



MOUSE CURSOR CONTROL SYTEM BASED ON SSVEP

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Abstract: This paper proposes a computer mouse-like device that is controlled by eye movements using a single channel of EOG. SSVEP BCIs have determined a user's intent or gaze through frequency spectrum analysis of the EEG signal. In this paper, a user independent human computer interface system using eye movement and blink feature detection is introduced. It describes a method of controlling the mouse cursor on a computer screen using the electrical potentials developed by eye movements known as Electrooculography. EOG signal is used to detect eye movement and features. The EOG signal is recorded from electrodes placed at appropriate positions around the eyes. The cursor control application is implemented offline. The detection accuracy for horizontal and vertical saccades movement are 100% and 98% respectively. In this paper we are providing idea to control mouse cursor using human eyes movement, mouse cursor moves when eye glance to a particular direction. It controls mouse moving by automatically affecting the position where eyesight focused. The system was validated using a series of tests on normal control individuals. The validation results show high accuracy and precision.

Keywords: Wireless Body Area Networks(BAN), Electrocardiography(ECG), Electroencephalography((EEG), eye movement, EOG (Electro-Oculography), HCI Human-computer interface.

I. INTRODUCTION

The steady state visual evoked potential (SSVEP) has provides popular paradigm for a brain-computer interface(BCI) due to its robust presence in electroencephalogram (EEG) signals. The SSVEP is evoked when a subject is repeated visual stimulation such that the reaction to a subsequent stimulus occurs before the effect of the previous stimulus has subsided. Each stimulus is typically tagged to a specific command or action that the user is able to perform. Stimuli can be presented through use of LEDs or LCD monitors can be employed to output a variety of stimuli through computer generated imagery (CGI) [1]. SSVEP BCIs have determined a user's intent or gaze through frequency spectrum analysis of the EEG signal. This is most commonly implemented using the Fourier transform, particularly the fast fourier transform(FFT).

Developing communication devices for disable people, have been intensively studied by many in the world. Brain Computer Interface (BCI), that allows a disable person to communicate with a computer through brain's electrical activities using Electrooculography (EOG), is one of the cutting-edge research topics for this purpose. A computer cursor controlled by eye movements and blink using two channels EOG has been proposed in previous work done. The device has outputs that represent five kinds of intentions, i.e. four directions of movements (up, down, right and left) controlled by eye movements, and one selection operated by an eye voluntary blink. In this paper, we propose a computer

cursor controlled by eye movements and winks using only one channel EOG. We live in a world today where humans are more integrated to machines than ever. We cannot imagine a world without the assistive hands of these machines [2]. This necessitates direct interfacing of humans and machines particularly computers. Human-computer interaction has become an increasingly important part of our daily lives. Here eyes as an input, the movement of user's eyes can provide a convenient, natural and high- bandwidth source of input. We are using eye tracking is technique for measuring the gaze or movement of an eye this helps identify where the user is looking and has various applications . It track the movement of eye with the help of MATLAB and co-ordinate of eye a computer mouse to move to a specific location on the screen. It can help specially them who have lost control over their muscles e.g. due to a progressive motor disease known as Amyotrophic Lateral Sclerosis (ALS) resulting in a complete destruction of the peripheral and central motor system. The resulting condition is called locked-in syndrome [3][4]. Bio potentials such as Electroencephalography (EEG), Electromyography (EMG), and Electrooculography (EOG) etc. are hot topics in HCI applications in recent years. In this work we are mainly interested in EOG [5][12]. Apart from its clinical use EOG in recent years have been used in diverse applications. The electrooculogram (EOG) method: The system using this method can be manufactured at a low price. And the installation of the electrode is easy. In addition, this method is noninvasive. EOG method can be used for a long time [6].

II. METHODS

Eye movements and (involuntary) eye blink generate electrical activities. These electrical activities are detected at certain positions of electrodes of biosignal acquisition devices, such as Electrooculogram (EOG) and Nexus-10 Acquisition Kit.

