EOG BASED HUMAN MACHINE INTERFACE TO CONTROL ELECTRIC DEVICES USING EYE MOVEMENT

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Abstract:- Rehabilitation devices are increasingly being used to improve the quality of the life of differentially abled people. Human Machine Interface (HMI) have been studied extensively to control electromechanical rehabilitation aids using biosignals such as EEG, EOG and EMG etc. among the various biosignals, EOG signals have been studied in depth due to the occurrence of a definite signal pattern. Persons suffering from extremely limited peripheral mobility like paraplegia or quadriplegia usually have the ability to coordinate eye movements. The current project focuses on the development of a prototype motor wheelchair controlled by EOG signals. EOG signals were used to generate control signals for the movement of the wheelchair. As a part of this work an EOG signal acquisition system was developed. The acquired EOG signal was then processed 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 prototype motorized wheelchair model.

Keywords - Electrooculography (EOG), Eye movements, Rehabilitation aids, BCI, HCI.

I. INTRODUCTION

Bio-based HCI (Human Computer Interface) has the potential to enable severely disabled people to drive computers directly by bio-electricity rather than by physical means. A study on the group of persons with severe disabilities shows that many of them have the ability to control their eye movements, which could be used to develop new human computer interface systems to help them to communicate with other persons or control some electrical instruments. With improvement in technology, there is a vast development in the field of rehabilitation techniques. Research is going on to develop reliable, low cost and easy to use devices. Out of all the rehabilitation techniques, HCI (Human Computer Interface) and HMI (Human Machine Interface) are the latest and most effective techniques. Researches in these fields are being carried out extensively. The main objective of the HMI system is conversion of signals generated by humans through various gestures to control some electromechanical devices. While in HCI system some key strokes or cursor movements on the screen are controlled by using these signals. In HCI and HMI both biosignals and non biosignals are used as a medium of control. The chief biosignals used in the Interface are Electromyography (EMG), Electroencephalography (EEG) and Electrooculography (EOG). HMI is commonly used by motor impaired patients to control wheelchair.

Rehabilitation devices are broadly classified into two categories; the first category includes all those devices which are biosignal and the second category includes non biosignal based devices. Non biosignal rehabilitation aids provide 100% accuracy and require less training for patients but the usage of these devices is limited to patients with partial or complete flexibility in their body parts. Biosignal based rehabilitation devices mainly use biosignals like EEG, EOG or EMG as control signals. The advantage of using biosignal approach is that when patients become completely paralyzed, the only resource available to them then is biosignals. However it usually needs user training and has lesser accuracy than non biosignal approaches. The biosignal approach usually requires user calibrations because biosignals produced by each individual are unique due to difference in individual physiological properties and skin conductance.

II. LITERATURE REVIEW

Satish Kumar et.al, 2015 have proposed a low-cost Electrooculogram (EOG) acquisition system that can be used efficiently in Human Machine Interface (HMI) systems. The proposed system consists of an Op-Amp based EEG/EOG amplifier circuit and ATMega8 microcontroller for analog to digital conversion and transferring of acquired data to PC. In this system five electrodes are used to acquire eye blinking, horizontal and vertical eye movements. In this system, the signals are first captured using EEG surface electrodes, amplified, filtered and then converted into digital form before stored into PC. The acquired EOG signal provides different eye related activities. Depending upon these eye related activities various systems can be developed to perform different tasks in real world, which provides a degree of independence to the user [1].

Kousik Srathy Sridharan, 2012 in his thesis work has built a portable system to acquire and analyse electro-oculographic (EOG) signals in real-time. The system contains two sub-systems; a hardware sub-system that consists of the filters, amplifiers, data acquisition card and isolation and the software sub-system that contains the program to acquire and analyse the signal and present the results to the observer .In his work, one paradigm records only normal blinks while the other records long blinks and the results showed differences in detection and error rates. The observations made from performance tests at various levels gave satisfactory results and proved the usefulness of the system for sleep state and drowsiness detection [2].

A Saravananet, 2015 have designed a system which incorporates Texas embedded processor, wireless communication solutions and highly-customized analog front ends. As a demonstration of concept, this technology uses instrumentation amplifiers as analog front end and further single supply quad op-amp for analog signal processing in an effective manner [3].

