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ANOVEL APPROCH OF EYE TRACKING AND BLINK DETECTION WITH A HUMAN MACHINE

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Abstract:

Human's especially handicapped people it is difficult to operate the system. This paper deals with interface of system and a people with their eye blinking. Here we can find out the eye blinking of any person who can operate the system with a detection function. By using this detection function we can estimate the position of an eye blink. The measurement of an eye blink parameter provides required information for eye controlled systems where human machine interface is needed.

INTRODUCTION:

Communication between human beings seems to be much simpler than between a man and a computer machine. This difficulty increases when a person is disable. The eye movement can be applied as a mean to communicate with a computer. The idea of such interface is the following. The human-machine interface device (one of the important components is a pic microcontroller) records the electro ocular graphic (EOG) signal and then EOG is processed in controller [1]. And in the end, the device generates steering signals for a computer.Blinks are a means by which the eye protects and lubricates itself. There are two forms of blinks, the first being voluntary and the secondary being involuntary. The former is longer lasting; the latter is shorter in duration, usually less than 300ms. The blink is composed of three distinct phases: the down-phase, the closure and the up-phase. The down-phase is the most rapid part of the blink; the up-phase is much slower. The duration of involuntary blinks increases about 50ms with drowsiness [15]. Adults can blink anywhere from six to thirty times per minute with a mean of sixteen per minute. The duration between blinks varies depending on the users activities. Reading and computer use reduce the average number of blinks per minute, which is why users' eyes often feel fatigued after an extended amount visual focus.There have been three different methods of doing this that have been used in research. The first and possibly least practical method, though used with a high degree of accuracy is the magnetic search coil. In this approach the eyelid is tracked through a magnetic coil attached to the subject's eyelid. The subject is then placed in a weak magnetic field and the current through the coil changes as a function of the angle of the coil relative to the magnetic field. The user's eye motions create the rotation of the coil. This method despite its complexity; provided data very similar to the other techniques.

The next method commonly used was infrared cameras with image processing algorithms. These systems process a video feed from a camera in real time to identify a user's face. The software then uses a masking system to identify the user's iris and track the eyelid closure by the disappearance of the iris (Tan and Zhang) [15]. Other developers attempted the same type of interface with a color CCD camera. Their approach was designed to operate in a car and was programmed to auto adjust to light levels and predict the users eye movement, using a C++ program run on a separate stand alone computer. (Tock and Craw)

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These developers were fairly successful, but problems arose if the program predicted eye movements incorrectly.Still other researchers tried to create more portable and low cost systems. One team used an off the shelf USB camera. Their software approach detected the eyes after applying an image mask to the user's entire face. They were able to achieve a detection rate of 95% after a complex software algorithm. Another approach was to use variance mapping of the user's face, and to simply track the user's face instead of trying to focus all the way down to the eyes. This method suffered from accuracy issues, however, due to the movement of the users head, creating situations where only one eye might be visible.

The third method of detecting blinks was infrared reflectivity. These systems were utilized to measure driver drowsiness by tracking the velocity of the driver's eyelid movement [17]. One such system is Opt alert, developed by an Australian company and intended to monitor the sleepiness of truck drivers. This system uses a ratio of amplitude and velocity of blinks as tracked through infrared reflectivity to determine if a driver is falling asleep.

In another research group an array of IR emitters and phototransistors was setup to measure user blinks for a sleep disorder study. They collected data using this setup and recorded it to a hard drive for later processing. They analyzed blinks to see if the amplitude, duration of closure, opening time and closing time of the eyelid. This system seems to measure blinks with a very nice signal to noise ratio based on the graphs included in the text of the paper. It is difficult to tell how much computer processing was done to the data as the authors mention that the peaks are normalized.

(1) A proposal of designing a eye blinking mouse for reliable communication in hands free environment.
(2) To build hardware that interfaces and communicates directly with computer and to give necessary commands.
(3) By using microcontroller software keil, development of controlling between hardware modules in the project. By using mat lab software, interfacing the eye blink .

