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Communication for Motor Neuron Disease Patients Via Eye Blink to Voice Recognition

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Abstract— Inthispaper, we present a real time method based on some video and image processing algorithms for eye blink detection. The motivation of this researchis theneed of disabling whocannotcommunicatewithhuman. A HaarCascadeClassifieris appliedforface andeyedetectionforgettingeyeandfacialaxis information. In addition, thesame classifier is used based on Haar-likefeaturesto find out the relationship between the eyes and the facial axis for positioning the eyes. An efficienteyetrackingmethodis proposedwhichusesthepositionofdetected face. Finally, an eye blinking detection based on eyelids state (closeoropen) isused forcontrollingandroidmobilephones.The methodisusedwith andwithoutsmoothingfilter toshowthe improvement ofdetectionaccuracy. Theapplication isusedin realtime forstudyingthe effectoflightand distance between the eyes andthe mobile device in order toevaluate theaccuracy detectionandoverallaccuracyofthesystem. Testresults show that our proposed method provides a 98% over all accuracyand 100% detection accuracy for a distance of 35 cmand an artificial light.

Keywords—Face recognition ; Haar cascade classifier ;open cv

I. Introduction

Facial paralysis is a disease making people losing facial movements, which is caused by nerve damages. People suffering from facial paralysis usually have muscles on one side of the face noticeably droop, which seriously impacts the person’s quality of life. What is worse, facial paralysis can incur eye damage even blindness, because the eyelid on the affected side can not fully close, which makes the eye dry and infected by debris. The most common form of facial paralysis is known as Bell’s palsy, which impacts 40,000 people in U.S. each year, where the typical symptom is the muscle dysfunction on one side of the face.

Human–Computer Interface (HCI) can be described as the point of communication between the human user and a computer. Commonly used input devices include the following: keyboard, computer mouse, trackball, touchpad and a touch-screen. All these devices require manual control and cannot be used by persons impaired in movement capacity. Therefore, there is a need for developing alternative methods of communication between human and computer that would be suitable for the persons with motor impairments and would give them the opportunity to become a part of the Information Society. In recent years, the development of alternative human–computer interfaces is attracting attention of researchers all over the world. Alternative means of interacting for persons who cannot speak or use their limbs (cases of hemiparesis, ALS, quadriplegia) are their only way of communication with the world and to obtain access to education or entertainment. A user friendly human–computer interface for severely movement impaired persons should fulfill several conditions: first of all, it should be non-contact and avoid specialized equipment, it should feature real-time performance, and it should run on a consumer-grade computer. In this paper, a vision-based system for detection of voluntary eye-blinks is presented, together with its implementation as a Human–Computer Interface for people with disabilities. The system, capable of processing a sequence of face images of small resolution (320 9 240 pixels) with the speed of approximately 30 fps, is built from off-theshelf components: a consumer-grade PC or a laptop and a medium quality webcam. The proposed algorithm allows for eye-blink detection, estimation of the eye-blink duration and interpretation of a sequence of blinks in real time to control a non-intrusive human–computer interface. The detected eye-blinks are classified as short blinks (shorter than 200 ms) or long blinks (longer than 200 ms). Separate short eye-blinks are assumed to be spontaneous and are not included in the designed eye-blink code.

To build our blink detector, we’ll be computing a metric called the eye aspect ratio (EAR). Unlike traditional image processing methods for computing blinks which typically involve some combination of Eye localization, Thresholding to find the whites of the eyes , Determining if the “white” region of the eyes disappears for a period of time (indicating a blink).This method for eye blink detection is fast, efficient, and easy to implement.

Section I contains the introduction of this paper, Section II contains the related work, Section III contains methodology, Section IV contains eye blink detection system, Section V contains system design and implementation.

II. Related Work

For severely paralyzed persons who retain control of the extraocular muscles, two main groups of human–computer interfaces are most suitable: brain–computer interfaces (BCI) and systems controlled by gaze [1] or eye-blinks.

