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Survey of Eye Blink Detection Techniques

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Abstract: *Blinking is a phenomenon that maintains eye moisture and prevents it from drying out. If blinking is not at its normal rate it results in an eye disease namely dry eye syndrome, which causes redness and irritation in eyes. People especially in IT sector are more prone to this disease since they spend most of the time looking at the monitors which reduces the blink rate. Hence this disorder is also called as computer vision syndrome. Eye blink detection can help in preventing this disorder. The paper aims at presenting the overview of various eye blink detection techniques.*

Keywords: *blink detection, eye anatomy, electrooculography, Gabor filter.*

I. INTRODUCTION

Blinking of an eye is more important to maintain the moisture in the eye. Blinking spreads the tears on the eye and it is useful to remove the unwanted things like dust particles on the eye. When eye becomes dry[1], command is sent to the eye muscle by brain in order to blink the eye. This blinking is called as the voluntary blinking. There are some factors which affect the blinking such as fatigue, drowsiness, etc. Hence blink detection can be used in vehicle safety to detect whether the driver is feeling drowsy or not. Therefore the accuracy of the blink detection is more important. Blinking is also used in the human computer interaction. It can be used for communication between the physically challenged people on the basis of various blink patterns. Due to these applications it becomes more important to detect an eye blink accurately. There are various methods for eye blink detection. The aim of this paper is to discuss various methods for eye blink detection and compare their performance on certain factors like accuracy, cost and ease of use. Before this it is necessary to have a look on the anatomy of the eye.

II. ANATOMY OF HUMAN EYE

Human eye [2] is spherical in shape. It consists of three layers. Outer layer (Sclerotic coat), Middle layer(choroid coat),innermost layer(Retina).

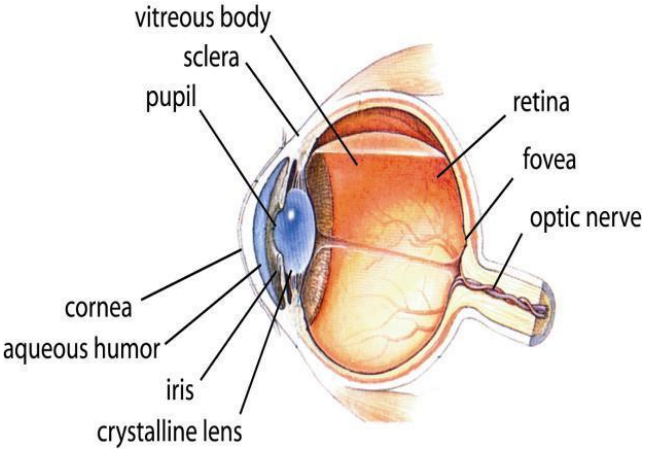

Figure 1: Anatomy of human eye [2]

2.1 Sclerotic coat

The outermost covering of the eye is called as the sclerotic coat or the sclera. It gives protection to the inner structure of the eye.
Cornea: The cornea is a part of the sclerotic coat. It is curved and convex in shape. It is the part through which the light ray enters the eye.
Aqueous humor: The space between the cornea and pupil is called as the anterior chamber and is filled with a transparent substance called aqueous humor

2.2 Choroid coat

It consists of blood vessels to supply nutrition to retina.
Iris: It is located behind the cornea and in front of the eye lens. The iris is opaque. It controls the amount of

the light that enters the eye by either constricting the pupil or expanding the pupil.

Vitreous Humor: The space between the lens and the retina is called as the oosterior chamber and is filled with a transparent substance called vitreous humor.

2.3 Retina

It is compared with the photo film of the camera. It converts the light waves into neural signals that the brain can process.

III. METHODS FOR EYE BLINK DETECTION

There are two approaches to detect an eye blink:

1. Biological Approach
2. Image processing Approach

3.1 Biological Approach

3.1.1 Scleral search coil method

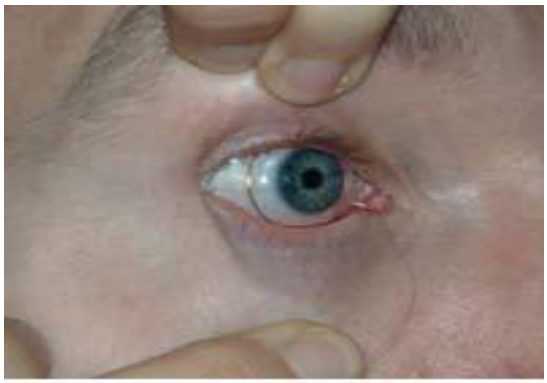

Figure 2: Search coil places in the human eye[2]