2. Design Methodology:

In our system, three to five electrodes are employed to attain the EOG signals. Figure 1.1 shows the electrode placement1 & 4 for detecting vertical movement 2 & 3 for detecting horizontal movement5 is for reference. Or only 1&2 with reference electrode can also be used.

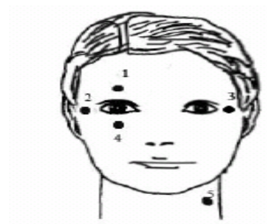

Figure 1.1 Electrode Placements

Outputs of electrodes are amplified and filtered this is our front end electronics after that using A/D convertor signal is digitized and this completes our Acquisition of Signal part. Now we combine all acquire signals from all electrodes and send them via RF interface for future Pre and post processing of signals and finally Eye movements and Eye blink events are extracted and sent as commands to drive cursor on screen which is part of application part, buttons one the cursors are clicked using eye moments and eye blink and designated action is completed but application circuit [21]. Eyes are organs that detect light and convert it into electro-chemical impulses in neurons. The simplest photoreceptor cells in conscious vision connect light to movement. In higher organisms the eye is a complex optical system which collects light from the surrounding environment, regulates its intensity through a diaphragm, focuses it through an adjustable assembly of lenses to form an image, converts this image into a set of electrical signals, and transmits these signals to the brain through complex neural pathways that connect the eye via the optic nerve to the visual cortex and other areas of

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the brain. Eyes with resolving power have come in ten fundamentally different forms, and 96% of animal species possess complex optical system Image-resolving eyes are present inmolluscs, chordates and arthropods.

The simplest "eyes", such as those in microorganisms, do nothing but detect whether the surroundings are light or dark, which is sufficient for the entrainment of circadian rhythms. From more complex eyes, retinal photosensitive ganglion cells send signals along the retinohypothalamic tract to the suprachiasmatic nuclei to effect circadian adjustment.

The human eye is an organ which reacts to light for several purposes. As a conscious sense organ, the mammalian eye allows vision. Rod and cone cells in the retina allow conscious light perception and vision including color differentiation and the perception of depth. The human eye can distinguish about 10 million colors.

In common with the eyes of other mammals, the human eye's non-image-forming photosensitive ganglion cells in the retina receive the light signals which affect adjustment of the size of the pupil, regulation and suppression of the hormone melatonin and entrainment of the body clock.

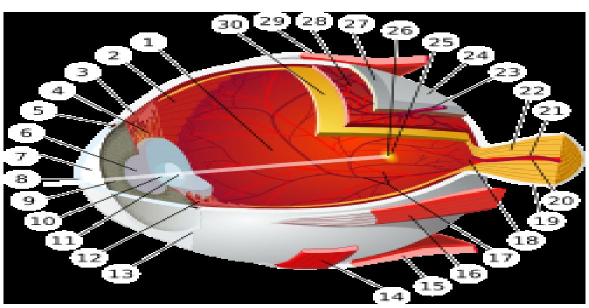

Figure 2.1 Overview of EYE

2. 1. Eye movement

The visual system in the brain is too slow to process information if the images are slipping across the retina at more than a few degrees per second. Thus, for humans to be able to see while moving, the brain must compensate for the motion of the head by turning the eyes. Another complication for vision in frontal-eyed animals is the development of a small area of the retina with a very high visual acuity. This area is called the fovea centra lis, and covers about 2 degrees of visual angle in people. To get a clear view of the world, the brain must turn the eyes so that the image of the object of regard falls on the fovea. Eye movements are thus very important for visual perception, and any failure to make them correctly can lead to serious visual disabilities.

Having two eyes is an added complication, because the brain must point both of them accurately enough that the object of regard falls on corresponding points of the two retinas; otherwise, double vision would occur. The movements of different body parts are controlled by striated muscles acting around joints. The movements of the eye are no exception, but they have special advantages not shared by skeletal muscles and joints, and so are considerably different.

