International Journal of Multidisciplinary and Current Research

Research Article

ISSN: 2321-3124
Available at: http://ijmcr.com

Analysis of Electrooculography signals for the Interface and Control of Appliances

Arthi S V[1] and Suresh R. Norman[2]

[1]M.E., Student, Applied Electronics, SSN College of Engineering, Chennai, India
[2]Associate Professor, Dept of ECE, SSN College of Engineering, Chennai, India

Accepted 20 Feb 2015, Available online 25 Feb 2015, **Vol.3(Jan/Feb 2015 issue)**

Abstract

Electrooculography (EOG) technology can be used for the interfacing of human-computer interface(HCI) systems for the control of appliances. The main objective of measuring and processing these signals is to help people succeed in dealing with the inconveniences in the physical world especially for the people who are immobile. EOG is the eye tracking methodology by placing electrodes and sensing the corneo-retinal potential (CRP) which is the resting potential between the cornea and the retina of the eye. This sensed potential is proportional to the movement of the eye. The electrodes convert the ion current obtained from the skin into electron current. The obtained bio signal is in terms of lower voltage and hence it is amplified, filtered and processed to remove unintentional blinks, noises and other artifacts. The ultimate aim is the analysis of these signals for the smart control of appliances.

Keywords:*Appliance control, Electrooculography, eye movement, human-computer interface.*

1. Introduction

Communication with the outside world is important for the person with neurological, ophthalmological, vestibular disorders and paralysis patients with little motor capabilities. A possible solution for communication and control without speech and hand movement must be used for differently abled people. The application of using Electrooculography signals to control the HCI systems is by the bio-electric potentials produced in the body, than by the normal pathways for communication. Control of objects through eyes gained the interest of researchers in recent years. There are many ways of obtaining the direction of eye gestures based on clinical observations and qualitative methods.

The various techniques used for eye movement detection are Infrared oculography (IROG),where a light source is focused at the eye [6]. The amount of light reflected to the detector differs with respect to the eye ball position. Here, the light source is fixed and measuring vertical movement of the eye is difficult since the eyelids occupy more of the surface of the eye.

The Video oculogram (VOG) records the eye movement using a camera and converts it into equivalent motion of mouse on the screen. Here, the person has to be stationary infront of the camera.

Scleral search coil (SSC) method is an invasive method which has a coil embedded in the lens of the eye [8]. This method is used for clinical observations for diagnostic purposes. When this coil of wire is moved in the magnetic field, it induces voltage in the coil which is attached to the eye. This produces a signal which is proportional to the position of the eye.

EOG is a technique which senses the potential developed between the cornea and the retina of the eye during eye movement. This technique is effective for the HCI systems as it is a non-invasive technique. Another advantage of this technique is that, the field-of-view is not restricted to a video camera or the sensors. EOG is cost effective, easy to use when compared to other techniques. The linear relationship between EOG and eye movement makes the waveform easier to analyze. The EOG technique has been used for many applications such as controlling a wheelchair [2], a keyboard [9] or a television [10]. This paper presents the analysis of the eye gestures using EOG technique for the smart control of the appliances with the help of wired electrodes and signal conditioning circuits.

2. Engineering analysis

A. Block Diagram

Signals from electrodes at five positions around the eyes are taken. Bio-signals obtained in the range of 0.05 - 3.5 mV are amplified with an instrumentation amplifier. The signal has a useful frequency range from 0 to 16 Hz and so it is filtered to remove noise. The output is recorded or displayed using a digital storage oscilloscope. The basic block diagram of EOG signal acquisition is as given in Fig.1.

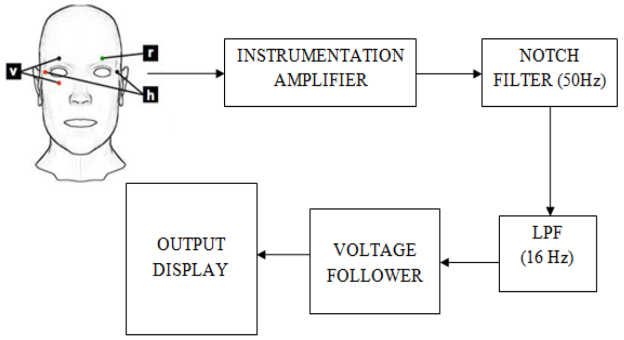

Fig.1 Basic block diagram of EOG signal acquisition

B. Electrodes

The medical electrodes transfer the ionic energy into electrical energy in the body. These currents can be amplified and used for diagnosing various diseases. The various types of electrodes are wet, dry and insulating electrodes. They can be sub segmented as Fetal scalp electrodes, Electrosurgical electrodes, TENS electrodes, Pacemaker electrodes, pH electrodes, Nasopharyngeal electrodes and ion-sensitive electrodes. Conductive gel is extremely useful when used to record electrical activity on the surface of the skin. The Ag/AgCl electrodes are mostly used which are conductive, but the other types (e.g. capacitance-based) are also used.