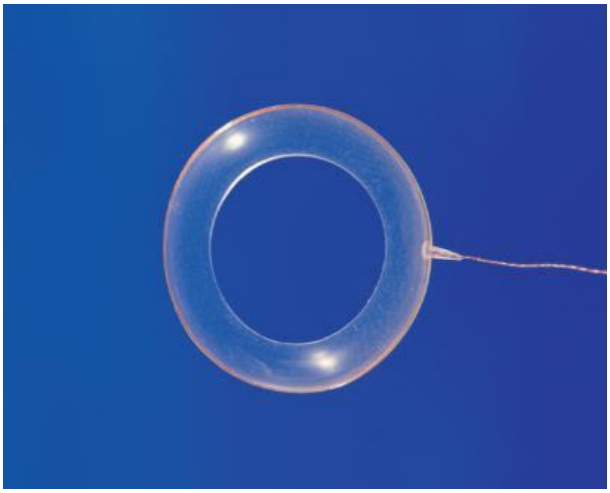

Figure 3: Search coil[2]

When a coil of a wire moves in magnetic field [2], it induces the voltage in the coil. If the coil is attached to the eye then the signal of the eye position will be produced. Small coils of wire are inserted into the contact lenses to measure the human eye movement. This is inserted into the eye at temporal canthus. This allows to record the horizontal movements of eye and for vertical movements keep the second set of field coils orthogonally to the first set.

3.1.2 Electrooculography

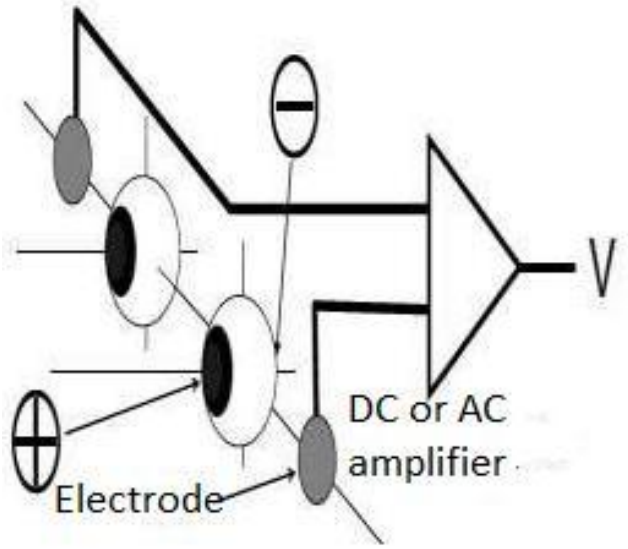

Figure 4: Principle of Electrooculography[3]

The Electro-Oculography (EOG)[3] method was introduced by Fenn and Hursh in 1934. It is a method for sensing eye movement and is based on recording the standing corneal retinal potential arising from hyperpolarizations and depo-larizations existing between the cornea and the retina; this is commonly known as an electrooculogram. A human eye-ball can be assumable as a spherical battery that the centre of cornea is positive and the retina is negative. Consequently, the micro-currents flow radially from the positive pole to the negative pole of the battery through the conductive tissue in the orbit. These currents generate the standing potentials around the eye. The standing potentials in the eye can thus be estimated by measuring the voltage induced across a sys-tem of electrodes placed around the eyes as the eye gaze changes, thus obtaining the EOG (measurement of the elec-tric signal of the ocular dipole). Sometimes, the EOG is also known as the electronystagmographic potential (ENG).

3.2 Image analysis Approach

In this approach the eye image is captured by using camera and various image processing techniques are used to observe an eye blink.