2.2Extra ocular muscles

Each eye has six muscles that control its movements the lateral rectus, the medial rectus, the inferior rectus, the superior rectus, the inferior, and the superior oblique. When the muscles exert different tensions, a torque is exerted on the globe that causes it to turn, in almost pure rotation, with only about one millimeter of translation. Thus, the eye can be considered as undergoing rotations about a single point in the center of the eye.

2.3 Rapid eye movement

Rapid eye movement, or REM for short, typically refers to the sleep stage during which the most vivid dreams occur. During this stage, the eyes move rapidly. It is not in itself a unique form of eye movement.

2.4 Saccades

Saccades are quick, simultaneous movements of both eyes in the same direction controlled by the frontal lobe of the brain. Some irregular drifts, movements, smaller than a saccade and larger than a micro saccade, subtend up to six minutes of arc**.**

2.5 Micro saccades

Even when looking intently at a single spot, the eyes drift around. This ensures that individual photosensitive cells are continually stimulated in different degrees. Without changing input, these cells would otherwise stop generating output. Micro saccades move the eye no more than a total of 0.2° in adult humans.

2.6 Vestibulo-ocular reflex

The vestibulo-ocular reflex is a reflex eye movement that stabilizes images on the retina during head movement by producing an eye movement in the direction opposite to head movement, thus preserving the image on the center of the visual field. For example, when the head moves to the right, the eyes move to the left, and vice versa.

2.7 Smooth pursuit movement

The eyes can also follow a moving object around. This tracking is less accurate than the vestibulo-ocular reflex, as it requires the brain to process incoming visual information and supply feedback. Following an object moving at constant speed is relatively easy, though the eyes will often make saccadic jerks to keep up. The smooth pursuit movement can move the eye at up to 100°/s in adult humans.

It is more difficult to visually estimate speed in low light conditions or while moving, unless there is another point of reference for determining speed.

2.8 Optokinetic reflex

The optokinetic reflex is a combination of a saccade and smooth pursuit movement. When, for example, looking out of the window at a moving train, the eyes can focus on a 'moving' train for a short moment (through smooth pursuit), until the train moves out of the field of vision. At this point, the optokinetic reflex kicks in, and moves the eye back to the point where it first saw the train (through a saccade).

2.9 Blink

Blinking is the rapid closing and opening of the eyelid. It is an essential function of the eye that helps spread tears across and removes irritants from the surface of the cornea and conjunctiva. Blink speed can be affected by elements such as fatigue, eye injury, medication, and disease. The blinking rate is determined by the "blinking center", but it can also be affected by external stimulus. When an animal (usually human) chooses to blink only one eye as a signal to another in a social setting (a form of body language), it is known as winking. Some animals (for example, tortoises and hamsters) blink their eyes independently of each other. Blinking provides moisture to the eye by irrigation using tears and a lubricant the eyes secrete.

The eyelid provides suction across the eye from the tear duct to the entire eyeball to keep it from drying out. Blinking also protects the eye from irritants. Eyelashes are hairs attached to the upper and lower eyelids that create a line of defense against dust and other elements to the eye. The eyelashes catch most of these irritants before they reach the eyeball. There are multiple muscles that control reflexes of blinking. The main muscles, in the upper eyelid, that control the opening and closing are the orbicularis oculi and levator palpebrae superioris muscle. The orbicularis oculi closes the eye, while the contraction of the levator palpebrae muscle opens the eye. The Müller's muscle, or the superior tarsal muscle, in the upper eyelid and the inferior palpebral muscle in the lower 2 eyelid are responsible for widening the eyes.

