International Journal of Combined Research & Development (IJCRD)
eISSN: 2321-225X;pISSN:2321-2241 Volume: 4; Issue: 10; October -2015

A Portable Eye Movement Controlled Human Computer Interface for Disabled

Anjali
VIT University
Vellore, India

Prof. Nadipi Reddy Prabhav
VIT University
Vellore, India

***Abstract* : In recent years, with advances in biosignals acquisition and processing, we can design an inexpensive rehabilitation devices that can interpret the information and improve the quality of the life of differentially abled people to communicate with their caretaker. The purposed system consists of an electrooculography (EOG) acquisition unit, a processing part, and an EOG controlled interface. As a part of this work an EOG signal acquisition system is developed which consists of an instrumentation amplifier, a band pass filter, a main amplifier, voltage divider, summing amplifier, buffer and diode limiter. The acquired EOG signal was then processed using Arduino software to generate various control signals depending upon the amplitude and duration of signal components. These control signals were then used to control the movements of the cursor on the developed human computer interface on Eclipse Juno software according to the eye movement.**

***Key words*— EOG, HCI, rehabilitation device, control signals**

I. INTRODUCTION

Detection and classification of eye movement is an important area of research. A study on the group of person with severe motor disability showed that their eye movements are unaffected which can be used to develop HCI and help them to communicate [1],[2],[3],[4].

The EOG is one of the very few methods for recording eye movements that does not require a direct attachment to the eye itself [5], [6]. EOG is a technique for measuring the resting potential of the retina by using pairs of electrodes [7]. The human eye can be seen as an electrical dipole with a positive pole at the cornea and the negative pole at the retina. By measuring the voltage induced across a set of electrodes placed in reference positions around the eyes, we can measure the electric signal of the eye's dipole as the eye-movement changes. The EOG value varies from 50 to 3500 µV with a frequency range of about DC-100 Hz. Its behaviour is practically linear for gaze angles of ±30 and changes approximately 20 µV for each degree of eye movement [8], [9].

The main aim of the work presented in this paper is to develop an inexpensive and easy to use biosignal acquisition system and rehabilitation technique: a portable eye movement controlled human computer interface for disabled. This work includes developing a data acquisition system for acquiring EOG signals, developing an algorithm for detecting basic eye movements and blinking, implementing rehabilitation devices i.e., graphical user interface which can be controlled using EOG, to test the developed interface on many subjects.

II. METHODOLOGY

The developmental work for EOG based human computer interface is shown in Fig.1 is consists of a signal acquisition unit, signal processing unit and an EOG controlled HCI for disabled.

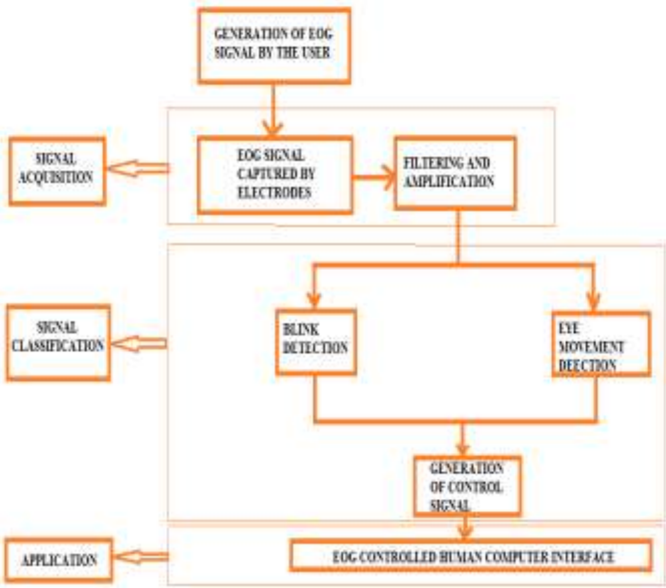

Fig. 1 Basic Block Diagram of EOG Based Human Computer Interface

EOG signals were acquired by placing electrodes around eye. The horizontal and vertical eye movements were acquired separately on the laptop by using data acquisition circuit (Arduino board). These signals were then displayed and processed using Arduino software. Then after processing we extract certain features of the EOG signal such as amplitude and time duration. Depending upon the direction of eye movement, separate control signals were generated by algorithm written in Arduino. These control signals were parallel in nature. They controlled the direction of cursor on the developed interface depending on the incoming data.

