Eye Waver Technology Based Assistive System for Disabled

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***Abstract* - In recent years many assistive systems for disabled have been developed. In this paper we present a unique assistive system for tetraplegic patient which works on eye waver technology. Tetraplegia also called as quadriplegia is a paralysis condition where a patient cannot move parts below neck. In some cases the patient may even become dumb. The patient will be bedridden and have to be taken care. The proposed assistive system is to enable communication between tetraplegic patient and caretaker. The proposed system works, based on eye movement of patient. A Haar Cascade Classifier methodology is used for getting eye and facial axis information. An efficient eye tracking method is used to detect and track the eye movement. The eye movement and blink of patient will be recorded by the system and it is processed and converted into corresponding voice output. The patient can also use this system for device automation, for controlling fan, light and other devices.**

***Keywords* - Haar Cascade, Facial landmarks, 68 points, EAR, Eye Blinks.**

I. INTRODUCTION

Tetraplegia or quadriplegia is a paralysis condition caused by illness or injury that results in the partial or total loss of use of all four limbs, the patient may also lose has difficulties in speech. Because of this, the patient cannot perform voluntary actions and becomes bedridden. The patient has to be taken care by someone always. It is difficult for the patients to make caretaker understand what they need. And even the patient face major problem like they won't be able to communicate with the world. There are many systems developed and introduced for the tetraplegic patients to communicate with the outside world. Such as Brain wave technique and Electro-oculography. In these techniques, electrodes are pierced through the epidermis of skin. The method is painful and patient will be conscious and uncomfortable. And there exists the idea to develop an eye-motion detection system for paralysis patients. The system incorporates different visual technologies, such as eye blink detection, eye center localization and conversion of the eye blink to speech. The system uses an efficient method which is based on image processing techniques for detecting human eye blinks and generating inter-eye-blink intervals. A Haar Cascade Classifier and Camshift algorithms for face tracking are applied forgetting facial axis information. Adaptive Haar Cascade Classifier from a cascade of boosted classifiers based on Haar-like features using the relationship between eyes and the facial axis applied for positioning the eyes.

II. LITERATURE SURVEY

Controlling mobile phones using eye blink detection in real time applications is a very challenging problem. The reason for this is, the movement of eye and the light varies with the distance between the mobile camera and the eye. The proposed method improves the accuracy of eye detection and blinking by 8%. The overall accuracy and detection accuracy of this method are 98% and 100% respectively when an artificial light is used. Each frame is captured at an average time interval of 71ms during execution which is suitable for real time application [1].

Quick menu selection is a easier system for disabled. The easiness depends on the precision of eye gaze and eye movement functions of the users. The user can change the size and number of menu options [2].

Adaptive Haar Cascade Classifier has been developed to increase the efficiency of Haar Cascade Classifier. Eye Detection accuracy is improved to 22.7%. From this method ESD values are calculated. Based on these values, the state of eyelid is classified as open or close. The average execution time for each frame taken is 15.787ms [3].

Image capturing and processing using blink detection is a demanding project. There are numerous ways to implement this project and each implementation involves many functional components. The best method to detect eye blinks is using infrared LEDs. This project makes the best use of technology and improves the accuracy [4].

Many applications use eye blink detection. A new approach for detection is proposed. Knowledge on face detection and golden ratio is necessary for making the eye detection process robust. Motion analysis technique is not reliable for eye detection because the background or environment changes results in false eye detection. The study benefits the disabled people [5].

III. METHODOLOGY

The system uses camera to stream video and capture frames. From every frames eye movement is detected and blinks are counted by using facial landmarks. Facial landmarks are used to locate the salient regions of face, such as Eyes, Eyebrows, Nose, Mouth, Jaw line. Facial landmarks can be applied to face alignment, head pose estimation, face swapping, and blink detection.

A. Facial landmarks

Facial landmarks are detected by using dlib, OpenCV, and Python. The pre-trained facial landmark detector present in the dlib library is used to estimate the location of 68 (x, y)-coordinates that represents the facial structure as shown in Fig. 3.1.

