IMPLEMENTATION OF ELECTROOCULOGRAM BASED HUMAN COMPUTER INTERFACE SYSTEM

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Abstract: Communication with surrounding world is necessary for the well-being of individuals with severe nervous system injuries or disorders. For instance, amyotrophic lateral sclerosis (ALS) deprives patients of their ability to speak and to move their extremities to control different devices, biomedical signals like EEG, EMG, EOG can be used. EOG based HCI has advantage over other signal based HCI. The current research paper focuses on EOG based Human computer interface system for controlling different devices. For that, it is required to develop the EOG signal acquisition system. The EOG signals are very small in amplitude, typically in millivolts. Hence, in order to generate the signals which are capable of controlling various devices, an amplifier with appropriate filters (for noise removal purpose) is required to be designed. This paper focuses on development of low cost EOG acquisition system and HCI system for controlling devices.

Keywords: Electrooculogram, Human Computer Interface, EOG acquisition system

I. INTRODUCTION

It is assumed that the population of people Aged 60 and beyond will range from one to three in 2030. People suffering from such miserable condition and living a cursed life in this advanced technological century. Science & technology must provide them a better quality of life by making them able to move without others help. Considering life span extension and the handicapped, the need for a rehabilitation device has been increasing [1]. Human computer interfacing (HCI) is a new modality to improve the life style of physically challenged and severely paralyzed patients. It can help specially them who have lost control over their muscles and may be sometimes cannot speak [2]. Several methods have been developed for detecting eye movement and blinking, including scleral search coils, electrooculography (EOG),infrared oculography and image based methods The EOG based methods are relatively more convenient, low-cost and easy to set up although the electrooculography sensors should touch the user’s face and can be uncomfortable. And for many applications, the accuracy of EOG based methods is adequate [3]. EOG signals appear over the skin surface (across the orbit) during the movement of the eye due to the difference in the dipole moment across the retina and the cornea of the eye Usually, EOG signal presents itself as an electric potential Having the signal peak amplitude in the range of 50 -3500 µV. The frequency of the EOG signal varies in the range of 0-35 Hz. As a review of the state of the art of electrooculogram (EOG) systems, there are several EOG-based HCI applications for different purposes in the literature. [4] In [1] authors developed a virtual keyboard that allowed the user to write messages and to communicate other needs based on EOG signals. Using this virtual keyboard user could type with a speed of 5 letters/25 seconds. In [5] authors developed EOG based communication systems based on 8 different types of movements with speed of speed of 12.1 letters/min. In [4] authors developed Labview based wireless EOG Based Human Machine Interface Control System for Motorized wheelchair. In [6] they Developed EOG based typing system for 8 types of distinct EOG patterns left, right, up, down, up-right, up-left, down-right and down-left. Their system achieved typing speed of 15 letters / min and an accuracy of 95.2%. In this paper, we have designed data acquisition module for EOG signal; which is simple, low cost and also useful for acquiring other biomedical signals like ECG and EMG as well. Then we have controlled device using different eye movements. Section II describes the HCI system implementation; section III provides insight on signal acquisition module; section IV discusses the EOG classification and device control using Labview followed by application module in section V.

II. HCI SYSTEM IMPLEMENTED

The HCI system implemented is shown if fig. 1. Disposable Ag/Ag-Cl electrodes were chosen for acquiring EOG signals, they are low cost & easy mounting electrodes. EOG can be measured by putting disposable electrode on region surrounding eye. There are two channels. (i) Horizontal channel (ii) vertical channel. Horizontal channel is for horizontal movement of eye like left, right. Vertical channel is for vertical movement of eye like up, down, blink. In fig. 2, left image shows the EOG measurement using Horizontal channel and right image shows the EOG measurement using Vertical Channel. Our system consist three parts:

- Signal acquisition
- Signal Classification
- Application/ device control

Fig. 1 Block Diagram of Implemented System
III. SIGNAL ACQUISITION MODULE

The signal acquisition module consists of an instrumentation amplifier (INA 128), low-pass and high pass filters and a notch filter. The description of them is given below.

A. Instrumentation amplifier

INA128 instrumentation amplifier with gain 1000 was used for amplifying signals as EOG signal is very low amplitude (millivolt) signal. INA128 is low power, general purpose instrumentation amplifiers offering excellent accuracy. laser trimmed for very low offset voltage drift and high common-mode rejection [7]. We can vary gain by simply changing resistance.

B. Low pass and High pass filters

EOG signal is a low frequency signal. To remove High frequency noise 2nd order sallen key low pass filter with cut off frequency $f_c = 27$ Hz was used. To remove DC drift, 2nd order high pass filter with cut off frequency 0.15 Hz was used. Fig. 3 (b) and (c) show the designed low pass and high pass filters.

C. Notch filter

To remove power line noise, notch filter with cut off frequency $F_c = 50$ HZ was used. Its design with typical component values is shown in fig. 3 (d).

At output of notch filter, we got waveform in DSO as shown in fig. 4 (a). The output of notch filter was applied to NI USB-6009. We used Labview software for displaying the acquired EOG signal. In Labview different eye movements acquired through EOG signal were classified. The commands in Labview have been designed according to eye movement. These commands were sent to the application module wirelessly via HC-05 Bluetooth module.
Fig. 4 Waveforms observed on DSO for (a) Continuous Blink movement; (b) Continuous up-down movement and (c) Continuous left-right movement.

Fig. 5 (a) shows the block diagram of EOG acquisition and display system using Labview. Fig. 5 (b) and (c) show the EOG signal waveforms displayed on Labview platform. Our system is also useful for acquiring other biomedical signal like ECG, EEG, and EMG. Fig. 5 (d) shows the acquired ECG signal through our system.

IV. EOG SIGNAL CLASSIFICATION AND DEVICE CONTROL

After acquiring EOG signal we must classify EOG signal according to different eye movements. Fig. 6 (a) shows the flow chart for left and right eye movement detection for horizontal channel. Fig. 6 (b) shows the same for vertical channel.

Fig. 6 (a) Flow chart for detecting horizontal eye movement; (b) flow chart for detecting vertical eye movement.
V. APPLICATION MODULE
The application module considered consists of a toy car with two DC motors, L293D motor driver and arduino UNO controller. This toy car is controlled wirelessly by EOG signals using HC-05 Bluetooth module. NI USB-6009 DAQ is costly. To reduce cost we should use microcontroller. Our EOG signal contains negative voltage. Our microcontroller can’t work with negative voltage. So 2.5 V is added through DC offset adder circuit. Output of DC offset adder circuit is applied to MSP430G2553 microcontroller. MSP430G2553 is 16 bit low power texas microcontroller. ADC10 is used to convert analog EOG signal into digital EOG signal, and EOG signal is transmitted to PC using UART.

![DC Offset Adder Circuit with 2.5 V](image)

VI. CONCLUSION & FUTURE WORK
In this work we have made EOG signal acquisition system. And we are acquiring EOG signal in LABVIEW and controlling device wirelessly through HC-05 Bluetooth. Now in future we will display EOG wave on Graphical LCD module and controlling device wirelessly without PC interface.

REFERENCES
[7] INA128 Datasheet