A. SSVEP

Steady state visual evoked potentials (SSVEP) activity has also been used for communication and control in BCI systems. SSVEP-based orthosis control requires less training than motor imagery-based control, but also requires focused attention to the blinking lights mounted on the orthosis [7]. SVEP is a BCI solution, which has had success in optimizing performance in terms of speed and accuracy, Known as SSVEP. Steady-state visual evoked potential (SSVEP) is defined as a resonance phenomenon arising mainly in the visual cortex when a person is focusing on a repetitive visual stimulation. For SSVEP-based BCI systems, each target presented in the field of vision was modulated by a specific frequency. SSVEP-based BCIs have received increased attention because they can provide relatively higher bit rates of up to 70bits/min while requiring little training[7][14]. An SSVEP Based BCI enables the user to select among several commands that depend on the application, for example, moving a cursor on a computer screen. Each command is associated with repetitive visual stimulus that has distinctive properties. An SSVEP response is possible with a large number of frequencies, ranging from 1Hz to 100Hz.. The SSVEP based BCI system requires the user attention to be focused on an oscillating visual stimulus [8].

The steady state visual evoked protocol has recently become a popular paradigm in brain-computer interface (BCI) applications. Typically (regardless of function) these applications offer the user a binary selection of targets that perform correspondingly discrete actions. Such control systems are appropriate for applications that are inherently isolated in nature, such as selecting numbers from a keypad to be dialled or letters from an alphabet to be spelled. However motivation exists for users to employ proportional control methods in intrinsically analogue tasks such as the movement of a mouse pointer [1]. This paper introduces an offline BCI in which control of a mouse pointer is directly proportional to a user's intent. Performance is measured over a series of pointer movement task .

B. Electrooculography

Recently, electrooculography (EOG) has gained more attention as a suitable method for successfully tracking eye movements [9]. Electrooculography uses electrodes placed close to the eyes to take advantage of this corneoretinal potential. The eye can be modeled as a dipole with its positive pole at cornea and negative pole at retina. This difference is due to the large presence of electrically active nerves in the retina compared to the cornea [10]. The process of measuring the changes in this potential is called Electrooculography By placing two electrodes on opposing sides of the eyes, the difference in potential measured by these electrodes changes as the eye moves. Typical voltage magnitudes range from 5-20 $\mu\text{V}/^\circ$ of rotation of the eye. With proper electrode placement, the position of the eye can be determined with an accuracy of

$\pm 2^\circ$ vertically and $\pm 1.5^\circ$ horizontally. The eyeMouse is a proof of concept device using the principles behind EOG to control a cursor on a monitor strictly with the user's eyes. Using five electrodes, the user can control the on-screen cursor simply by looking at the exact position they want the cursor to move. The goal of the project was provide cursor control comparable to a traditional USB mouse providing the user with a hands free method of interacting with their monitor. The hope was to successfully implement smooth and continuous control of a cursor to prove that such a device could be extended to be used to replace a mouse for a computer screen [9].

C. Position Of Electrodes

In this paper, the positions of the electrodes of single channel EOG is shown in Fig.1. Hence, the EOG measures the voltage differences between EOG_h and EOG_v. Two signal components: EOG_h and EOG_v corresponding to horizontal and vertical movements are detected.

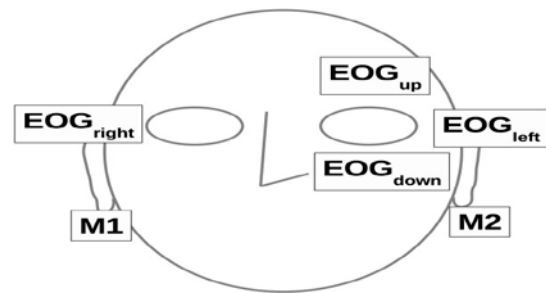


Fig.1. Electrode-placement

This position is similar to the Optimum Electrode Position proposed in [11]. However, the authors used two channels (three electrodes) EOG that is placed around right-side eye and on ear as reference. While, our proposed system use only single channels (two electrodes) EOG.