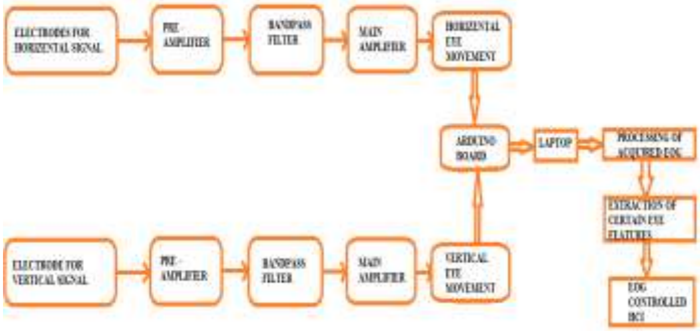

Fig.2 System organisation

A. Electrode placement

EOG signals were measured by placing electrodes on the region surrounding the eye. They were recorded from two separate regions: horizontal and vertical. Horizontal electrodes were positioned on the temples for detecting horizontal eye movements (left and right eye movement) and vertical electrodes were placed roughly above the midline of the eye for detecting vertical movements (up and down cornea movements) and a reference electrode was either placed at the tip of the nose or on the forehead. Five electrodes were used to acquire the EOG signal.

Fig. 3 Placement of electrode

B. Electrodes used

Steel washers were used as electrodes to acquire EOG signals from the eye of the subject as they are cheap and easily available.

C. Amplifier and filtering circuitry

Since the EOG signal amplitude range was in microvolts, they were very much susceptible to various noise sources. So in order to process the signal, our first task is to amplify it to a level where we can use it to drive other processing circuits. So in order to process the signal, our first task is to amplify it to a level where we can use it to drive other processing circuits. IC INA128, differential amplifier was used as a pre-amplifier. The pre amplifier INA128 (gain=26) amplifies the EOG signal to an appropriate amplitude.

The output of pre-amplifier was given to first order band pass filter was used to filter out the other than frequency related noise from the original or required signal. As we know that EOG signals' frequency from 0 to 40 Hz; and generally as discussed filter of band 0.1 to 41Hz is designed. The main source of noise present in the signal was power line noise and baseline wandering. Base line wandering was due to the presence of low frequency components in the signal. These two noises were removed by using a band pass filter. After main amplifier, IC741 (gain=19), the amplified EOG signal was ready for further processing.

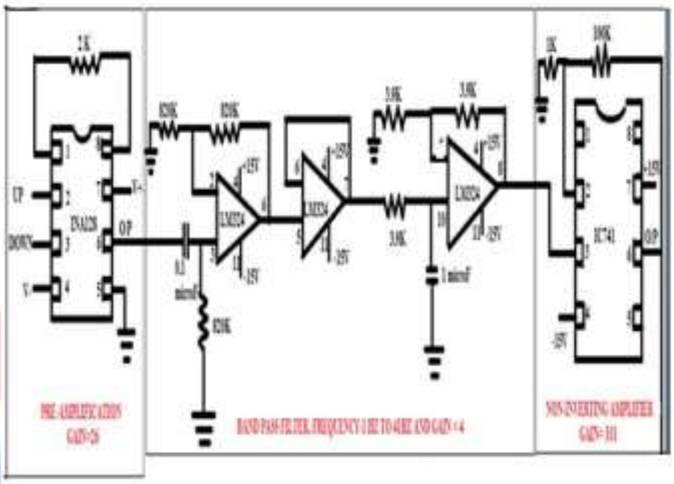

Fig.4 Signal amplification and filtering

After amplification, the signal was around 5 volt peak-to-peak. For the further processing of EOG signal, it must only reside in positive domain. So the best way to do that is to add an offset of 2.5 volt DC voltage. The offset was obtained through voltage divider circuit. The obtained offset was then added to the filtered and amplified EOG signal (V_2) through the summing amplifier circuit. The output signal of summing amplifier must be converted in the range of (0 – 5) volt as the microcontroller on the Arduino board can get damaged if it exceeds 5 volt. This was achieved by directly passing the output of the summing amplifier through the diode limiter. Once the desired range was attained, it was then used to enable the analog to digital converter to perform analysis on it. The EOG obtained from the patient was in the analog form, which should be converted into digital form to interface it to PC. Analog EOG signal was converted into digital form by built-in ADC of Arduino microcontroller. We get digital EOG signal with no loss of original details.

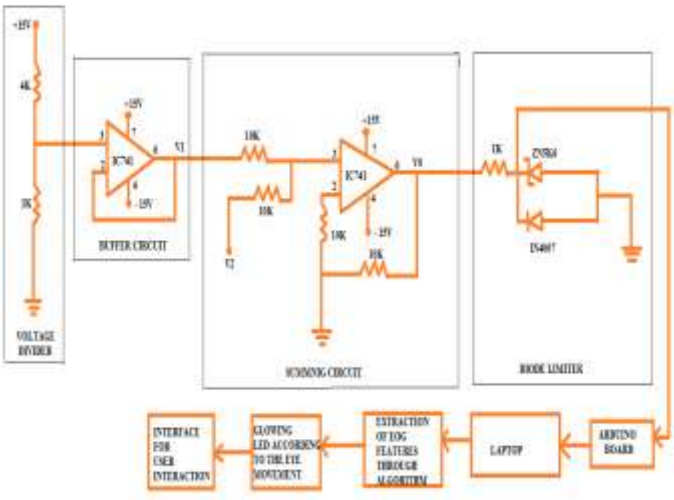

Fig. 5 Remaining part of acquisition circuit

D. EOG classification and control signal generation

After interfacing with personal computer using Arduino board, separate algorithms were used for identifying blink and eye movements. An EOG signal corresponding to up–down eye movements was dominant in vertical channel. Hence for easy analysis, up–down and blink classification algorithm was applied to EOG signals from vertical channel. Similarly for classifying right – left eye movements the algorithm was applied to EOG signals from horizontal channel. Both algorithms were carried out simultaneously and in parallel. Signal amplitudes and duration were compared with the corresponding threshold values. When signal amplitude exceeds the threshold value, it is considered to be a valid signal for recognition and corresponding to it a control signal was generated. This method is very simple and easy to implement. This kept the system in minimum error and maximum control. The generated command signals were used to glow the 5 LEDs.