A brain–computer interface is a system that allows controlling computer applications by measuring and interpreting electrical brain activity. No muscle movements are required. Such interfaces enable to operate virtual keyboards [2], manage environmental control systems, use text editors, web browsers or make physical movements [3]. Brain–computer interfaces hold great promise for people with severe physical impairments; however, their main drawbacks are intrusiveness and need for special EEG recording hardware.

Gaze controlled and eye-blink-controlled user interfaces belong to the second group of systems suitable for the people who cannot speak or use their hands to communicate. Most of the existing methods for gaze communication are intrusive or use specialized hardware, such as infrared (IR) illumination devices [4] or electrooculographs (EOG) [5]. Such systems use two kinds of input signals: scanpath (line of gaze determined by fixations of the eyes) or eyeblinks. The eye-blink-controlled systems distinguish between voluntary and involuntary blinks and interpret single voluntary blinks or their sequences. Specific mouth moves can also be included as an additional modality. Particular eye-blink patterns have the specific keyboard or mouse commands assigned, e.g., a single long blink is associated with the TAB action, while a double short blink is a mouse click [29]. Such strategies can be used as controls for simple games or for operating programs for spelling words.

The vision-based eye-blink detection methods can be classified into two groups, active and passive. Active eyeblink detection techniques require special illumination to take advantage of the retro-reflective property of the eye. The light falling on the eye is reflected from the retina. The reflected beam is very narrow, since it comes through the pupil and it points directly toward the source of the light. When the light source is located on the focal axis of the camera or very close to it, the reflected beam is visible on the recorded image as the bright pupil effect (Fig. 1). The bright pupil phenomenon can be observed in the flash photography as the red eye effect.

An example of the gaze-communication device taking advantage of IR illumination is Visionboard system [4]. The infrared diodes located in the corners of the monitor allow for the detection and tracking of the user's eyes employing the bright pupil effect. The system replaces the mouse and the keyboard of a standard computer and provides access to many applications, such as writing messages, drawing, remote control, Internet browsers or electronic mail.However, the majority of the users were not fully satisfied with this solution and suggested improvements. A more efficient system was described in [9].

III.Methodology

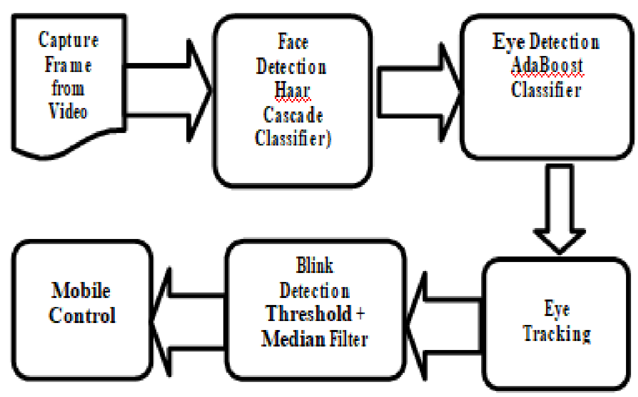

Fig7:Eye blink to control mobile (EBCM) phones general block

A. FrameCapturing

Thefirst stepoftheproposedEBCMapplication isthe initialization.Aftertaking ashort videooftheparticipant'sface using the front camera of the Samsung mobile. A process Framemethodwillbeused to createtheframesfrom the captured video. Afterwards the coloredframes will be converted to grayscale frames by extracting only the luminancecomponentasshowninfigure .

B. FaceDetection

TheHaarclassifier isusedinEBCMalgorithmforface detection.Haarclassifierrapidly detectsanyobject,basedon detectedfeaturenotpixels,likefacialfeature.However,the areaoftheimagebeinganalyzedforafacialfeatureneedstobe regionalized to thelocation with thehighest probability of containing the feature. By regionalizing the detection area, falsepositivesareeliminated.Astheresult,thefaceisdetected andmarked with color rectangle and will be used later to approximateanaxisoftheeyesforeyedetectionstep.