3.2.1 Lucas-kanade and Normal flow

Before detecting an eye blink, accurate face detection and eye detection is important. In this algorithm for face de-tection boosted classifier is used. For tracking the face LK algorithm is used. The disadvantage of this

algorithm is, if the face moves fast then tracking will be lagged. Lucas Kanade feature tracker does not rely on the specific facial features like eye corners, but uses a set of currently visible points with strong local contrast detected by the fast feature detector.
Eye's normal flow [4] is responsible for detection of eye blink together with all the intermediate states such as partial blinks, squints etc.
Matjaz Divjak et al. [5] carried out this experiment on 320*240 images. It takes 35 ms to process one im-age. Approximately 20 ms is spent for detection and tracking, and 15 ms is spent for normal flow calculation. Accuracy for blink detection obtained is 94%

3.2.2 Spacio temporal filtering and variance maps

Morris et al.[6] proposed a blink detection system using spa-cio temporal filtering and variance map. Spacio temporal filtering is used to locate the head and find the eye feature points. These feature points are accurately tracked in suc-ceeding frames by using modified version of LK tracking algorithm with pyramidal implementation.
Accurate head and eye tracking results are obtained at a pro-cessing rate of more than 30 frames per second in more than 90% cases with a low false positive blink rate of 0.01%, but head movements affect the variance map computation and cause a sharp drop in performance.

3.2.3 Using an open eye template

Chau and Betke [7] describe a system that detects eye blinks in real-time using correlation with an open eye template. In this method motion analysis techniques are used followed by online creation of a template of the open eye which is to be used for the subsequent tracking and template matching that is carried out at each frame.
In this if the large head movement occurs the system will be reinitialised. For a 320*240 webcam images 95% overall blink detection accuracy is obtained. The drawback of this process is that it only gives information about only two states of the eye i.e. open or close. It does not give any information about the intermediate states of the eye.

3.2.4 Gabor filter for eye blink detection

Kohei Aai et al.[8] proposed the method of eye blink de-tection using the gabor filter. In this method deformable template is used to detect an eye.This method roughly detects a position of an eye. It matches between eye template and source images. Template is created by using a gaussian smother. Although deformable template method is faster than classifier method, the robustness is still less. In this method if deformable template fails to detect an eye then vi-ola jones classifier is used to detect an eye. This classifier uses adaboost at each node of the cascade. The combination of viola jones classifier and deformable template makes it easier to detect an eye location. Even if the background conditions like illumination or gaze angle changes, these methods perform better as compared to other methods.

Gabor method is used to extract the arcs of the eye. Images of eyes taken from the video frames are calibrated first, from which eye location and eye template are obtained. These values are used to detect an eye therefore template matching is accelerating the whole process. These images are given to gabor filter as an input to extract the arc of the eye. Longest arc is the upper arc and the second longest arc is the lower arc. Arc lines can be detected by using connected labeling method.

This method is not only useful for detecting the open eye but it will also tell that percentage of open eye. In this way this method is detecting the blinking using arcs of the eye.

IV. OTHER METHODS

In addition to above mentioned methods there are other methods also which are discussed below and there performance is compared with each other.

Motion analysis using kalman filter and mean shift tracking are used for eye detection but this method will fail when eyes are closed and occluded.[9]

Eye detection using Hough transform[10] is proposed. It is used in order to find the pupil.Eye detection using Hough transform is susceptible against the noise influence.

Morphological filter is used to eliminate the undesired information in image of the eye. This method will not work when noises have the same shape and size as that of pupil.[11]

Eye detection using template matching[12] is used. In this method previously stored image is compared to the new image. But the simple template matching cannot deal with the eye expressions, variations and illumination.

For blink detection Hough transform[13] is used in order to find the iris location. Spacio-temporal filtering and variance map is used to locate the head and find the eye feature points. Lucas-Kanade and optical flow method is also used to detect an eye blink. These methods have one common problem that these are difficult to implement in real time systems due to their time consumption.

Where in the above discussed methods, Gabor filter method uses viola jones classifier and template matching to find the eye region and to detect an eye blink Gabor filter is used which gives the success rate of almost 100%.[8]

V. CONCLUSION

Among the methods discussed, Biological approach will give more accuracy as compared to image analysis approach but due to the discomfort to the subject these methods are not widely used.
As compared to the Biological methods, image analysis ap-proach is convenient to use. From the above discussed meth-ods, Gabor filter does work for the detection of arc like two dimensional feature extraction, so that blink detection using Gabor filter gives blink detection accuracy upto 100% irre-spective of the head position as compared to Lukas Kanade Normal flow algorithm which is giving accuracy upto 94% whereas optical flow method is giving accuracy upto 95%.

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