C. Placing of Electrodes

The properties of EOG signal varies depending on the placement of electrodes. The various configurations such as 3/4, 4/5, 7/8 are used for different applications. Here, the first number denotes the number of active electrodes placed and the second number denotes the total number of electrodes including the reference electrode. The 4/5 electrode configuration is used here as it is a compromise between the other two configurations. The wires used in the 7/8 configuration are a disadvantage. The different measurement systems are as shown in Fig. 2.

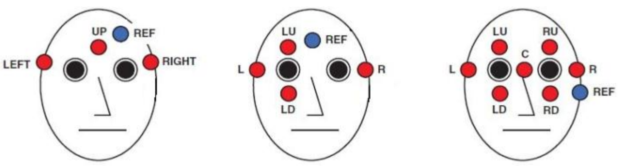

Fig.2 Different measurement systems

3. Signal processing

A. Instrumentation amplifier

The INA118 is a low power, general purpose amplifier offering high gain for the project. Current-feedback input circuitry provides wider bandwidth of operation even at high gain. It provides a high common-mode rejection of about 110dB at G=1000. A single external resistor sets any gain from 1 to 10000. The block diagram of the instrumentation amplifier is as shown in Fig. 3.

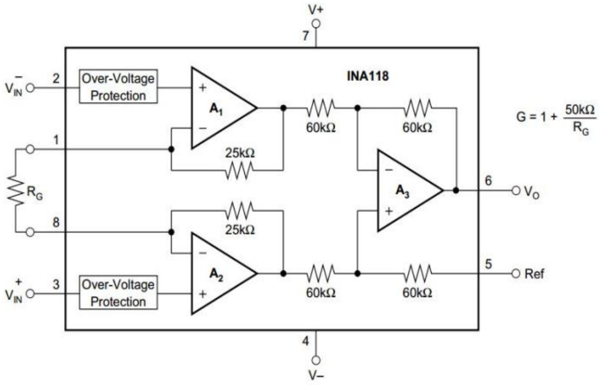

Fig.3 Instrumentation amplifier

B. Notch filter

Filters are electronic circuits used to remove unwanted frequency components from the signal, to enhance the wanted signal or both. This project requires a filter of high gain and hence twin T notch filter is used which can tune up to 100 dB. Here, the required frequency to be filtered is 50Hz. Hence the resistance and capacitance values are chosen appropriately. The notch filter used is as shown in Fig. 4.

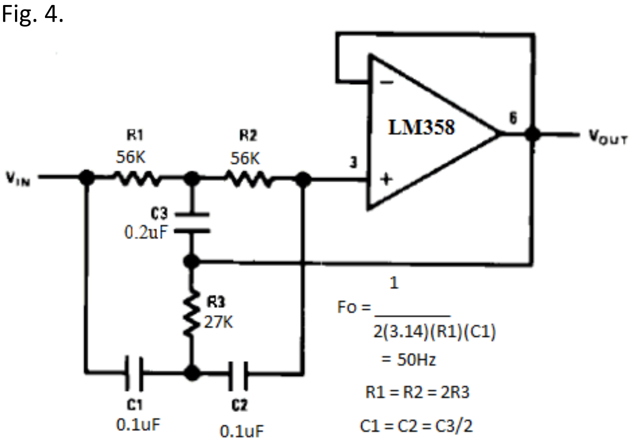

Fig. 4 Notch filter

C. Low Pass filter

The noises and other artifacts come under high frequencies and hence they must be removed. Thus a low pass filter with the frequency range from 0 to 16Hz is designed and the corresponding resistor and capacitors are chosen accordingly.

D. Voltage follower

A voltage follower (buffer) is one that provides electrical impedance transformation from one circuit to another. It is designed to have an amplifier gain of 1. Buffers are used in impedance matching, the benefit of which is to maximize energy transfer between circuits or systems. It is used as an intermediate to connect a high output impedance to low input impedance device. It has an output voltage equal to the input voltage. It provides isolation thus avoiding loading effects.

E. DC bias removal

The resting potential between the eyes do vary depending on various parameters such as lighting, nature of the skin, conductivity of the type of electrodes used and placement of electrodes. After the amplification process, the resting potential is also amplified, but it is not desired in the EOG signal. A simple differentiator circuit is used to remove DC drifts and to provide better high frequency response.

4. Experimental results

An operational amplifier needs an offset so it can work correctly in case while working with negative and positive voltages. Adding a simple offset would make the reading unstable because of the fact that the potential depends on environmental factors. To solve this issue, op-amps need to work with dual polarity supply. This can be done with 7805 ICs without the need for a dual power supply.