C. EyeDetection

Todetecttheeye,first,theHaarcascadeclassifiershould betrained,inordertotrainthe classifiers,the AdaBoostalgorithmandHaarfeature algorithms mustbeimplemented, twosetofimagesare needed.Onesetcontainsanimageor scenethat doesnot contain theobject.

The EBCMusedalldetectedelementsfromtheHaar CascadeClassifier, andtheresultshowthedetectedeyein colorrectangle.

D. EyeTracking

Thecorneal-reflectionandpupil-centerare thetwoeye’s partsthatarethemostimportantpartstoextractthefeatures thatwillbeusedinEBCMmethod.Thesefeatureshelpus in trackingtheeyesmovement.By identifyingthecenterof the pupilandthelocationof thecornealreflection,thevector betweenthemis measured.Besides,withfurthertrigonometric calculations,point-of-regardcanbefound.The EBCMmethod succeeded in making the face and the eye's pupil moved togetherinthesamedirectionsynchronouslyandwiththesame direction.LetsupposethatXisthehumanfacewhichhasbeen detected,P1andP2are twopoints relatedtothelefteye,and they aremovingsynchronously withthemovementofX.

E. Eye Blinking

Eyeblinkingand movementcanbedetectedwithrelatively highreliabilitybyunobtrusivetechniques.Though,thereare few techniquesdiscoveredforthe activescenewhere the face andthecameradevicemoveindependently andtheeyemoves freelyineverydirectionindependentlyoftheface. Although caremustbetaken,thateye-gazetrackingdataisused ina sensibleway,sincethe natureofhumaneyemovementsis a combinationofseveralvoluntary andinvoluntarycognitive processes.

IV. EYE BLINK DETECTION SYSTEM

Vision-based eye-blink monitoring systems have many possible applications, like fatigue monitoring, human–computer interfacing and lie detection. No matter what the purpose of the system is, the developed algorithm must be reliable, stable and work in real time in varying lighting conditions. The proposed vision-based system for voluntary eyeblink detection is built from off-the-shelf components: a consumer-grade PC or a laptop and a medium quality webcam. Face images of small resolution (320 9 240 pixels) are processed with the speed of approximately 28 fps. The eye-blink detection algorithm consists of four major steps (Fig. 3): (1) face detection, (2) eye-region extraction, (3) eye-blink detection and (4) eye-blink classification. Face detection is implemented by means of Haar-like features and a cascade of boosted tree classifiers. Eye localization is based on certain geometrical dependencies known for human face. Eye-blink detection is performed using the template matching technique. All the steps of the algorithm are described in more details in Sects. 3.1–3.4. The algorithm allows eye-blink detection, estimation of eye-blink duration and, on this basis, classification of the eye-blinks as spontaneous or voluntary.