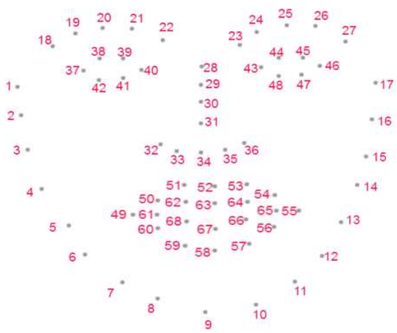

Fig. 3.1 Facial landmarks

The facial regions can be accessed via simple Python indexing

- The mouth can be accessed through points [48, 68].
- The right eyebrow through points [17, 22].
- The left eyebrow through points [22, 27].
- The right eye using [36, 42].
- The left eye with [42, 48].
- The nose using [27, 35].
- And the jaw via [0, 17].

B. Eye Aspect Ratio (EAR)

By using facial landmarks and indexes of particular face parts we can extract specific facial structures. In blink detection, only two sets of facial structures, the eyes are considered**.** Each eye is represented by 6 *(x, y)*-coordinates as shown in Fig. 3.2.

Fig. 3.2 Eye representation by 6(x,y)-coordinates

By using this image the relation between the width and the height of the coordinates are compared and an Eye Aspect Ratio (EAR) is calculated by using the equation.

$$EAR = \frac{||p1 - p5|| + ||p2 - p4||}{2||p0 - p3||}$$

Where p1, p2, p3, p4, p5, p6 are 2D facial landmark locations. The numerator of the EAR equation computes the distance between the vertical eye landmarks and the denominator computes the distance between horizontal eye landmarks.

The EAR is approximately constant while the eye is open, but will rapidly fall to zero when a blink is taking place. Using this simple equation, we can avoid image processing techniques and simply use the ratio of eye landmark distances to determines if a person is blinking.

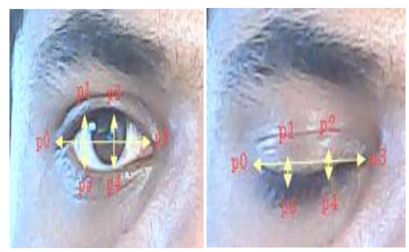

Fig. 3.3 Eye landmarks when eye is open (left) and close (right).

When the eye is fully open (left part of Fig. 3.3) the EAR would be larger and relatively constant over time. However, once the person blinks (right part of Fig. 3.3) the EAR decreases dramatically, approaching zero.

C. Detecting blinks with facial landmarks

After detecting the eye, the *(x, y)*-coordinates of the facial landmarks of the eye is recorded. The distance between two sets of vertical eye landmarks the distance between horizontal eye landmarks is computed and by combining both numerator and denominator final EAR is calculated. EAR is set to some predefined threshold value. If the eye aspect ratio falls below the threshold value and then rises above the threshold, then it is taken as one blink.

IV. EXPERIMENTAL ANALYSIS

The proposed system designed using a Raspberry Pi 3B and Zebronics Camera. The system streams the video from camera and captures the frames. At every frame image is processed and by using the facial land markings of shape predictor library. The shape predictor uses HOG (Histogram Oriented Graphics) and determines the edges of face using 68 points as mentioned earlier. The facial landmarks detection locate the important regions of the face including the eye, nose, ears and mouth, Out of those 68 points (landmarks), 6 points are use to mark each eye. The left and Right eyes are extracted and are outlined in green line as shown in the fig 4.1.

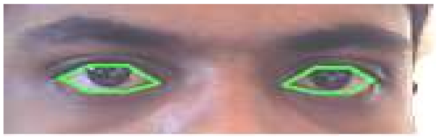

Fig. 4.1 Outline of the eye

The performance parameters that are necessary are:

- The distance between patient's eye and camera lens has to be maintained at distance of 10-13 inches.
- The light condition has to be maintained. During night the background has to be lightened.
- Only the patient or user in use should face the camera.

