Man Machine Interface based on Eye Movement Detection System

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Abstract—This paper illustrates that voice based or touch screen based system cannot be used with severely injured or paralyzed patients, we need to design some things which do not use voice or limbs. In this project our objective is to design a Human Machine interface, which can be controlled using EOG Signals and final output is to be used to move cursor on the Graphic Display which has several buttons and each button on clicking by blinking of eyes activated corresponding appliance or action. We will provide RF interface between acquisition/processing part and application so that it’s easy to handle and easy to install in homes and hospitals.

Key words: Electro-oculogram (EOG), Corneal-retinal potential (CRP), Signal conditioning, Bio potential amplifier, Instrumentation amplifier, Embedded system, Ophthalmoscopy

I. INTRODUCTION

The eye movements have attracted many researchers in the past. A seminal review of major types of eye movements [1] illustrates the advantages and the disadvantages of various types of eye movement detection methods. To list a few, magnetic field search coil technique [2], Video Oculography (VOG) system and Infrared Oculography (IROG) are some of the commonly used eye movements’ detection systems [3]. However since the electro-oculography (EOG) provides an effective, low cost and non-invasive method for detection of full range of eye movements it has been a frequently used system in ophthalmoscopy. It is commonly used in for the diagnosis and prognosis of several diseases such as best’s disease [4] and multiple sclerosis [5]. Besides the clinical ap-plications of EOG, it has been the theme of research for development of assistive technologies by human-machine interface [6, 7].

The electro-oculogram is the measure of potential between the cornea and the retina of the eye called the corneal-retinal potential (CRP). This potential is generated due to the hyper-polarization and depolarization of retinal cells. During the process the cornea establishes a relatively positive potential with respect to the retina. Information about the changing position and the speed of the eye movement can be acquired by the placement of electrodes around the eyes. The EOG is acquired using a bi-channel electrode placement system, namely horizontal and vertical channels. The strength of the EOG signal varies from 10-30mV [8] with frequencies in the DC-10Hz band [9]. The recording of the EOG has been associated with several problems [10]. In addition to EOG signal produced from the eyeball rotation and movements it is also affected by different sources of artifacts like head movements, electroencephalogram (EEG) signals, electrode placement, etc. Hence, it becomes necessary to develop an amplifier which eliminates the shifting resting potentials arising due to these artifacts and simultaneously avoid saturation. Most of the commercially available EOG amplifiers are costly and uses intricate design. Hence, the development of dedicated topology for the maximization of overall circuit performance in a cost effective manner has been the motive behind this study. Additionally, this system follows the trend of integrating real-time embedded systems with wireless transmission for diagnostics [11, 12], making it more practicable to implement on newer and smaller platforms.

II. LITERATURE REVIEW

We don’t find abetting technology for sternly injured or paralyzed patients in Indian hospitals. In recent days many technologies based on IR radiation, based on camera, based on EEG are developed and tested to assist such patients. The camera based systems are costly as these requires expensive image processing implemented in high end computing platforms and are immense and require more power. On other hand the IR based system blocks eye or both eyes completely and as these system are to be used for long time (24X7) these systems are ruinous for eyes. The EEG based system holds great promises for people with severe physical impairments but they too have drawback like intrusiveness and require special EEG recording hardware. So a low cost, low power, condensed and system which is harmless to eyes is really necessary to develop. Previews of existing system are shown below:

Fig. 1: IR Led based eye movement detections
Due to presence of large electrically active nerves in the retina as compared to front of the eye, electrical signals called as electoculogram (EOG) are produced by the potential difference between retina and cornea of the eye. In the eye ball the cornea is part is positive pole and retina is negative pole which is shown by many experiments. In horizontal and vertical way a voltage up to 16uv and 14uv per 1° is generated by the eye respectively.

The typical eye movement generated EOG waveforms are as shown in figure 1. The upward or downward rolling of eye generates positive or negative pulses, with the increment of rolling angle the amplitude of the pulse will be increased and the width of pulse will be proportionate to the period of the eyeball rolling process.

Independent measurements can be obtained from the two eyes, but as the two eyes move in conjunction in the vertical direction, it is sufficient to measure the vertical motion of only one eye together with the horizontal motion of both eyes (Arslan and Jehanzeb, 2007). Hence, the EOG is acquired by five electrodes placed around the eye, as shown in Fig. 5.

One electrode (A) is placed 2 cm above the right eye and another electrode (B) is placed 1 cm below it in order to detect vertical motion. Similarly, two electrodes (C and D) are placed on outer side of each eye with 2 cm distance from the eye in order to detect horizontal motion. The electrode is placed at the mastoid. When the gaze is shifted to the left, the positive cornea becomes closer to the left electrode, which becomes more positive (Greene et al., 2004), with zero potential at the right electrode, and vice versa. As a result, eye movement will generate voltage up to 16 uV and 14 uV per 1° in horizontal and vertical direction (Tetsuya and Masashi, 2005). The typical eye movements and the corresponding EOG waveforms are shown in Fig. 3. In Fig. 3, positive or negative pulses will be generated when the eyes rolling upward or downward. In (Yu-Luen, 2001; Yu-Luen et al., 2000), the amplitude of pulse will be increased with the increasing of rolling angle, and the width of the positive (negative) pulse is proportional to the duration of the eyeball rolling process.

Furthermore, the EOG signal is also a result of a number of factors, not only including eyeball and eyelid movement, but also containing different sources of artifact such as electroencephalograph (EEG), electrocardiograph (ECG), electromyogram (EMG), electrodes placement, head
movement and influence of the lumiance (Arslan and Jehanzeb, 2007). Therefore, it is necessary to eliminate the shifting resting potential (mean value) (Barea et al., 2002). To avoid this problem an AC high-gain differential amplifier which amplification is about 8000 times is used, together with a high pass filter with cut-off frequency at 0.159 Hz and a low pass filter with Cut-off frequency at 10 Hz.