D. EEG Acquisition

EEG was recorded using electrodes. This allows the frequencies of interest to be fully contained within an individual FFT. The F_s used for cursor movement is 512 for all cases. The individually frequency (fans) is given to each case that is 10 Hz, 12 Hz, 6Hz, 6.5Hz for Right, Up, Down and left eye movement direction. The EOG makes it possible for the user to affect the direction of the cursor's movement on the screen by the frequency of brain's oscillation.

E. Eye movement features

The features corresponding to horizontal and vertical eye movements are detected from the derivative of EOG_h and EOG_v respectively. Instead of horizontal and vertical eye movement, blinks are also detected. This is subsequent closing and opening of eyelids. Blinks are of two types: a) reflex blink (in response to something invading in the eye and also as part of scared response) b) involuntary blinks (spontaneous blink controlled by brains blink generator) and b) voluntary blinks (controlled blink) [12].

III. SYSTEM ARCHITECTURE

The proposed wireless body area sensor network for mouse cursor control system based on SSVEP into a broader steps system is illustrated in following steps.

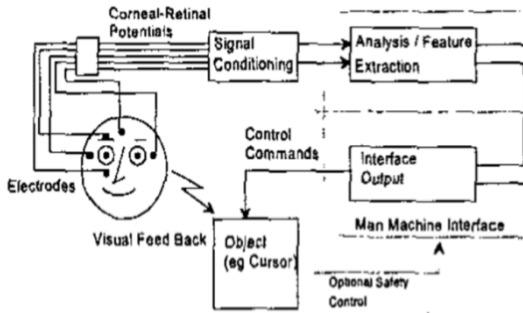


Fig.2. Basic EOG Control System

The ability of humans to visually follow the path of an object with the help of dynamic corrections is for the majority an easy task. Electro-ocular gram (EOG) is the electrical recording corresponding to the direction of the eye and makes the use of EOG for applications [13]. It records electrical readings from the electrodes placed on human face around eyes. Then it analyse the signals generated from electrodes and extract features corresponding to generated signals. After that cursor on object moves as per command it fetches from signals. As most of the machines that need to be operated are computer controlled. A simplified system of HCI that controls the spatial movement of an object is shown in Fig.2. With suitable controlled experiments with pre-defined gaze targets for test subjects to fix their gaze on, the errors can be investigated [13].

The investigation acquired EOG data from a number of volunteer subjects while they fixated their gaze on specific target points. Specific features of the recorded EOG were extracted during analysis to assist with the selection of a method to classify the movement based on EOG and to generate an output that is representative of the required movement.

A. Smoothing

The smoothing is done by removing unnecessary noise present in signal and baseline drift. The drift of the signal from the baseline is modeled by a high degree polynomial and it is then subtracted from the original signal to remove the baseline drift. After the baseline drift removal, the Noise removal and Smoothing is done. The EOG Signal were smoothed by using Savitzky-Golay filter as it minimizes the least square error in fitting a polynomial with the frames of the data signal [12].

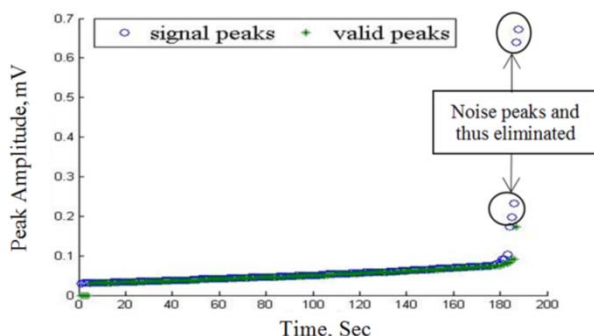


Fig.3. Noise peak removal in automatic threshold determination

B. Feature Detection

Saccades corresponding to horizontal and vertical eye movements are detected from the derivative of EOG_h and EOG_v respectively. From the EOG signal characteristics it can be concluded that when the signal amplitude increases then the corresponding eye movement is towards the rightward direction for EOG_h or towards the upward direction for EOG_v. Similarly decreasing amplitude indicates eye movement in opposite direction. So saccades can be detected by simply observing the change in amplitude i.e. by observing the derivative of the signals.

