the left direction. When he wants to choose a particular word in the chart, he has to reach up to that point and then just blink. This can be a little more interactive than the previous scheme and can also save time as the patient wont go through the pain of answering all the questions till he reaches the desired one. This chart is simply a basic model. It can always be developed upon.

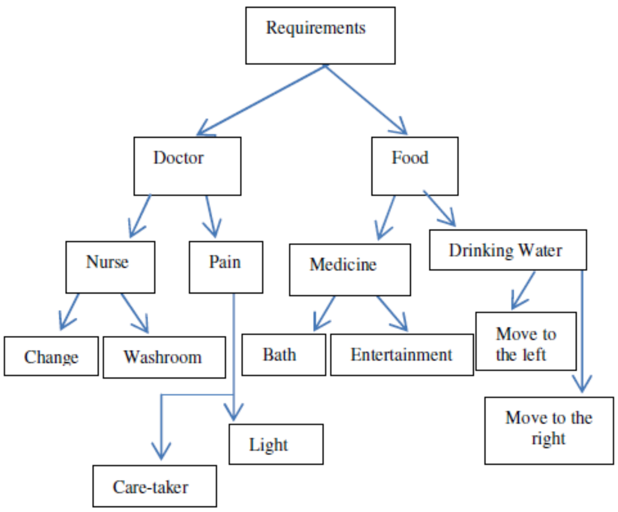


Fig. 7. Morse Code Based Language Flowchart.

### D. Matlab Simulations

- The initial implementation of the project has been done using Matlab and we have followed the 1st language scheme.
- To detect the eye movement for the basic recognition of a Yes and a No, the following steps are involved:
  1. The camera passes the real-time video to the Matlab software for further processing.
  2. Matlab processes the video and extracts the eye section from the video. This is done using Viola-Jones algorithm.
  3. Continuous frames of the video are captured at very small time intervals and are saved onto the system with constant over-writing of older frames with newer ones. Thus, at a time, a limited number(around 100 frames) are stored on the system.
  4. The iris is located on every frame using Edge Detection Algorithms.
  5. Consecutive frames are compared to find any difference in the coordinate of the iris.
  6. When a horizontal movement beyond a threshold value is detected, the output is taken as a Yes.
  7. When a vertical movement beyond a threshold value is detected, the output is taken as a No.
- The current status of the project is that Matlab extracts the eye section from the real-time video and is able to capture frames of this video at a time interval specified by the user, both in individual codes.

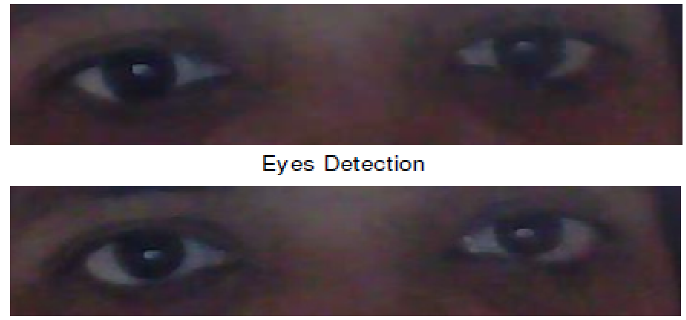


Fig. 8. Eye Section Captured by Viola Jones Algorithm.

## V. RESULT

The following results are obtained

- Matlab access the real-time video.
- Individual frames of the video are extracted at a time interval specified by the user.
- It captures the eye section using Viola Jones Algorithm.

## VI. CONCLUSIONS

This research work will provide patients with complete paralysis the benefit of communicating with the outside world. It will not just help him/her meet his personal needs but also give them the chance to interact with other people. This can make them much more self-reliant and will also not let them feel isolated in todays fast-paced and developing world. But at the same time, there is always scope for improvement. Some of the areas that can be worked on are:

- Some more sophisticated language schemes can be developed that will enable the patient to not only use the existing words on the system but also add new words and use them in future.
- The Android application on the tablet can be synced to other Sentence Builder and Dictionary applications that are already available in the market, thus making the communication easier for the patient. The patient will not have to literally convey every word/letter in a sentence; instead, a lot of the sentence/word completion will be done automatically by the available apps itself.
- An automatic system that will enable the patient to turn the tablet ON/OFF can be developed, thus ensuring that the tablet is ON only when the patient wants to communicate.

**ACKNOWLEDGMENT** : We are indebted to the HuT labs and Electronics and Communication Engineering department at Amrita Vishwa Vidyapeetham, Amritapuri Campus for their constant support and guidance for this work.

## REFERENCES

[1] Kingshuk Mukherjee, Debdatta Chatterjee(2015), - Augmentative and Alternative Communication Device Based on Eye-Blink Detection and Conversion to Morse-Code to Aid Paralyzed Individuals, International Conference on Communication, Information Computing Technology (ICCICT).

[2] Manoj Challagundla K.Yogeshwar Reddl, N.Harsha Vardhan3(2014), -Automatic Motion Control of Powered Wheel Chair by the Movements of Eye Blink, IEEE International Conference on Advanced Communication Control and Computing Technologies (ICACCCT).

[3] I. Garca, S. Bronte, L. M. Bergasa, N. Hernandez, B. Delgado, M. Sevillano (2010), -Vision-based drowsiness detector for a Realistic Driving Simulator, 13th International IEEE Annual Conference on Intelligent Transportation Systems Madeira Island, Portugal.

[4] Harry Septanto, Ary Setijadi Prihatmanto, Adi Indrayanto (2009) ,-A Computer Cursor Controlled by Eye Movements and Voluntary Eye Winks Using A Single Channel EOG, International Conference on Electrical Engineering and Informatics 5-7 August 2009, Selangor, Malaysia.

[5] Gregg Norris and Eric Wilson (1997), -The Eye Mouse, An Eye Communication Device.

[6] Daugman, John(January 2004), -How iris recognition works, IEEE-Transactions on Circuits and Systems for Video Technology, Vol.14(1).pp.21-30.