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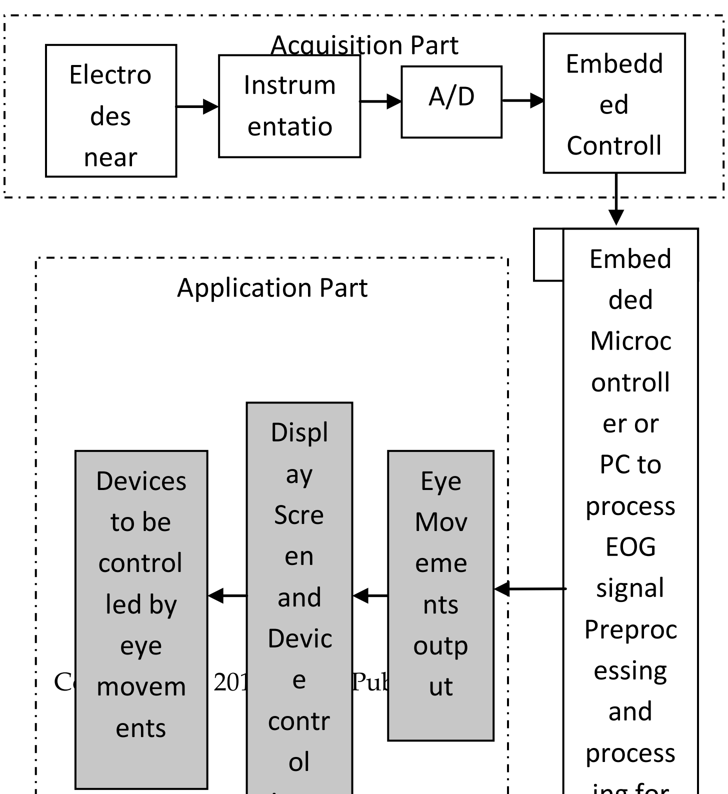
These muscles are not only imperative in blinking, but they are also important in many other functions such as squinting and winking. The inferior palpebral muscle is coordinated with the inferior rectus to pull down the lower lid when one looks down. Also, when the eyes move, there is often a blink; the blink is thought to help the eye shift its target point.

3. INTRODUCTION

This chapter introduces about the blocks of the design and specifications of each device individually to know what is its operation and importance of the device in our project. This chapter deals with how the device is interfaced into the design of project

BLOCK DIAGRAM / PROCESS



3.1 THE DETECTION FUNCTION FOR EYE BLINK DETECTION

The EOG signal can be very noisy and is non-stationary in its nature. An example of EOG signal recorded in vertical and horizontal plane. The main source of noise in EOG signal is a signal of electrical activity of face's muscles. A movement of a head or speaking can also disturb EOG signal [42][43]. The rapid change of amplitude of EOG signal is caused by the saccadic movement of eye's ball. Three spikes which appeared in a vertical plane are eye's blinks. Blinks of eye are very well seen in a signal which is recorded in a vertical plane. A high change in the potential distribution around the eye is a result of movements of muscles of upper and lower eyelid. This potential is greater in a vertical plane than in a horizontal plane. The sampling frequency for that work is 100 Hz. An idea of the detection function comes from ECG signal processing. The concept of such device consists of two steps. The first step is a filtering process (including robust nonlinear filtering and linear filtering) and the second step is nonlinear operation (square or absolute value function) [36][44].

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Then the description function is made. Because EOG signal contains signal components from DC-100 Hz, it is possible to construct a cascade of digital filters to detect an eye's blink. But the range of frequency for blinks is from 1 Hz to 10 Hz. The purpose of the signal filtering is to attenuate noise and enhance those features of the signal used for detection as this leads to an increased probability for correct detection of blinks. The detection function is created by the device .The detection function is implemented in the following way.

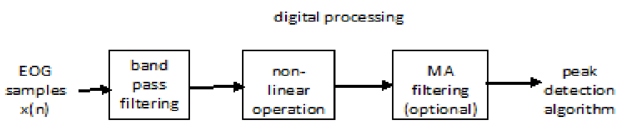

Figure 3.1 Detection Function

The first step is rejection of any outliers from signal by an application of non-linear median filter. The length of window of a median filter is 10 samples. The second step is the band pass filtering realized by serial joined of three FIR filters .

