

Assistive Technology for People with Complete Paralysis

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Abstract - Communication is a basic human right, and is essential for learning and interacting with friends, family and peers. People with complete paralysis should be supported in every way possible to communicate. Also studies have proved that the misfortune of the paralyzed rests in the lack of means to identify their needs. We therefore propose a system where the communication with the paralyzed can be brought into reality, with the aid of eye patterns. A device to track the motion of the eye will be preset to many levels with the consent of the patient for the corresponding requirements. For instance the need for water shall be indicated by the blinking of the eye. Hence, from this project we hope to introduce a successful system that can assist the paralyzed. It does so by tracking the person's eye and identifying the blink patterns, and employs this pattern to control various appliances and play audio messages.

Key Words: Communication, blink patterns, complete paralysis

1. INTRODUCTION

Assistive Technology (AT) is essential to lead a quite self supportive & independent life for people with severe disabilities. Disabilities resulting from various reasons such as traumatic injuries, spinal cord injuries as well as road accidents make its victim to find that daily life is quite difficult without continuous help from others. For the purpose of improving their daily life the AT's are necessary. Among the different kinds of AT's, the most important AT's are considered those that provide communication as it can improve the users lifestyle quite drastically.

Paralysis is the complete loss of muscle function for one or more muscle groups. Paralysis can cause loss of feeling or mobility in the affected areas. Paralysis can be localized, or generalized, or it may follow a specific pattern. Most paralyzes caused by nervous system damage (i.e. spinal cord injuries) are constant in nature; however, there are forms of periodic paralysis, including sleep paralysis, which are caused by other factors. Paralysis is most often caused by the damage to the nervous system, especially the spinal cord. Major causes are stroke, trauma with nerve injury, poliomyelitis, amyotrophic lateral sclerosis (ALS), botulism, spina bifida, multiple sclerosis, and Guillain-Barré syndrome. According to a survey by the Christopher and Dana Reeve foundation, nearly 1 in every 50 people are paralyzed.

Fully paralyzed patients require 24 hour support. But in the present day and age, it is not possible for anyone to be available at all times. So in those situations where the patient is alone in a room, he/she could use this application to call for help if required or switch on/off a light, a fan or any other appliance. Hence, our application will help the patient to be self-sufficient to a certain extent.

There are innumerable applications which can be derived from eye blink detection and these are not limited for usage by only paralyzed people. An efficient, real time blink detection algorithm can be used for almost any purpose. It can be used for switching on/off appliances such as a television or a microwave oven. It can also be used to send an email or call someone on Skype. All this can be accomplished with just a few eye blinks.

Innumerable techniques have been devised for face tracking in recent times. CamShift face tracking algorithm, Haar face tracking algorithm and face tracking using Eigenfaces are some of these. There are some techniques devised for blink detection as well. Some of them are software-oriented i.e. using image processing, and a few are hardware-oriented using sensors. Some of the image processing techniques currently used include blink detection using Gabor filters, contour extraction, and eye blink detection using Median blur filtering. The hardware-based approaches are primarily using infrared and magnetic sensor. The advantage of using sensors is that the entire system would be more compact. However, risks involving the safety of the eye are too high and outweigh the advantages of a sensor system. If the frequency of the infrared light emitted by the sensor is outside the visible spectrum, it could cause permanent damage to the eyes.

The primary purpose of this paper is to propose a system that can assist the paralyzed. It does so by tracking the person's eye and counting the blinks, and employs this count to control various appliances and play pre-recorded audio messages.

Although a number of techniques have been implemented for eye blink detection, there is no application that has been developed to actually put the blink detection to practical use. The principal contribution of this paper is the conceptualisation of system which will go a long way in helping the paralyzed and disabled to achieve some level of independence. Moreover, the algorithm provided by has been improved upon, by incorporating face tracking, so as to reduce the effect caused by movements in the background.