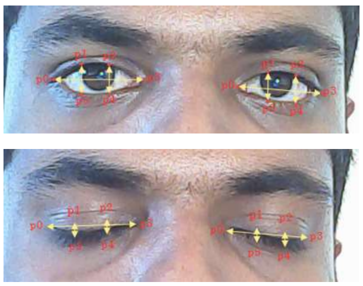

Fig. 4.2 Eye landmarks when eye is open (top) and close (bottom).

With respect to the fig. on the *top* we have the eyes that are fully open with the eye land marks marked with red dots. Then at the bottom we have eyes that are closed. The fig shows the plots of the EAR over time.

Table.1 shows the variation of EAR during an eye blink.

TABLE I: Variation of EAR during eye blink.

Time (msec)	Aspect Ratio
20	0.33
40	0.34
60	0.33
80	0.36
100	0.35
120	0.09
130	0.35
140	0.32
160	0.33

As we can see, the EAR is almost in the range 0.32 -0.36 when the eye is opened. The experimental value taken is equal to 0.33. The value rapidly drops to a value in the range 0.09-0.13, and then raises again, indicating that a blink has taken place.

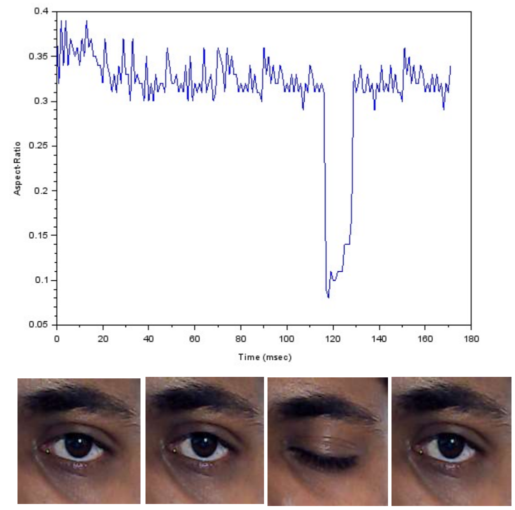

Fig. 4.3 Plot of EAR vs. time

The designed system senses the eye waver i.e. eye blink using the above mentioned values. The threshold value of the aspect ratio varies as per the patient's gaze and how wide they can open there eyes. There are two cases of consideration:

1) When the patient is completely awake
2) When the patient is sleepy.

Case1: When the patient is completely awake mode:

There are multiple muscles in the eye which control the eye blinking. The main muscle is in the upper eye lid, which controls the blinking of the eye. When the patient is completely awake, these muscles will be contracted so the eye is wider. During this case the EAR will be in the range 0.32-0.36. Usually this is considered as the normal case of operation. The completely awaken eye is as shown in the fig 4.4.

Fig 4.4: Completely awaken eye

Case2: When the patient is sleepy mode:

The upper eye lid relaxes during the sleepy condition. This makes this eye lid slide down a bit. The eye width will get reduced. This in turn reduces the EAR. During this case the EAR will be in the range 0.25-0.29. The sleepy eye and its EAR is as shown in the fig. 4.5.

Fig. 4.5. Sleepy eye

V. RESULT ANALYSIS

The program coded for detecting the eye wavers are compiled using OpenCV platform that supports python code, and OpenCV library. The code imports the image processing libraries like numpy, scipy, dilb, and shape predictor.

The eyes so extracted are used to count the number of blinks made by patient. This is fed as the input to the computing block of statements in the python code. The code converts the blinks into predefined voice commands. Few of the combinations of eye blink (input) and its corresponding output (voice) is as given in the table 2.

Table 2: Combinations of eye wavers and its corresponding voice outputs

Number of Blinks	Output Voice
1	Water
2	Washroom
3	Light
4	Fan
5	Emergency

VI. CONCLUSION

Eye blink detection is a very challenging problem for communication in a real time application. This is due to the movement of the eyes and the variation of light. The proposed method provides a better improvement for eye detection and blinking. Artificial light is used to improve the accuracy of detection as well as the blinking for a distance equal to 13 inches. Using the hardware each frame takes an average of 60-70 ms for execution which is very efficient for real time application.