W S Wijesoma et.al, 2005. In this paper a complete system is presented that can be used by people with extremely limited peripheral mobility but having the ability for eye motor coordination. The Electrooculogram signals (EOG) that results from the eye displacement in the orbit of the subject are processed in real time to interpret the information and hence generate appropriate control signals to the assistive device. The effectiveness of the proposed methodology and the algorithms are demonstrated using a mobile robot for a limited vocabulary [4].

Ali Marjaninejad, Sabalan Daneshvar, 2014. In this paper an EOG based low-cost real-time wheelchair navigation system for severely disabled people is present d using signal processing techniques, bio-amplifiers and a microcontroller driven servomotor. All the digital signal processing and execution of commands were performed utilizing a microcontroller which drastically reduced the total cost of this project. The servomotor has been synchronized with the computed eye direction resulted from processing the horizontal EOG signal. The speed of the wheelchair was also regulated with the same EOG signal. Performed tests indicated that in 98.5% of trials, subjects could navigate to their targets in presence of simple obstacles in their first attempts which confirm the feasibility of the proposed system [5].

III. SYSTEM DEVELOPMENT

The eye is known to have a resting potential and acts as a dipole in which the anterior pole (cornea) is positive and the posterior pole (retina) is negative as shown in the figure 1.1.The magnitude of this cornea-retinal potential is in the range 0.4-1.0 mV. This difference in potential can be explained by the metabolic activities in the eye. The Electrooculogram (EOG) signal thus is derived from the polarization potential, also known as the Corneal-Retinal Potential (CRP), generated within the eyeball by the metabolically active retinal epithelium. The CRP is produced by means of hyper-polarizations and de-polarizations of the nervous cells in the retina .Electrooculography (EOG) is a technique for measuring this resting potential. The resulting signal is called the Electrooculogram.

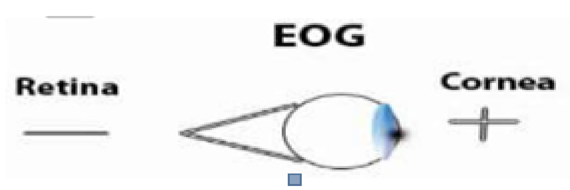

Fig. 1: Polarity of Eye

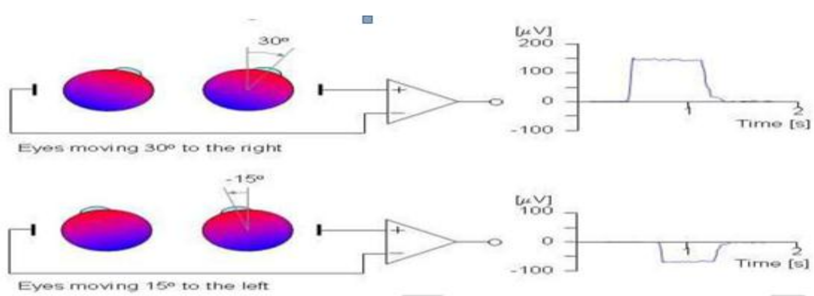

Fig.2: EOG signal based on eyeball movement

The amplitude of the EOG signal is known to be in microvolt range (15 - 200 uV) and most of the information is contained in 0 Hz to 38 Hz frequency range with dominant component in 0 to 25 Hz range. Specially designed electrodes for EOG are placed on the corners (lateral canthi) of both the eyes. When the eyes look left the positive end of the dipole (the eye) comes closer to the electrode on the left canthus and the negative end to the right canthus. The vice versa is observed for the eyes looking towards right. Ideally the difference in potential should be proportional to the sine of the angle the eye produces with respect to the central axis.