1) In this step a low-pass filtering is realized with the 32 order low-pass FIR filter and the cut-off frequency is 30 Hz.
2) At this step, signal is filtered by the high-pass FIR filter and the cut-off frequency is 1.5 Hz. The Chebyshev window with 20 decibels of relative sidelobe attenuation is also used. The order of the filter is 62.
3) Again a low-pass FIR filtering is implemented, the order of the filter is 60, the cut-off frequency is 8 Hz, and the Chebyshev window with 20 decibels of relative side lobe attenuation is also used.

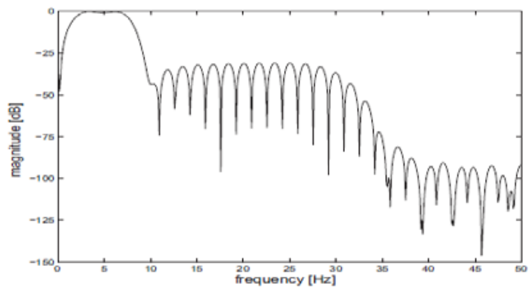

Figure 3.1.2 The frequency characteristic of a band pass filtering of the proposed detection function

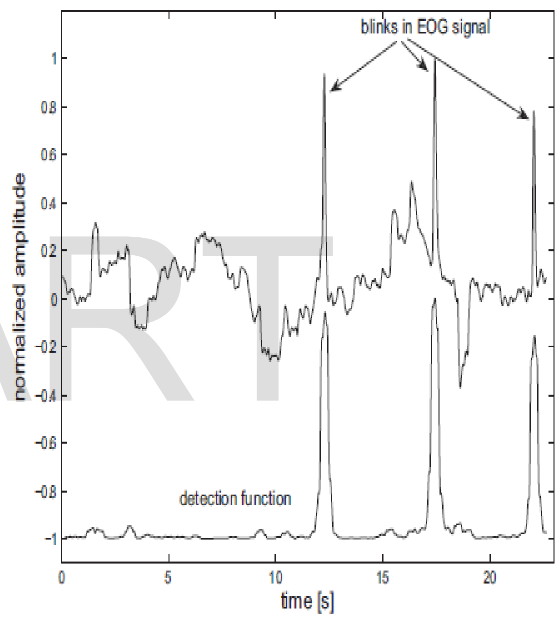

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Figure 3.1.3 . Illustration of presented detection function of blinks with respect to EOG signal (eyes make small saccadic movements) [26].

The frequency characteristic of the proposed cascade of the band-pass linear filters. The next step is a nonlinear operation and smoothing of a obtained signal with a moving average filter.

This operation can be described in the following way

$$y(n) = \frac{1}{2N+1} \sum_{i=-N}^{N} (x_f(n+i))^2$$

where *xf* (*n*) is the output signal of band pass FIR filtering, 2*N* + 1 is a length of the moving average filter. In this work *N* = 18. Such value of *N* guaranties that detection function has only one peak.

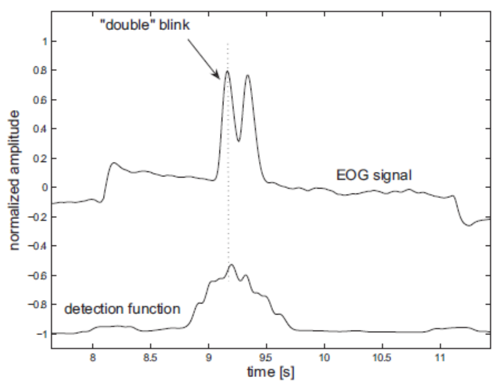


Figure 3.1.3. The example of the detection function waveform and its corresponding the first derivative in the moment when eye blink occurs [26].

In the case of appearance of two blinks, the detection function can detect only the first Blink. This situation is not a significant problem, because the location of first blink is detected, and in order to detect second blink (in short time interval) another method can be used.