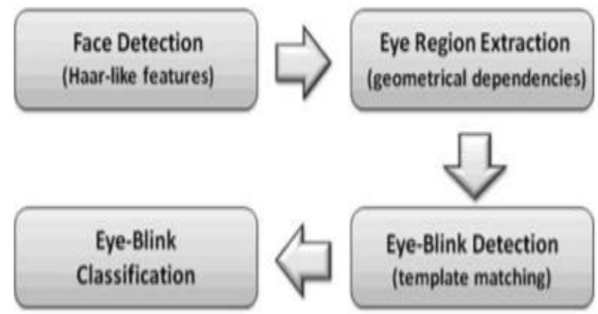

Fig. 3 Scheme of the proposed algorithm for eye-blink detection

A. Face detection

Face detection is a very important part of the developed eye-blink detection algorithm. Due to the fact that face localization are computationally expensive and therefore time consuming, this procedure is run only during the initialization of the system and in cases when the tracked face is ‘‘lost’’. Thus, for the system working in real time, the chosen method should work possibly fast (less than 30ms per single image for speed of 30 fps). On the other hand, the accuracy of the selected approach is also important. The trade-off must be found between the high detection rate, misdetection and error rate. The chosen method should perform robustly in varying lighting conditions, for different facial expression, head pose, partial occlusion of the face, presence of glasses, facial hair and various hair styles. Numerous solutions have been proposed for face detection. They can be divided into: (1) knowledge-based methods employing simple rules to describe the properties of the face symmetry and the geometrical relationships between face features [28], (2) feature-based methods based on the detection of mouth, eyes, nose or skin color [20, 21], (3) template matching methods based on computing the correlation between the input image and stored patterns of the face [22] and (4) modelbased methods, where algorithms are trained on models using neural networks [23], Support Vector Machines (SVM) [24] or Hidden Markov Models (HMM) [25]. In the developed algorithm, the method derived from the template matching group developed by Viola and Jones [6], modified by Leinchart and Maydt [26] and implemented according to [15] was used.

The method was tested on a set of 150 face images, and accuracy of 94% was achieved. The speed of the algorithm was tested on face images of different resolution using Intel Core2 Quad CPU at 2.4 GHz processor. The results are presented in Table 1.

Table 1 Face detection times using cascade of classifiers and Haar-like templates

Image size	Single face (ms)	4 faces (ms)
3,264 × 2448	11,860	11,937
2,448 × 1,836	6,531	6,547
1,632 × 1,224	2,953	3,000
1,280 × 960	1,828	1,875
640 × 480	484	516
320 × 240	156	157

B. Eye-region extraction

The next step of the algorithm is eye-region localization in an image. The position of the eyes in the face image is found on the basis of certain geometrical dependencies known for the human face. The traditional rules of proportion show the face divided into six equal squares, two by three [7]. According to these rules, the eyes are located about 0.4 of the way from the top of the head to the eyes (Fig. 4). The image of the extracted eye region is further preprocessed for performing eye-blink detection. The located eye region is extracted from the face image and used as a template for further eye tracking by means of template matching. The extraction of the eye region is performed only at the initialization of the system and in cases when the face detection procedure is repeated.

Fig 4 : Rules of Human Face proportion

C. Eye-blink detection

The detected eyes are tracked using a normalized crosscorrelation method (1). The template image of the user's eyes is automatically acquired during the initialization of the system.

$$R(x',y') = \frac{\sum_{x',y'}[T'(x',y')I(x+x',y+y')]}{\sqrt{\sum_{x',y'}T(x',y')^2\sum_{x',y'}I(x+x',y+y')^2}} \quad (1)$$

where R correlation coefficient, T template image, I original image, x, y pixel coordinates. The correlation coefficient is a measure of the resemblance of the current eye image to the saved template of the opened eye (Fig. 5). Therefore, it can be regarded as the measure of the openness of the eye.

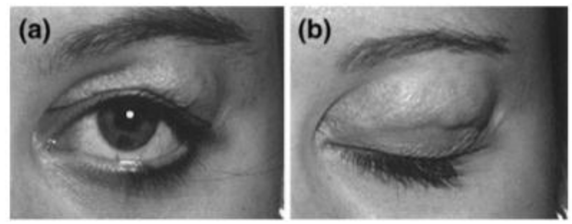

Fig 5: Example eye images used as templates

An example plot of the change of the correlation coefficient value in time is presented in Fig. 6.

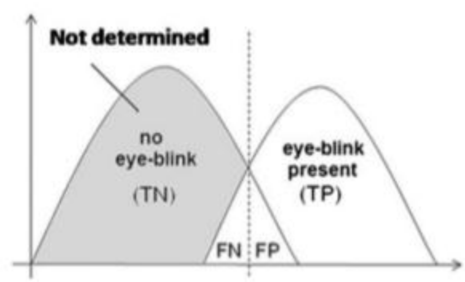

Fig 6: Possible distributions of the eye-blink detector output

It uses two webcams—one for pupil tracking and second for estimating head position relative to the screen. Infrared markers placed on the monitor enable accurate gaze tracking. The developed system can replace the computer mouse or keyboard for persons with motor impairments.