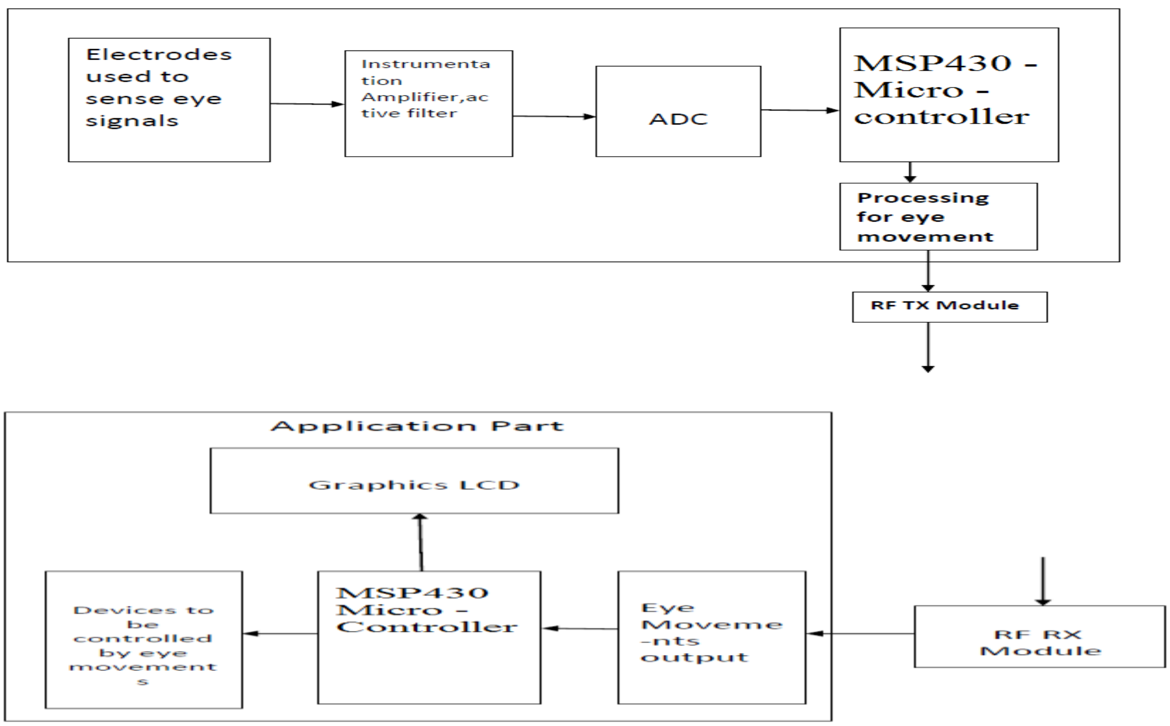

Fig. 3: EOG Block Diagram of the System

A. Method used for EOG based assistive technique

Basic Block Diagram of EOG based HMI system is given in Fig 4.

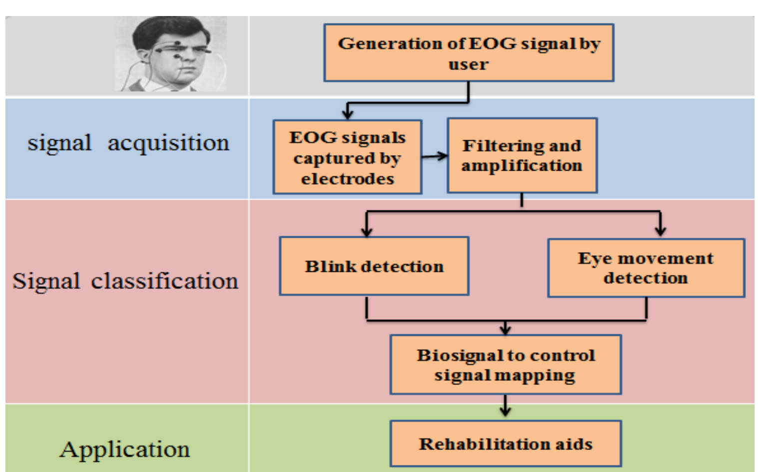

Fig. 4: Basic Block Diagram of EOG based HMI system

The development work involved three parts:

1. **Signal acquisition part** included development of DAQ.

2. **Signal classification part** included classification of basic eye movement types and blink.

3. **Application part** involved implementation of rehabilitation devices which can be controlled using EOG.

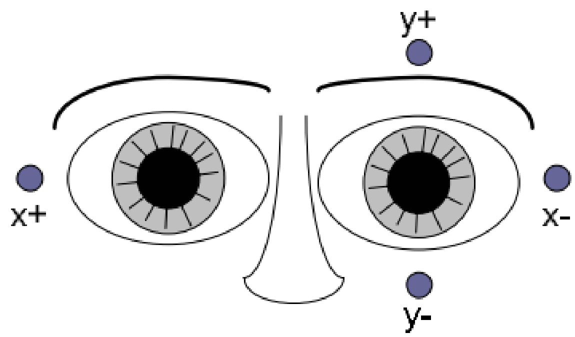

Fig. 5: Electrooculography electrode placements

EOG signals were measured by placing electrodes on the region surrounding the eye. They were recorded from two separate regions: horizontal and vertical. Horizontal electrodeswere for detecting horizontal eye movements (left and right eye movement) and vertical electrodes were for detecting vertical movements (up and down cornea movements).