3.2 Software implementation *Algorithm*

Step1 : start

Step2 : EEG sensor is connected to drivers head

Step3 :EEG signal is processed and given to PIC microcontroller

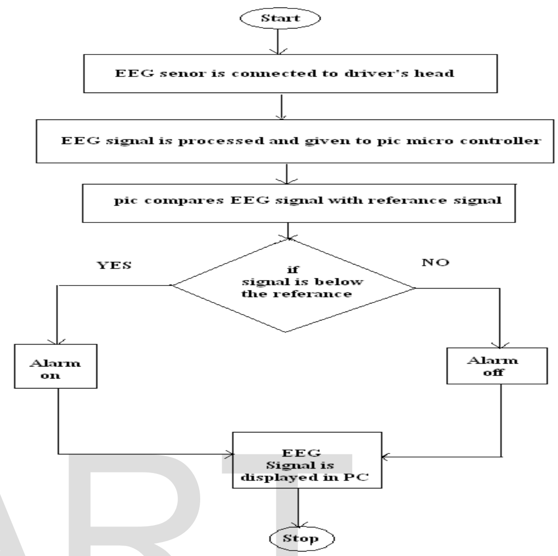
Step4 : PIC compares the EEG signal with the reference signal

Step5 : If the signal is below the reference signal ALARAM is ON otherwise it will be in OFF state

Step6 : EEG signal is displayed on the PC

Step7 : stop

3.3 Flow chart:



IV. RESULTS

4.1. Results and Discussions

The human machine interface is used to control windows-based computer application as the virtual mouse for one or double clicking. Such approach can be very useful for people with limited upper body mobility or for testing human sight sense. The following are results of the human machine interface

Figure 6.1 Screen shot of a human machine interface

The above screen shot shows that when we move the eye towards left, right, up and down directions it will display the special symbols like " & ", " @ ", "$" , "* " .We already coded a special symbol to each direction in the human machine interface.

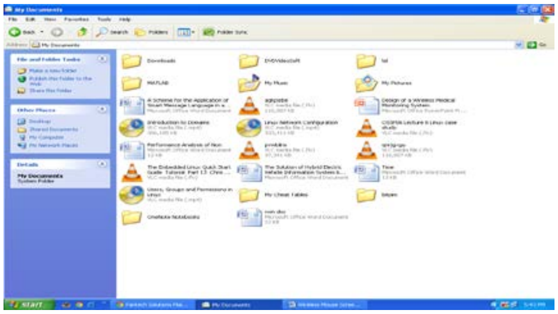


Figure 6.2 Screen shot of movement of mouse

The above screen shot shows the direction of the mouse when we move the eye towards different directions and by clicking the eye single time it will selest the file and by clicking the eye double it will open the selected file of the human machine interface.

V. CONCLUSION:

The primary object of this project is to provide a Eye based mouse control system and a method there of that detects the driver's fatigability in time by a processing circuit that processes an EEG (electroencephalogram) signal.In order to achieve this object, the present invention includes an EEG detection circuit, a micro-control circuit and a processing circuit. The way to detect drowsiness of the driver is by the EEG detection circuit to get an EEG signal of a human brain. The micro-control circuit receives the EEG signal and generates a control signal that is sent to the processing circuit. In accordance with the control signal, the processes and analyzes the EEG signal so as to learn the fatigability of the person [26].

Moreover, the processing circuit includes a conversion unit, a processing unit and a recognition unit. The conversion unit receives and converts the EEG signal into a conversion signal while the processing unit receives and processes the conversion signal to generate a processing signal that is sent to the recognition unit for generating a detection result related to the drowsiness of the body [32]. The detection result is sent back to the micro-control circuit for output of the detection result.

VI. FUTURE ENHANCEMENT

In this project we used wired transmission of EEG signals. But we can use wireless transmission by using zigbee, wi5, etc for EEG signal transmission. And also we can use micro electrodes instead of this surface electrode which will give more accurate values.

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