C. Classification

After the features of interest are extracted from both the horizontal and vertical signals, they are classified. Horizontal and vertical saccades are extracted from the derivative of EOG_h and EOG_v respectively. An oblique saccade is found when a horizontal and a vertical saccade occur simultaneously.

IV. SIMULATION AND RESULTS

The AVI_SSVEP_Dataset, EOG data were acquired and the data were then analyzed according to the method proposed using MATLAB. The AVI data set has been used to analyze the frequency for movement of cursor. Each subject was required to complete trials consisting of four distinct left, right, up and down pointer movement task. Each movement task required the subject to move the pointer over a laterally placed target icon. The application has been created on MATLAB environment with operating system as windows 8.1. The whole system is achieved using a custom MATLAB script. MATLAB is high computing language for technical computing.

The eye movement features were detected and classified for different data sets corresponding to different subjects. The frequency of data set decides the movement of cursor at particular location in target graph. When eyes focused on particular location at screen, it generates the corresponding frequency and moves the cursor with eyes at that location. We set the whole scenario of eye movement on graph. The cursor moves with in the dimensions of graph area. The features were finally used to control a mouse cursor. The cursor control application had been implemented offline. In the developed system, eye movement, pupil position are determined with a series of algorithms coded in MATLAB. Further algorithms are to allow the user to control and move the mouse cursor with his/her eye movements. The validation results show high accuracy and precision.

The validation protocol consisted of a series of five trials per subject performed in a proper-illuminated environment. Test subjects were requested to execute a sequence of pre instructed tasks designed to test control system. The accuracy of the system is obtained through a subroutine coded in MATLAB that calculates the system’s decision for moving the cursor into the desired destination. Every individual has to perform this process at the beginning of the application.

A. Experimental Setup

The experimental aimed is to move cursor just by the movement of eye. The subjects were used for the experiment where they were asked to follow a moving cursor on the screen and also blink as per the instruction given on the screen. The experiment was conducted in a controlled environment. During the experiment the subjects were instructed to keep calm and to keep their body and head movements as minimum as possible. This is because body and head movements may constitute EMG noise to the EOG signal [12]. A pictorial view of the measured EOG signal and EOG measurement is shown in Fig.4.

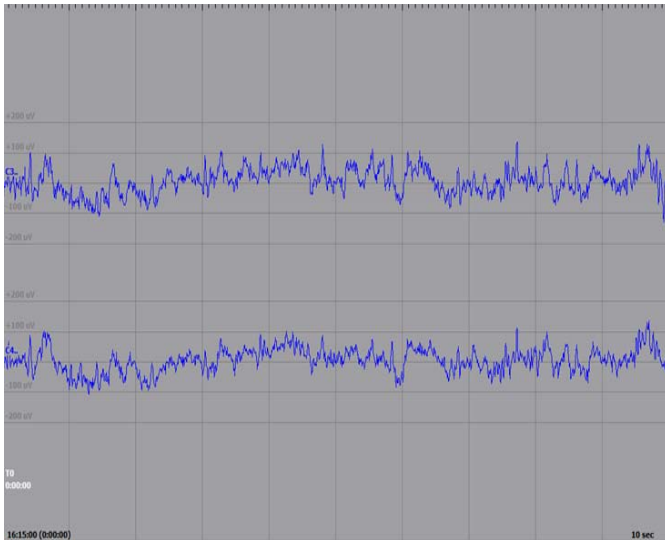


Fig. 4. Measured EEG data for one subject.

B. Signal processing and single cycle extraction

Initially a four second (1200 samples) epoch of EEG was collected. Rectangular sliding windows corresponding to single cycle sample length of the four stimuli (10 Hz, 12 Hz, 6.5 Hz, 6 Hz) were sequentially slid over the epoch and submitted to an FFT operation individually. The resulting arrays of complex components corresponding to each of the four stimuli fundamental repetition rates were then passed to each control mode analysis engine simultaneously. The epoch was then updated by four samples on a first in first out basis and the sliding windows and the FFT process repeated [1].