2. DESIGN & CONSTRUCTION

The system consist of a high quality camera mounted on a screen, a processor and speakers. Camera records video continuously which is processed frame by frame to detect eye blink patterns. These patterns are used as input for the system. The system analysis these blink pattern and required functionality is obtained. Individual eye blinks (Left and Right eye) are detected and are encoded to binary bit patterns. Involuntary eye blinks are avoided by taking into account the time taken for blinking.

1.1 Detecting Eye Blinks

The System uses dlib facial landmarks to detect eye blinks. The pre-trained facial landmark detector inside the dlib library is used to estimate the location of 68 (x, y) coordinates that map to facial structures on the face. The indexes of the 68 coordinates is given in the figure below:

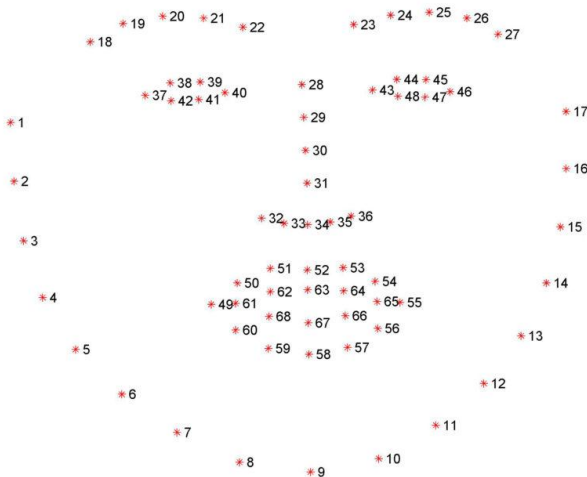


Fig -1: Coordinates that map to facial structures on the face

In order to detect the eye blinks, we'll be using a metric called the eye aspect ratio (EAR), introduced by Soukupová and Čech in their 2016 paper, Real-Time Eye Blink Detection Using Facial Landmarks. The traditional image processing methods for computing blinks typically use some combination of Eye localization and thresholding to find the whites of the eyes, determining if the "white" region of the eyes disappears for a period of time.

The eye aspect ratio instead uses a better solution that involves a very simple calculation based on the ratio of distances between facial landmarks of the eyes. This method for eye blink detection is fast, accurate, and easy to implement.

$$EAR = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|}$$

where p_1, \dots, p_6 are the 2D landmark locations, depicted in the figure 2. These 6 (x, y) coordinates around the eye. The points p_1, \dots, p_6 corresponds to the points 37 to 41 in figure 1. The equation was introduced by Soukupová and Čech in their 2016 paper, Real-Time Eye Blink Detection Using Facial Landmarks. The EAR value would be constant while the eyes are open and rapidly falls when eyes are closed. The equation is actually, a ratio of distance between vertical landmark points to that of horizontal landmark points. The denominator is weighted since there is only one set of horizontal points but two sets of vertical points.

EAR values for both eyes are calculated. Left Eye EAR is used to detect left eye blink and Right Eye EAR is used to detect right eye blink. The average of both EAR values is used to detect blinking of both eyes.

1.2 Ignoring Involuntary Eye blinks

Another challenge for the system is to filter out involuntarily eye blinks. The average human's eye blinks at a speed of 300 to 400 milliseconds or 3/10th s or 4/10th s of a second. But a voluntarily blink can last long. In our system any blink which last more than a threshold time is considered as a voluntarily blink.

2. METHODOLOGY

The flow chart of the total procedure is shown below.

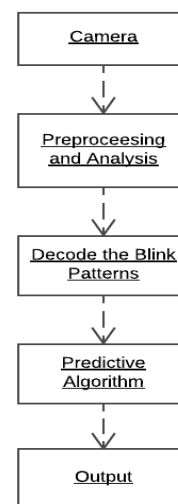


Fig -2: System Blocks

The system records Eye blink patterns from the user and encodes them to binary bit patterns. A left eye blink is mapped to 1 and right eye blink is mapped to 0. The system highlights different user selectable options and chooses the options based on user's eye blink.