B. ***Flowchart***

1) Flowchart for blink detection

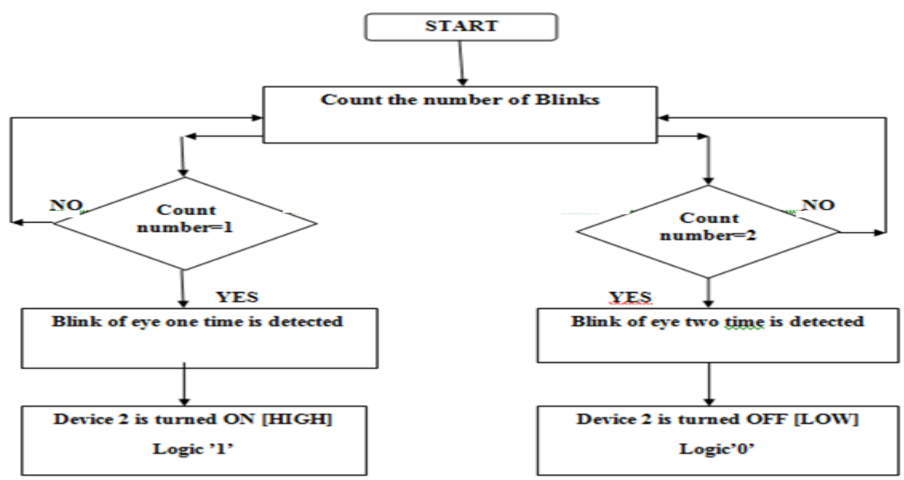

Fig. 6: Flowchart for blink detection

2) Flowchart for detecting right-left eye movement

An EOG signal corresponding to right-left eye movement was dominated in horizontal channel. Hence for easy analysis, right-left classification algorithm was applied to EOG signals form horizontal channel. Algorithms were carried out simultaneously and in parallel.

Right and left eye movement we experienced almost the same amplitude and the amplitude of EOG signal was around 290μv. But there was a slight difference in the voltage during movement of eye from right to left.

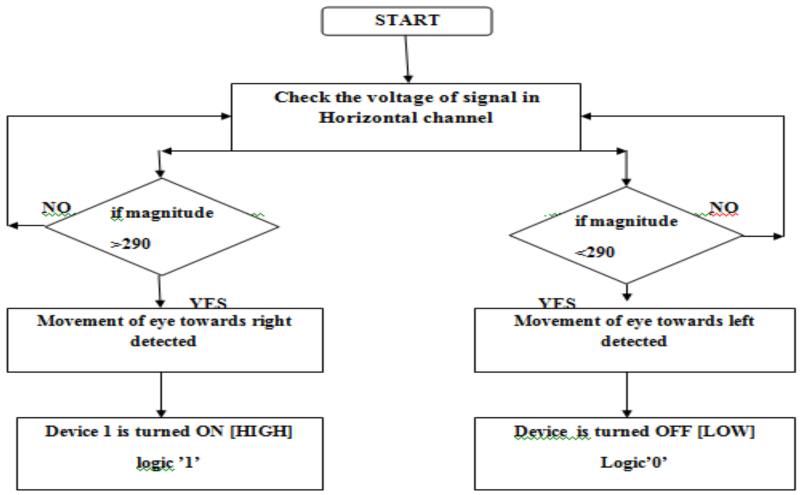

Fig. 7: Flowchart for detecting right-left eye movement

IV. RESULTS

In the present work, an EOG signal acquisition system has been designed and implemented. Additionally, a new 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 project, an EOG based Human Machine Interface has been developed. This HMI was able to generate control signals during various eye movements and blinks. The following figures below indicate the system results in for different eye movements.