E. Interface development

The human computer interface was developed on the Eclipse Juno software. The developed interfaced displays 5 options to the patent like T.V., food, medicine, water, doctor etc., and the cursor moves on the interface depending on the eye movement of the user and selection will be done by the voluntary blink.

Fig. 6 Developed human computer interface (HCI)

III. RESULTS AND DISCUSSION

The waveforms corresponding to six distinct basic eye movements had been acknowledged during the system development, viz. blink, rest, up eye movement, down eye movement, left eye movement and right eye movement. Blink, up and down movement EOG signal were obtained from vertical channel. Highest peak in the vertical channel was obtained from blinking. The amplitude obtained for up eye movement was comparatively lesser than blink movement and was in upward direction. Whereas the EOG obtained for downward movement is in downward direction. Right and left EOG signal were obtained from horizontal channel. The EOG obtained for right movement was in downward direction with relatively low amplitude compared to the EOG signal obtained for the left eye movement. The EOG for left eye movement was obtained in upward direction.

TABLE1

Average voltage corresponding to different eye movement

SI. No.	Eye movement	Average voltage (in volts)	Direction of EOG signal
1	Blink	4.5 volts	Upward
2	Up	1.3 volts	Upward
3	Down	1.0-1.6 volts	Downward
4	Right	0.9 volts	Downward
5	Left	1,14 volts	Upward

Separate eye movements and duration between individual eye movements can be formulated to produce individual control signals. These control signals were used for glowing five LED's connected to the digital pins of the Arduino boards in parallel based on the incoming data. These control signals were parallel in nature. Similarly, the separate algorithm was written to control the cursor movement on the developed Human Computer Interface (HCI).

IV. CONCLUSION

In the present work, an EOG signal acquisition system has been designed and implemented. Additionally, an algorithm for EOG classification and control signal generation was also developed. This algorithm required much less user training than other classification algorithms. Hence it is very much useful for the implementation of rehabilitation aids. As a part of this paper, an EOG based Human Computer Interface has also been developed. This HCI was able to generate control signals during various eye movements and blinks. These control signals were used to glow LED's by various eye movements and blink. This EOG based HCI control system for disabled will be a good assistive technique for people suffering from extremely limited peripheral mobility. In this paper, only five control signals were generated. This can be extended with a little modification in the algorithm. Accuracy of the circuit can be improved by using electronic components with high precision and less tolerance. Accuracy of the EOG classification algorithm can be increased. The use of the generated control signal to the control the movement of the cursor on the interface has to be achieved.

REFERENCES

[1] Desai, Yash Shaileshkumar. "Natural Eye Movement & its application for paralyzed patients". *International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue4- April 2013*

[2] Rafael Barea , Luciano Boquete, Jose Manuel Rodriguez-Ascariz, Sergio Ortega and Elena López, "Sensory System for Implementing a Human Computer Interface Based on Electrooculography", *Sensors* 2011, *11*, 310-328.

[3] Jobin Jose, "Development of EOG Based Human Machine Interface Control System for Motorized Wheelchair", Master in Biotechnology & Medical Engineering Thesis submitted to National Institute of Technology Rourkela, 2013.

[4] Lv, Zhao, et al. "Development of a human computer Interface system using EOG." *Health* 1 (2009): 39.

[5] Qiuping Ding, Kaiyu Tong, and Guang Li"Development of an EOG (Electro-Oculography) Based Human-Computer Interface", IEEE 2005.

[6] Barry R. Greene, Stephen Meredith, Richard B. Reilly and Gary Donohoe, " A novel, portable eye tracking system for use in Schizophrenia Research*", ISSC 2004, Belfast, June 30 - July 2.*

[7] Postelnicu, Cristian-Cezar, Florin Girbacia, and Doru Talaba. "EOG-based visual navigation interface development." *Expert Systems with Applications*39.12 (2012): 10857-10866.

[8] Merino, Manuel, et al. "A method of EOG signal processing to detect the direction of eye movements." *Sensor Device Technologies and Applications (SENSORDEVICES), 2010 First International Conference on*. IEEE, 2010.

[9] Barea, Rafael, et al. "EOG-based eye movements codification for human computer interaction." *Expert Systems with Applications* 39.3 (2012): 2677-2683.