IV. PROPOSED METHOD

The proposed eye movement detection algorithm for EOG driven human computer interface consists of three main blocks: namely, the preprocessor, the feature extracting unit and the training/recognition module, as shown in Fig. 4.

Two channels EOG amplifier was developed for the acquisition of horizontal and vertical eye movement signals. For the electrode placement scheme as shown in Fig. 1, the positive horizontal channel electrode (H1) was placed on the right canthus of the right eye and the negative horizontal channel electrode (H2) was placed on the left canthus of the left eye. And the positive vertical channel electrode (V1) was placed 2cm above the cornea and the negative vertical channel electrode (V2) was placed 1cm below the cornea of the eye. The common reference signal was taken from the reference electrode (R) placed on the forehead.

The methodology for the designing of EOG bio potential amplifier has been explained in Fig. 5. For the study, instrument amplifier IC AD620 having an adjustable gain was used. Initially, out-of-band frequencies were removed by band pass filtering in the cutoff range between same that of the useful EOG signal range i.e., 0.1-30Hz. The pre-amplification stage followed another instrumentation amplifier with the adjustable gain maintained between 0-500. Further, suppression of the low frequency components was done by implementation of 10Hz low pass filter. Since, all the circuitry used DC sources and the frequencies above the 10Hz were rejected so the role of ambient noises due to 50Hz power line interference was neglected. The analog output available was digitized by using Analog-to-digital converter IC ADC0804 and its output was provided to the input of the encoder IC HT640. The parallel digitized data was hence converted to serial data and feed to the ASK Transmitter module TX 01 433MHz. The ASK Receiver module RX 02 was kept at the receiver end for the reception of the serial data. This serial data was decoded to its parallel form by the use of decoder IC HT648. The analog signal was recovered to its original form by use of Digital-to-Analog converter IC DAC0800.

A. Experiment Paradigm and Data Acquisition

Typically, the EOG signal consists of eye movements in the vertical, horizontal, diagonal directions and blinks. The blink can be involuntary blink having amplitude around 50mV or a voluntary forced blink with amplitude of 500mV approximately [8]. The experimental tasks involved the execution of various combinations of eye movements by each subject. The eye movement combinations used for the present study are as follows:

1) Continuous Right (R) and Left (L) eye movements for 5sec.
2) Right (R) and Left (L) eye movements for 10sec followed by central eye-gaze or hold for 10sec followed by Up (U) and Down (D) eye movements.
3) Continuous forced blinks and normal blinks.
4) Right (R) – Up (U) and Left (L) – Down (D) diagonal eye movements each with 5sec hold.

The output of the EOG amplifier was feed into the NI USB 6008 DAQ card. The signals were then visualized on the computer screen after the creation of sub vi in the LabVIEW soft-ware. The screen shots of the images seen while the acquisition of the EOG signals during the execution of different tasks.
V. RESULTS AND DISCUSSION

The red lines in the figures shows the signal acquired from the horizontal (H) channel and the black lines show the signal acquired from the vertical (V) channels. The Fig. 6 shows the R-L eye movements executed by the subject for 5sec. The phenomenon involved behind this resultant is that during the straight ahead eye-gaze, equilibrium is established in the eye dipole and EOG output is zero. While when the eye-gaze is shifted to right, the positive potential is picked up with respect to the second electrode and similarly, the reverse is resultant when the eye-gaze is shifted to left. The visualization of the acquired signals on the computer screen confirmed the occurrence of well-defined EOG peaks.

The Fig.7 shows the resultant when the subject executed R-L eye movements for 10sec followed by 10sec central eye-gaze followed by U-D eye movements for 10sec. It is evident from the observation that the U movement’s produces positive peaks while the D movement’s produces negative peaks.

The Fig. 8 which shows the continuous forced and normal blinks clearly indicates that the two blinks are segregated due to production of positive potentials with different amplitude.

The Fig. 6 showing the R-U and L-D diagonal eye movements each with 5sec hold shows the production of another interesting result with different combination of eye movements. This resultant demonstrates that even further combinations of eye movements could be made which could holds grounds for the development of intelligent assistive technology based upon implementation of classification algorithms on the EOG signals [8, 13, 14].

VI. CONCLUSION

Our research is aimed at build EOG-Based assistive apparatus for severely disabled people with the ability of controlling their eye movement, or as an alternative communication way in some special occasions.

In our research, the EOG signals are employed as the carrier of information; the different EOG pulses that result from looking up, down, left, right and blinking are encoded as the commands to control the external apparatus and environment. However, EOG signals from eye movements are easily corrupted by difference interferences in real environment, and its waveforms are always changed across different trials and individuals, which will cause big difficulties in accurate detection of eye movements.

In order to improve the stability and reliability of EOG-based HCI system in real environment, a novel modality of eye movement detection based on EOG signal is studied in this paper. The spectral entropy and LPCC coefficients combined with the method of dynamic time warping and band-pass filtering are applied to the detection and recognition of various types of EOG pulse produced by different eye movement. Experimental results reveal that the proposed method can achieve good performance of eye movement detection for real-life EOG data.

Based on the proposed EOG detection method and existing bio based HCI platform that we have finished, our future work is to develop some practical user interfaces for various purposes such as: spelling and environment controlling that allow users to write a letter, send Email and control some household devices, etc.
REFERENCES