The eye acts as a dipole in which the anterior part is positive and posterior part is negative. Left gaze can be defined as a condition when cornea approaches the electrode near the outer canthus of the eye, providing a negative trending change in the recorded potential. One factor to be considered here is that the human eye is always active. Therefore, validation should not be performed involuntarily. Thus eye movement codification must be used. The goal is to develop control strategies upon eye movements such as blinks. The normal wave when the person is looking straight is as given in the Fig. 5. Here there is no movement of the eye and hence there is no potential developed.

Fig. 5 EOG wave of a person looking straight without moving the eye.

When the waveform was analyzed for vertical movement, the top and down movement of the eye is detected. Additionally, the blinks are dominant in this mode. The waveform for the movement of the eye towards the top is inverted to that of bottom. The results obtained for an eye moving in the top direction is as shown in Fig. 6 and the eye moving in the bottom direction is as shown in Fig.7.

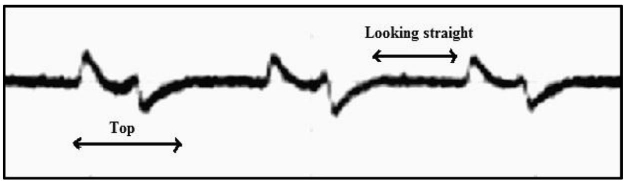

Fig.6 EOG wave of the person moving the eye in the top direction

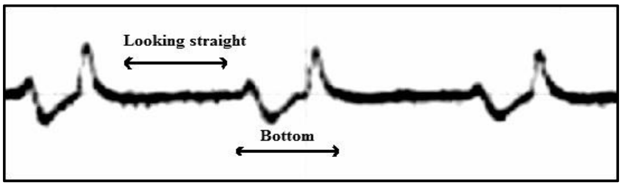

Fig.7 EOG wave of a person moving the eye in the bottom direction

The human eye blinks are partially involuntary which can be made voluntary for control purposes. In that case, the number of blinks can also be counted. The voluntary blinks at regular time interval are as shown in Fig. 8. Some of the involuntary blinks with large amplitude are as shown in Fig. 9.

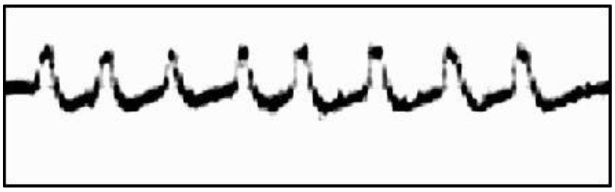

Fig.8 Series of voluntary blinks at regular interval

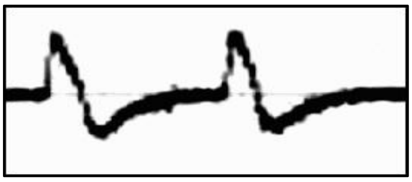

Fig.9 Involuntary random blinks

When the waveform was analyzed for horizontal movement, left and right gaze of the eye are detected. The waveform for the eye moving in the left is inverted to that of the eye moving in the right direction. The waveform obtained for an eye moving in the left direction is as shown in Fig. 10 and the eye moving in the right direction is as shown in Fig. 11.

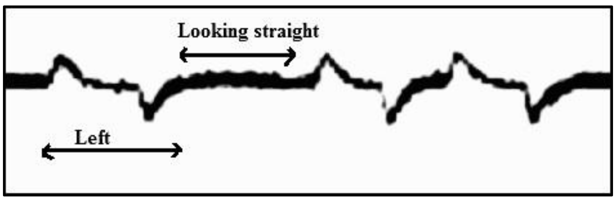

Fig.10 EOG wave of a person moving the eye towards the left direction

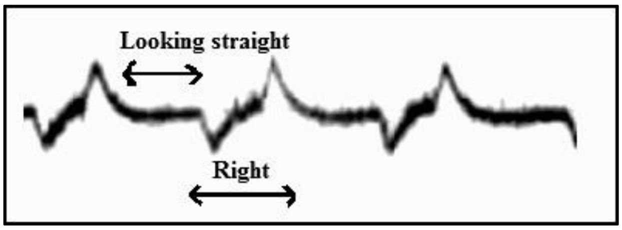

Fig. 11 EOG wave of a person moving the eye towards the right direction

The 4/5 electrode configuration includes both the horizontal and vertical placement of electrodes. Thus the eye movement towards top-left, top-right, bottom-left, bottom-right can also be detected. This helps in increasing the ability to control appliances.

