International Conference on Mechanical, Industrial and Energy Engineering 2014
25-26 December, 2014, Khulna, BANGLADESH

ICMIEE-PI-140214

Fatigue Estimation through Face Monitoring and Eye Blinking

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ABSTRACT

Face detection is the general case of face localization. It is a human-computer interface technology that determines the location of faces in arbitrary images. It detects face from input image from camera. From the face template eye pair is detected, where this system automatically locates the user's eye. Blinks are related to several environment states and the present report describes a simple, reliable way to measure blinks from the video stream of an eye obtained during eye tracking, where the source of the eye video is a video camera attached to a head-mounted eye tracker. Computer vision techniques are employed to determine the moments that a blink starts and ends for the purpose of calculating blinking rate. The video is first processed to show blocks of eyelid and pupil movements and is then analyzed for blink starts and ends. The moment of a blink start is reported when the eyelid starts to move quickly exceeding a predetermined threshold. The end of a blink arises when the pupil size increases by less than a separate threshold. Several different blink patterns from different stage are measured. Drowse condition is determined by the analysis of blinking rate from different situation. The system has ability to count blinking rate accurately around 94%. In this study observed that if the blinking rate is approximately 3 blink/minute then it can be considered as drowse condition.

Keywords: Fatigue, face monitoring, eye blinking rate, drowse condition.

1. Introduction

Face detection is a very important part of the developed eye-blink detection. An eye blink is defined as when the upper and lower lids are touching each other and the eye is temporarily hidden. A typical blink has amplitude of 400 μV and lasts for about 200 - 400 ms. A common definition of blink duration is the time difference between the beginning and the end of the blink, where the beginning and end points are measured at the point where half the amplitude is reached. The blinking activity is also affected by fatigue, disease and drowsiness etc. That is why blinking also has been used as one common parameter for measuring fatigue and drowsiness. The method of blinking detection can be broadly classified into following:

I. Image Analysis: Capture eye image by using camera. Several image processing steps are needed to observe the blinking.

II. Biological Approach: By using EOG [4] (Attach the surface electrode onto surrounding eye. Blinking is detected by measuring eye muscle potential in vertical and horizontal direction) or EEG [5] (Attach the surface electrode into skull surface in order to measure brain activity).

The method (II) is relative expensive and not convenience compared than method (I) since method (I) burden the user as several electrodes have to be attached onto user's skin. In this paper blinking rate detection is based on image analysis approach. Among the blinking application, the utmost important of blinking detection method is accurate against eye shape changes, varies of blinking speed and varies of users.

Firstly face is detected from captured image of camera. This process is done by the get_connected_component. Classifier 'haarcascade_frontalface_alt' is used to find out the face detection. Eye pair in a form of rectangle box is detected. Classifier 'haarcascade_mcs_eyepair_big' is used to detect eye pair. From the eye pair one eye is split. This method has 94% accuracy on eye state detection. By using simple model of head and eye, it determines the head-independent motions of the pupil and eyelids. Eye is tracked in real time. Opened eye template is used to find and track the eye position. Blinking is estimated by comparing the similarity between opened eye template and current image. When user closes the eye during blinking process, the similarity will decrease. Otherwise, the similarity will maximum when user fully open the eye. It detects blinking by tracking upper eyelid and measuring distance between its apex and center of iris. A counter is used to count accurate blink per minute. Blinking rate at different condition is measured. By this process it is easily represented the drowsy condition of eyes.

2. Methodology

The system initialize by capturing image from the web camera. User face is detected automatically from the image. This process is a real time process. There is no time dely. After detect face eye pair is detected. From the eye pair rectangle split one for single eye. Then detect pupil from the detected eye. Openness and closeness condition depends on threshold value. Blinking is estimated by comparing the similarity between opened eye template and current image. After this a general counter is used to find out blinking rate.

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3. Eye blinking rate estimation