The future work will be improving the proposed system to track the eye gaze and convert it into voice command and adapting the application for a real time application.

REFERENCES

[1]. Aree A. Mohammed, Shereen A. Anwer, "Efficient Eye Blink Detection Method For disabled helping domain", International Journal of Advanced computer Science and Applications (IJACSA), Vol. 5, No. 5, 2014.

[2]. Shinya Esaki, Yoshinobu Ebisawa, Akira Sugioka, Manubu Konishi, "Quick Menu Selection Eye Blink For Eye-Slaved Nonverbal Communicator with Video-Based Eye-Gaze Detection", 19th International conference –IEEE/EMBS Oct.30-Nov. 2, 1997 Chicago, IL.USA.

[3]. Chinnawat Devahasdin Na Ayudhya, Thitiwan Srinark, "A Method for Real-Time Eye Blink Detection and its Application".

[4]. Keval Lakhani , Anusha Chaudhari, Kena Kothari , Harish Narula, "Image Capturing using Blink Detection", Keval Lakhani et al, / (IJCSIT) International Journal of Computer Science and Information Technology, Vol. 6 (6), 2015, 4965-4968.

[5]. Muhammad Awais, Nasreen Badruddin, Micheal Drieberg, "Automated Eye Blink Detection and Tracking Using Template Matching", 2013 IEEE Students Conference on Research and Development(SCOReD),16_17 December 2013, Putrajaya, Malaysia.

[6]. Topal, C., Gerek, Ö. N. and Doğan, A., "A head-mounted sensor-based eye tracking device: eye touch system", *Proc. of the 2008 Symp. On Eye tracking research and applications*, 2008, pp. 87-90.

[7]. Viola, P. and Jones, M., "Rapid Object Detection Using Boosted Cascade of Simple Features," *Proc. of the Conf. on Computer Vision and Pattern Recognition (CVPR),* Hawaii, USA, December 9-14, 2001, Vol. 1, pp. 511-518.

[8]. Bradski, G. R., "Computer Video Face Tracking for Use in a Perceptual User Interface," *Intel Technology* J., Q. 2, 1998.

[9]. Adolf, F., "How-to build a cascade boosted classifiers based on Haar-like Features," *OpenCV's Rapid Object Detection,* 2003.

[10]. Hewitt, R., "Seeing with OpenCV A Computer-Vision Library," *SERVO*, January 2007, pp. 62-66.

[11]. Hewitt, R., "Seeing with OpenCV Finding Faces in Images," *SERVO*, February 2007, pp. 48-52.

[12]. Hewitt, R., "Seeing with OpenCV Follow That Face," *SERVO*, March 2007, pp. 36-40.

[13]. Masaki Nakanishi, Yasue Mitsukura, Yijun Wang, Yu-Te Wang "Online Voluntary Eye Blink Detection using Electrooculogram, 2012 International Symposium on Nonlinear Theory and its Applications.

[14]. Alice Frigerio, Tessa A Hadlock, Elizebeth H Murray and James T Heaton "Infrared Based Blink Detection glasses for facial pacing towars a bionic blink"

[15]. Michael Chau and Margrit Betke, "Real Time Eye Tracking and Blink Detection with USB Cameras" 2005. Boston University, USA . May 12, 2005.

[16]. S Saravanakumar, and N Selvaraju, "eye Tracking and Blink Detection for Human Computer Interface", International Journal of Computer Applications, VOL. 2, No. 2, May 2010, pp 7-9.

[17]. K Lin, J Huang J Chen, and C Zhou, "Real Time Eye Detection in Vedio Stream", Fourth International Conference on Natural Comutational, 2008,pp 193-197.

[18]. Akhi Gupta, Akash Rathi, Dr.Y.Radhika "hands free pc control of mouse cursor using eye movement" International Journal of Scientific and Research Publications, Volume 2, Issue 4,April 2012.

[19]. Pu Han Jian-Ming Liao, "Face detection based on adaboost" Apperceiving Computing and Intelligence Analysis, 2009. ICACIA 2009. International Conference on, 23-25 Oct. 2009,pp. 337-340.