Conclusion

The technique of EOG used in the project is an inexpensive yet reliable human-computer interface that detects eye movements, a medical technique based on sensing signals by using electrodes placed around the eyes. The EOG signals obtained were amplified sufficiently using an instrumentation amplifier in order to provide accurate measurement for the analysis. Further improvements in the analysis were made by filtering the high frequency components and removing the power line noise. The resulting EOG signals were obtained in the digital storage oscilloscope and the directions of the eye movement were differentiated based on the amplitude and the time period. The results obtained were reliable. Thus the analysis of EOG signals and the interface lets people who cannot manipulate an object with their hands to have more options in controlling the appliances. Further improvements can be made in placing the electrodes around the eyes such that they are more comfortable to wear. The system can also be made wireless.

References

[1] R. Barae, L. Boquete, and M. Mazo, System for assisted mobility using eye movements based on electrooculography, *IEEE Trans. Neural Syst. Rehabil. Eng.*, vol. 10, no. 4, pp. 209–218, Dec. 2002.

[2] R. Barea, L. Boquete, M. Mazo, and E. Lpez, Wheelchair guidance strategies using EOG, *J. Intell. Robot. Syst.*, vol. 34, pp. 279–299, 2002.

[3] M. W. Shen, C. Z. Feng, and H. Su, Spatial and temporal characteristic of eye movement in human–computer interface design, *SpaceMed.Med.Eng. (Beijing)*, vol. 16, pp. 304–306, Aug. 2003.

[4] J. Hori, K. Sakano and Y. Saitoh, Development of communication supporting device controlled by eye movements and voluntary eye blink, 26th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., San Francisco, USA, pp. 4302–4305, Sept. 2004.

[5] J. B. Hiley, A. H. Redekopp, and R. Fazel-Rezai, A low cost human computer interface based on eye tracking, in *Proc. IEEE Conf. Eng.Med. Biol. Soc.*, vol. 1, pp. 3226–3229, 2006.

[6] K. U. Schmitt, M. H. Muser, C. Lanz, F. Walz, and U. Schwarz, Comparing eye movements recorded by search coil and infrared eye tracking, *J. Clin. Monitor. Comput.*, vol. 21, pp. 49–53, Feb. 2007.

[7] M. W. Johns, A. Tucker, J. R. Chapman, E. K. Crowley, and N. Michael, Monitoring eye and eyelid movements by infrared reflectance oculography to measure drowsiness in drivers, *SomnologieSchlafforschungSchlafmedizin*, vol. 11, pp. 234–242, 2007.

[8] A. Sprenger, B. Neppert, S. Koster, S. Gais, D. Kompf, C. Helmchen, and H. Kimmig, Long-term eye movement recordings with a sclera search coil eyelid protection device allows new applications, *J. Neurosci.Methods*, vol.170, pp. 305–309, May 30, 2008.

[9] H. S. Dhillon, R. Singla, N. S. Rekhi, and R. Jha, EOG and EMG based virtual keyboard: A brain–computer interface, in *Proc. 2nd IEEE Int.Conf. Comput. Sci. Inf. Technol.*, pp. 259–262, 2009.

[10] L.Y.Deng, C.L.Hsu, T.C. Lin, J.S. Tuan and S.M.Chang, EOG based human-computer interface system development, *Expert Syst. Appl.*, vol. 37, pp. 3337-3343, April 2010.

[11] Ali BulentUsakli and SerkanGurkan , Design of a Novel Efficient Human–Computer Interface: An Electrooculagram Based Virtual Keyboard , IEEE transactions on instrumentation and measurement, vol. 59, no. 8, pp. 2099 – 2108, August 2010.

[12] Andreas Bulling, Jamie A. Ward, Hans Gellersen, and Gerhard Troster, Eye Movement Analysis for Activity Recognition Using Electrooculography, IEEE TRANSACTIONS on Pattern analysis and Machine Intelligence, vol. 33, no. 4, April 2011.

[13] Andres U beda, Eduardo Ianez, and Jose M. Azorin, Wireless and Portable EOG Based Interface for Assisting Disabled People, IEEE/ASME Transactions on Mechatronics, vol. 16, no. 5, October 2011.

[14] WatcharinTangsuksant, ChittaphonAekmunkhongpaisal, PatthiyaCambua, TheekapunCharoenpong, TheerasakChanwimalueang, Directional Eye Movement Detection System for Virtual Keyboard Controller, Biomedical Engineering International Conference, 2012.

[15] Shang-Lin Wu, *Lun-De Liao, Shao-Wei Lu, Wei-Ling Jiang, Shi-An Chen* and Chin-Teng Lin, Controlling a Human–Computer Interface System With a Novel Classification Method that Uses Electrooculography Signals, IEEE transactions on biomedical engineering, vol. 60, no. 8, pp. 2133 – 2141, August 2013.