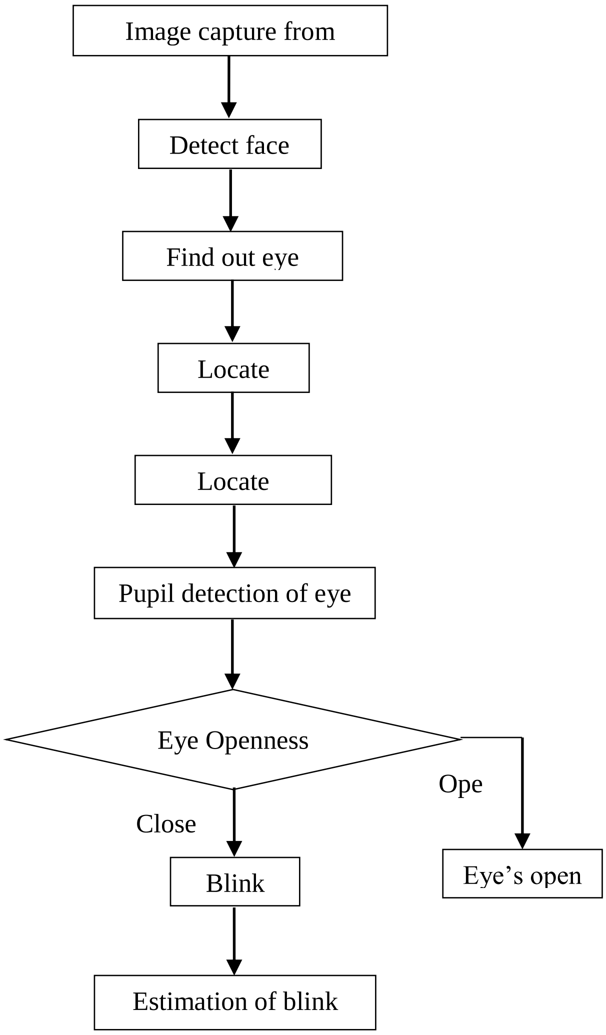

Fig. 1: Flow diagram of eye blinking rate estimation

The aim of the system is to create an eye blinking rate estimation system simple strategy, a regular web camera and the computer vision library OpenCV. OpenCV is incorporated with Microsoft Visual Studio. This system is done with some sample coding feature that helps to find out specific location of face. This system also helps to find out the eye blinking. By the system finally estimate the drowsiness condition and the eye blinking rate range.

3.1 Image Capture from Webcam

Build in camera of laptop (hp pavilion g4 22190TU) is used to capture image. 1.3MP camera has resolution 640x480.

3.2 Face Detection

The face detection is the first step in the implementation of the system. The first necessity is to load the classifiers. . The classier haarcascade frontalface alt.xml. is used for detect face. Face detection is done by get connected component. Cascade is loaded to execute the cvHaar Objects detection method. The image is grey scaled to make the Haar detection more robust. Since a grey image is more useful for the rest of the program as well, the grey image becomes the basis for the entire process. It firstly searches windows to image. Before that image need some minimal pre-processing. It analyzes the motion of face. Reset search windows for the accurate matching of the template. Then finally detect face.

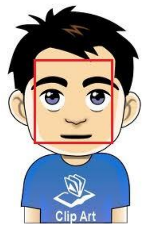

Fig. 2: Face detection

3.3 Eye Detection

Classifier 'haarcascade_mcs_eyepair_big' is used to detect eye pair. From the eye pair one eye is split. By using simple model of head and eye, it determines eyes in face.

The eye detection is done in a similar method to that of face detection in that it uses the same method but a different classifier. The classifiers used for the left and right eye detection are haarcascade_lefteye_splits.xml and haarcascade_righteye_splits.xml respectively. The eye detection is done separately for each eye Haar classifier.

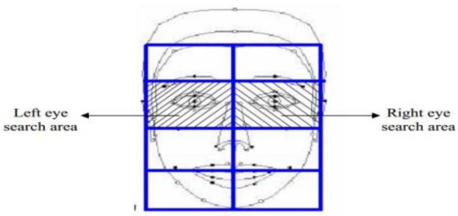

Fig. 3: Eyes detection from face

3.4 Blink Detection

Centroid is located from detected eye. Centroid is determined by simple geometric method. Width and height divided by two and common point of these is the Centroid of rectangle box. Where x and y represents two axis.

(*eye).x+ (*eye).width/2,…………………………...….(i)

(*eye).y + (*eye).height..……..…………………...….(ii)

The pupil detection is very complex process. It is very tough to find out exact circle of the eye. To find out pupil some pre-processing is done by equalizing the histogram image. And finally find out the dark area of the eye. Then this combination is done with the help of threshold value.

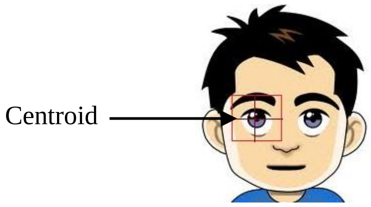

Fig. 4: Centroid detection

The moment of a blink start is reported when the eyelid starts to move quickly exceeding a predetermined threshold. The end of a blink arises when the pupil size increases by less than a separate threshold. If the pupil is found in the eye then the eye is open and if the component is not found then the eye is closed. And this close stage is defined as blinking stage.