A. 5.1 Eye movement detection

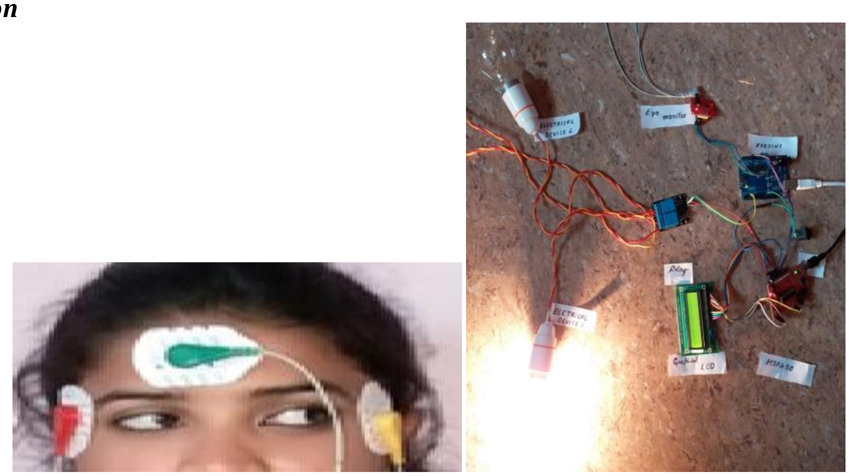

Fig. 8: Left eye movement was detected and device-1 is turned ON

The Fig. 8 shows movement of left eye and EOG electrode placement Vertical EOG signals and horizontal EOG signals were processed in parallel.Signal amplitudes were compared with the corresponding threshold values. Once it crossed the threshold, the duration for which it holds the threshold value was calculated. If both duration and amplitude condition were satisfied, it generated one control signal. Control signal was generated in such a way that it remained high for the next 2 seconds. Even though the input signal changed, its values did not vary during this time. This kept the system in minimum error and maximum control. The generated command signals were used to turn on the electric bulb and it is shown in Fig. 8.

B. Eye Blink sensor output

In blink detection, the comparator was used to detect blinking action. If amplitude of the signal was above threshold and pulse duration was within the range, it detected as blinking and device-2 is controlled .

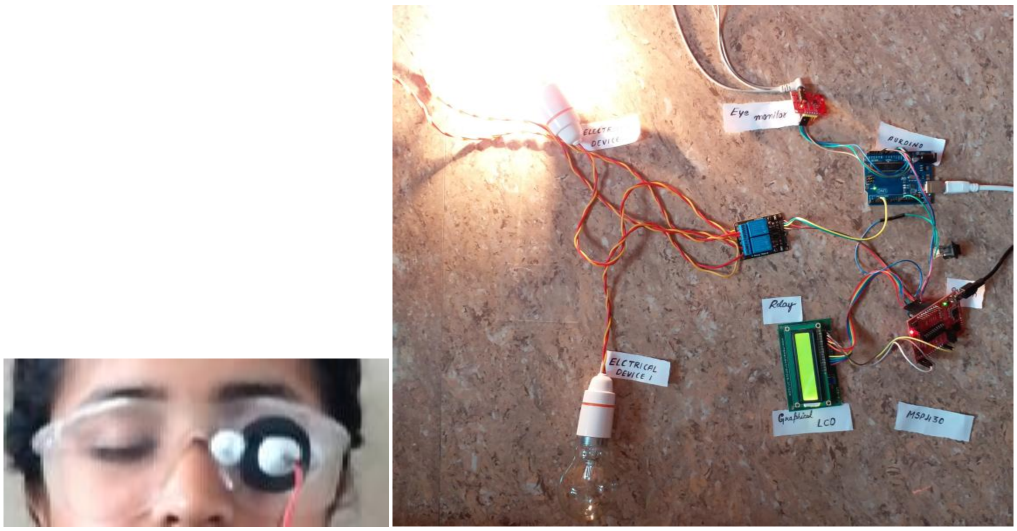

Fig. 9:Eye blink was detected and decive-2 is turned ON

V. Conclusions

In the present work, an EOG signal acquisition system has been designed and implemented. Additionally, a new 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 project, an EOG based Human Machine Interface has also been developed. This HMI was able to generate control signals during various eye movements and blinks. These control signals were used to control electric device model by various eye movements and blink. This EOG based HMI control system for electric device will be a good assistive technique for people suffering from extremely limited peripheral mobility. From the application point of view, control signals generated can be used to control HCI systems or other communication devices. As a whole, great prospects lie ahead for the current project which can be implemented with some further modifications.

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