C. Frequency Spectrum

The AVI data set has been used to analyze the frequency for movement of cursor. The amplitude signals are measured from frequency corresponding to left, right, up and down movement. It picks the frequency from current cursor position and shows the corresponding amplitude spectrum. The basically frequency spectrum of an electrical signal is the distribution of the amplitudes and phases of each frequency component against frequency. An Individual frequency range is given to the different directions as shown in Table 1. The Fs 512 is set to all directions. The dataset vectors shows the vectors used during the mouse cursor movement in different

directions. These dataset vectors decides the frequency range of current position of cursor.

TABLE 1 shows the data values used during cursor movement in MATLAB.

Movement	Frequency(fans)	Fs	Dataset Vectors
Right	10 Hz	512	e06
Up	12 Hz	512	e3
Left	6.5 Hz	512	e6
Down	6 Hz	512	e9

D. Controlling the Cursor movement

The generated control signals corresponding to different gaze direction were used to move the mouse cursor in the direction of the gaze. The movement of the mouse cursor was fully smooth as compared to other related work done. It is a well known that the movement of the eyes causes electrical potentials that are artifacts during EEG measurements of brain waves. This paper describes the method of controlling the mouse cursor on a computer screen using the electrical potentials developed by eye movements.

E. Extracted Features

These eye movement features were extracted namely: Left, Right, Up, Down and Blink. The oblique saccades were then found. These features were classified to generate control signals corresponding to directions for the cursor to move on the screen. Movement of cursor started when the software decodes a given pair of movement potentials when the eyes are moved to given direction. At this point cursor starts moving from the rest (Centre) position. Movement of the cursor is stopped when the eyes are moved in the opposite direction and the software decodes the associated potentials for that direction. Moving the eyes again in the same opposite direction will cause the cursor to move again but in the opposite direction to the first movement. This sequence can be repeated for cursor movement/stopping in any given direction. SSVEP BCIs have determined a user's intent or gaze through frequency spectrum analysis of the EEG signal.