V. SYSTEM DESIGN AND IMPLEMENTATION

In term of blink detection, we are only interested in two sets of facial structures – the eyes. Each eye is represented by 6(x,y)-coordinates,starting at the left-corner of the eye (as if you were looking at theperson), and then working clockwise around the remainder of the region:

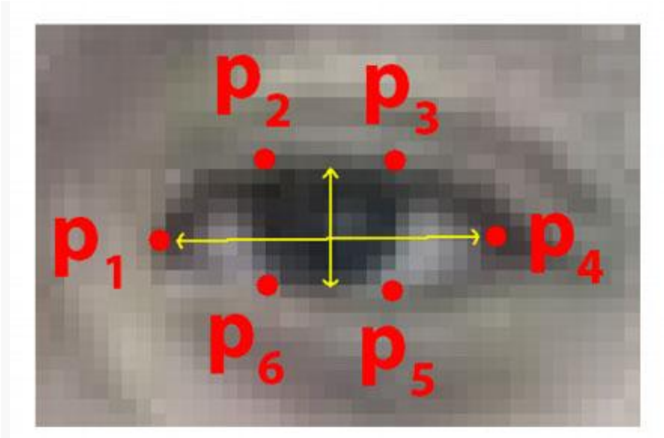

Figure 8: The 6 facial landmarks associated with the eye.

Based on this image, we should take away on key point:

There is a relation between the *width* and the *height* of these coordinates.Based on the work by Soukupová and Čech in their 2016 paper, *Real-Time Eye Blink Detection using Facial Landmarks*, we can then derive an equation that reflects this relation called the *eye aspect ratio* (EAR):

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

Where *p1, ..., p6* are 2D facial landmark locations.
The numerator of this equation computes the distance between the vertical eye landmarks while the denominator computes the distance between horizontal eye landmarks, weighting the denominator appropriately since there is only *one* set of horizontal points but *two* sets of vertical points.

Implementation steps are as shown in the fig 9 and are as follows

Firstly, patient's face is captured using camera.A medium quality web cam is usedfor the capturing of face. A computer vision application that is capable of detecting and counting blinks is implemented. Then, the face is recognized and eye part of the patient's face is extracted.

Using EAR(Eye Aspect Ratio) equation, ratio of the eye is calculated.After this, blinks are detected in sequence and these sequences are converted into a voice output.

VI. RESULTS AND DISCUSSION

The proposed project aims to bring out a solution for the paralyzed people without any harm to their body externally or internally. It overweighs the previously developed prototypes in this field because none of the components are in direct contact with the patient's body hence it definitely will prove to be safer. Use of Raspberry pi is simple and also developing tremendously in the market today. The tool had advantages over the older conventional tools.

VII. CONCLUSION AND FUTURE SCOPE

To make cost effective: The main objective of developing algorithm of a real time video Oculography system is that to provide cost effective for those people who cannot afford. The existing technique for such patients to communicate is too costly.
Thus, it is necessary to design a system which is affordable to common people which includes cost effective components for designing.

Electrode less system: To develop a system in which the patient can communicate without any application of electrodes. Because this electrodes need to be pierced to the skin of human body which is very painful. The use of electrodes is the technique available as of now which is cost effective but it is painful and makes the patient conscious every time and this technique is uncomfortable too.

Fast: There are few algorithms which are developed for video Oculography system for communication. The main objective of this project is to develop an algorithm which is extremely fast compared to the existing ones.

Accuracy: The main objective of this project is to develop an algorithm which is more accurate compared to the existing ones.

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