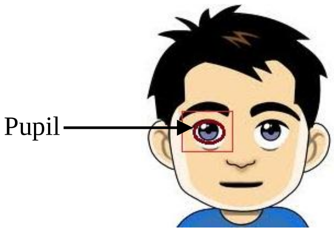

Fig. 5: Pupil detection

The moment of a blink start is reported when the eyelid starts to move quickly exceeding a predetermined threshold. The end of a blink arises when the pupil size increases by less than a separate threshold. If the pupil is found in the eye then the eye is open and if the component is not found then the eye is closed. And this close stage is defined as blinking stage.

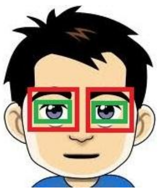

Fig. 6: Blink detection

3.5 Blink Estimation

A counter is used to count the blinking rate. This blinking rate is calculate by following formula

```
time_t end = time(NULL);
 time_t diff = end - start;
double res=counter/(double)(diff/(double)60)
```

Firstly time is zero. Time is calculated by different between initial and ending time of blink.

If x number of blink found in y second then blinking rate is expressed as

Blinking rate= $\frac{x}{y} \times 60$ blink/min…………………..….(iii)

4. Experimental Result

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Table 1 Blinking rate during conversation.

No. of persons	Blinking rate (blink/min)			Average blinking rate (blink/min)
Person 1 (age 23)	15.87	15.37	16.23	
Person 2 (age 24)	14.54	18.3	16.11	16.4
Person 3 (age 22)	17.43	14.6	19.2	

Table 2 Blinking rate during reading.

No. of persons	Blinking rate (blink/min)			Average blinking rate (blink/min)
Person 1 (age 23)	7.45	7.65	8.12	
Person 2 (age 24)	6.52	6.92	7.6	7.54
Person 3 (age 22)	8.31	7.47	7.84	

Table 3 Blinking rate during test (at noon 1.45-3 pm).

No. of persons	Blinking rate (blink/min)			Average blinking rate (blink/min)
Person 1 (age 23)	5.20	5.54	4.15	
Person 2 (age 24)	5.11	4.98	5.15	4.98
Person 3 (age 22)	4.76	4.85	5.04	

Table 4 Blinking rate during drowsiness (at midnight).

No. of persons	Blinking rate (blink/min)			Average blinking rate (blink/min)
Person 1 (age 23)	4.15	3.98	1.67	
Person 2 (age 24)	3.22	2.64	2.18	
Person 3 (age 22)	2.95	2.73	2.25	3.33
Night guard-1 (age 35)	4.1	3.92	4.6	
Night guard-1 (age 35)	3.8	2.7	3.7	

The present study measured the normal blinking rate at different conditions. Firstly blinking rate is measured at normal conversation time. From table 1 it shown that the average blinking rate is approximately 17 during conversation. Table 2 and 3 shown that the blinking rate during reading and rest period approximately 8 and 5 respectively. Table 4 shows that during drowsiness condition blinking rate is 3 approximately. From the above discussion it can be mention that when the blinking rate range approximately 3 then it's easily recognize the person is in drowse.

4.1 System accuracy and success rate

Table 5 System accuracy calculation

No. of Obs.	Actual Blink Rate (Blink/min)			Blink Rate Count by System Blink/min	Accuracy (Actual B/m– Practical B/m)/actual B/m×100%
1	17.7	15.87	90.5	1	17.7
2	16	15.37	95.2	2	16
3	7.94	7.45	94	3	7.94
4	7.13	6.92	97	4	7.13
5	5.2	5.11	98	5	5.2
6	4.6	4.15	90.4	6	4.6
7	4.27	3.98	93	7	4.27

The actual blinking rate is not exactly the same as the blink count by the system. Some environmental condition influence the system.. The system accuracy was calculated as 94%.

Blinking rate estimation is very complex process. Environment condition is the major factor to find out the blinking rate. Blinking rate also varies on different condition such as reading paper, conversation, rest period, soporific condition or drowsiness condition. The system can work perfectly with sufficient light condition, but worse condition need more time to find out face and eye blink. And also that time blinking rate is very low. In movement condition (body, head rotation) it's very hard to find exact blink rate. Though the system has some shortcoming it is done accurately as much as possible. This real time eye blinking estimation efficiency is higher than other non-real time process. Experimental results have shown that the proposed system is very sensitive to face background and head orientations. It can work only with frontal view.

5. Conclusion

OpenCV was incorporated in Microsoft Visual Studio effectively. Face and eye has been detected successfully by this real time process. Real time process help to find out the exact blinking rate that dignify the process work advancement. On the basis of eye blinking rate drowsy condition is mentioned.

This paper can be developed further by incorporating head movement cancellation, implementing a gaze tracker using a web-camera, implementing the system on a GPU, fatigue estimation though skin monitoring, implementing the system on automobile to improve its safety with attached alarming system, implementing the system on designed for use by people with severe paralyzed or afflicted with diseases such as ALS(Lou Gehrig's disease), high resolution camera can be used for better performance.

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