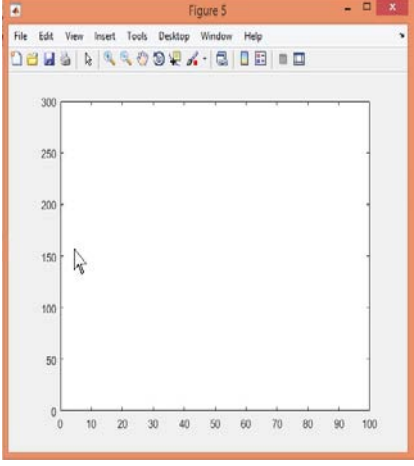
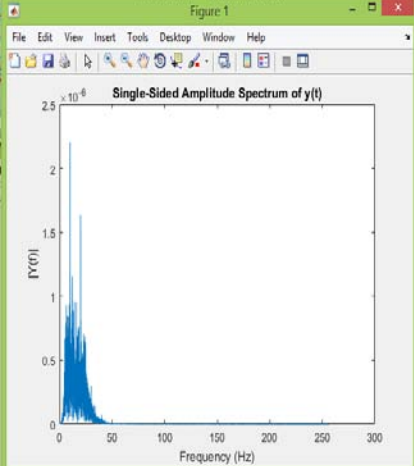
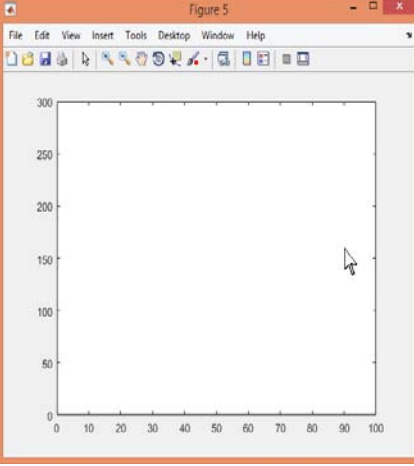
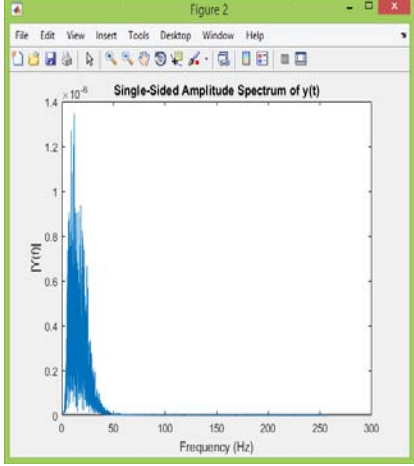
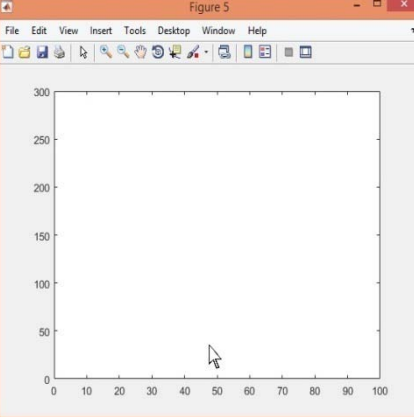
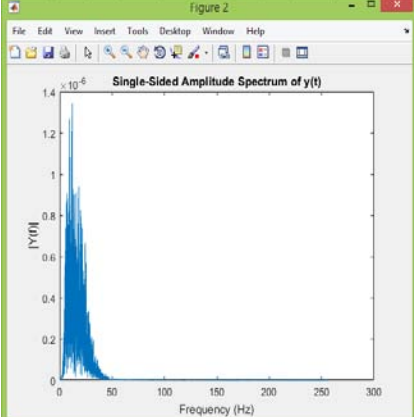
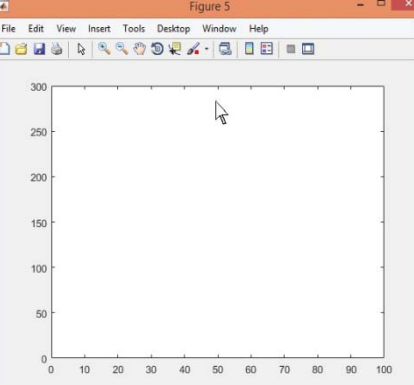
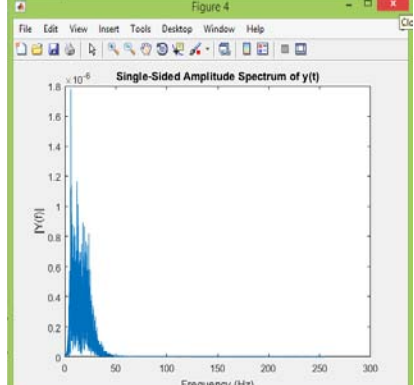
Description	Cursor Movement	Amplitude Spectrum
<p>a) Cursor moves left when eye move a glance to left and corresponding frequency spectrum when eye moves left.</p>		
<p>b) Cursor moves right when eye move a glance to right and corresponding frequency spectrum.</p>		
<p>c) Cursor moves down when eye move a glance to down and corresponding frequency spectrum.</p>		
<p>d) Cursor moves Up when eye move a glance to Up And corresponding frequency spectrum.</p>		

Fig.5. Cursor movement direction & corresponding frequency spectrum generated when eye moves to a given location.

V. CONCLUSION

This paper mainly focused on the detection and classification of eye movement and blink features from the EOG signal and generate control signals to control a mouse cursor. Using our proposed positions of electrodes, it is possible to develop mouse-like devices utilizing only single channel of EOG. This proposed system is more advantageous than the image processing based systems in the sense that it is less expensive and better accuracy is achieved with minimum effort. This paper introduces an offline BCI in which control of a mouse pointer is directly proportional to a user's intent.

VI. REFERENCES

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