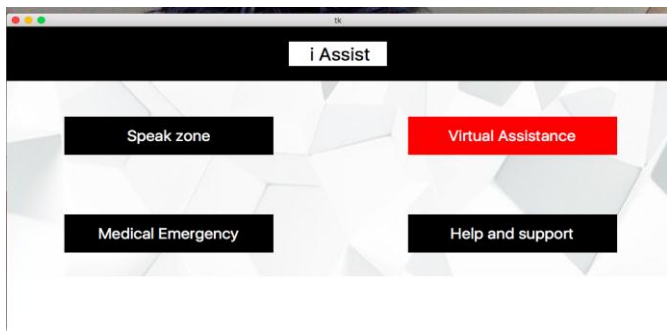


Fig -3: Application Screenshot

The above figure is a screenshot from the application. Here a right eye blink followed by left eye blink would choose virtual assistance. Similarly if the patient blinks his left eye blink twice then a medical emergency is initiated. Navigation through the entire system is done through different eye blink patterns which the user would be thought at training period. He himself can enter into training session later on using these navigation patterns.

The system is built using python, openCV and dlib. Tkinter is used to provide a pleasing GUI for the user.

2.1. Speech from blinks

In order to produce speech we use two methods. First method records the left eye/Right Eye blinks and encode them to binary bit patterns and produce speech from pre-recorded voice samples. This approach can be used by the paralyzed to speak common phrases.



Fig -4: Common Phrases Screen

The second method provides the user with an onscreen keyboard. This is a specially designed keyboard which takes eye blinks as input. Three different keys in the keyboard would be highlighted by three colours at a time. An eye blink from the user would produce another popup to choose from these three keys. Once the required text is produced it is converted to speech by a Text-To-Speech Engine and voice is produced. By using the onscreen keyboard the paralyzed can communicate much like the abled persons. The onscreen keyboard has special keys for home automation.

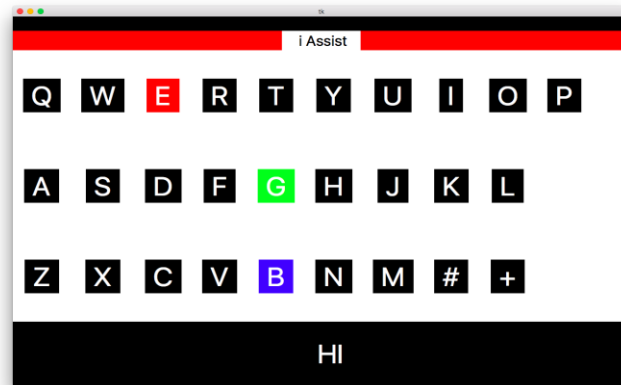


Fig -5: Onscreen keyboard highlighting 3 keys

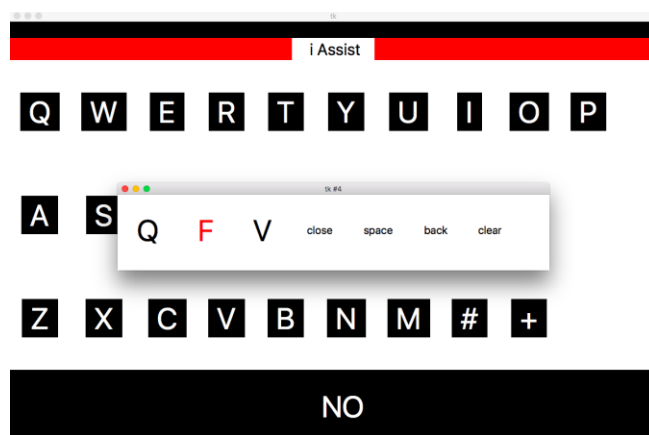


Fig -6: Popup to choose from three keys

4. RESULT AND DISCUSSION

The completed system was tested with a paralyzed human subject. In the test the subject was able to control home appliances, produce pre-recorded as well as arbitrary audio messages. He was able to produce speech of his own thought with a speed of 1 word per 40 seconds.

5. CONCLUSION

The system is quite new system and a helping hand for numerous people with motor neuron paralysis. The system not only enhance communication with disabled but also make them self reliant and lead a life similar to that of aided people. The system could be altered for individual for their personal needs.

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