A NOVEL ANALYSIS OF EOG THROUGH LABVIEW FOR PROSTHETIC ARM CONTROL SYSTEM DESIGN USING PIC MICROCONTROLLER

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***Abstract* – This paper aims at presenting a method to control and guide a robotic arm by means of ocular movement. The designed system allows a semiautonomous robotic arm to be commanded by a PIC microcontroller by using the biosignals resulting from eye movements, produced by the user through contractions of an arbitrary eye muscle, after suitably processing it using LabVIEW.**

***Keywords* – Human-Machine Interface (HMI), Electro-oculography, Prosthetic arm, LabVIEW, PIC microcontroller.**

I. INTRODUCTION

Human-Machine Interface is one of the most important aspect of Assistive technology that is designed specifically to rehabilitate an individual from his or her present set of limitations due to some disabling condition. Establishing an alternative channel through HMI for people with mild to severe paralysis or those with loss of upper limb is very much essential to carry out a normal life. There have been many efforts made for enabling such an interface. One such solution is a prosthetic arm fitted to the person controlled using a biosignal acquired from the person. The Electrooculography based HMI i.e, EOG controlled HMI is one of the most useful systems in Augmentative and Alternative aids for people with upper limb paralysis and amputees to communicate and control activities. Electrical signals arising from different parts of the body can be used as command signals for controlling prosthetic systems fitted to a person's body. This control of fitted device is possible if the person is able to generate the signal intentionally whenever required and also the HMI is able to understand and interpret it for further action. In this paper, a system has been designed that will aid people with upper limb disability to control the movements of a robotic arm to perform activities like grasping by using their eye ball movements.

II. ELECTROOCULOGRAPHY

Electrooculography is an electrical technique for recording movements of the eye. It is based on the fact that the eye acts as an electrical dipole between the positive potential of the cornea and the negative potential of the retina. In normal conditions, the retina has a bio-electrical negative potential related to the cornea. Thus, rotations of the ocular globe cause changes in the direction of the vector corresponding to this electrical dipole. Electrooculography is used to record an "electrooculogram" (or "EOG" for short) by attaching small electrodes to the skin around the eye. These may be attached at the inner- (closest to the nose) and outer- (closest to the nearest ear) corners of the eye.

The electrical potential between the two electrodes when the eye is at rest (i.e. not moving) gives useful information about the retina. When the eye moves the electrical potential between the electrodes changes and may be recorded continually over a period of time. This method can therefore be used to record and study how movements of the eye vary over a period of time.It is based on the fact that the eye acts as an electrical dipole between the positive potential of the cornea and the negative potential of the retina. In normal conditions, the retina has a bio-electrical negative potential related to the cornea. Thus, rotations of the ocular globe cause changes in the direction of the vector corresponding to this electrical dipole.

The recording of these changes requires placing five electrodes on the face around the eyes, as can be seen in Figure 1. This figure shows the position and names of each electrode used (VU, VL, HR, HL and REF). Two electrodes are placed on the right and the left of the eyes (HR and HL) to detect horizontal eye movement. Vertical movements of the eyes are detected by two electrodes placed on the top and bottom parts of the eye (VU and VL). The reference electrode (REF) is placed on the forehead, approximately in the FPz position of the International System 10/20. Finally, the ground (GND) is placed on the ear lobe.

If the eye is moved from the center position towards one electrode, this electrode receive signal from the positive side of the retina and the opposite electrode receive signal from the negative side of the retina. Consequently, a potential difference occurs between the electrodes. Assuming that the resting potential is constant, the recorded potential is a measure of eye position.

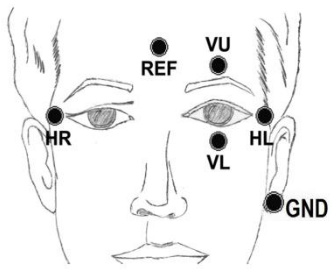


Figure.1. Electrode positions for EOG measurement.

III. MATERIALS AND METHODS

(A) WORK FLOW:

The proposed robotic arm control through EOG involves the following steps:

(i) Acquisition of EOG signal and amplification using Bioinstrumentation amplifier module.
(ii) Processing of EOG signal using LabVIEW software.
(iii) Generation of control signal for activation and control of the robotic arm using PIC microcontroller.
(iv) Activation and control of robotic arm.

The block diagram of the entire work is as follows :

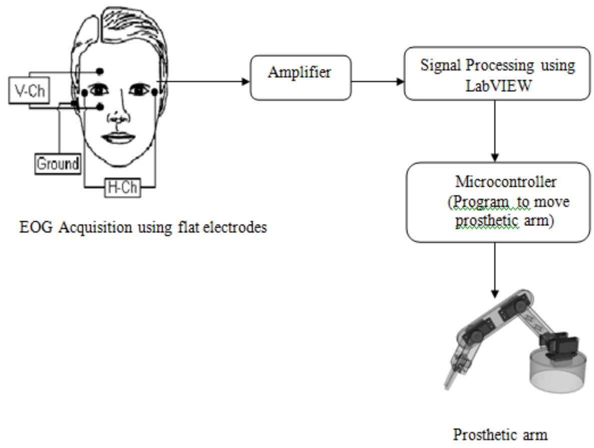


Figure. 2 Block diagram of the work done

(B) METHODOLOGY:

The EOG signal is acquired by placing flat electrodes with positioning as shown in the figure. 1. The acquired EOG signal is then amplified using a bioinstrumentation amplifier consisting of dual Op-amp and is further amplified using a differential amplifier. The amplified signal is then fed to a probe setup interfaced to a system with LabVIEW software by use of a DAQ assistant. LabVIEW is a very much user friendly graphical programming platform that helps to perform sophisticated measurements, test and control with ease.

A VI is created in the LabVIEW platform for detecting the positive and negative peaks and also a Matlab script is include for blink signal separation. Based on the peaks detected, microcontroller generates a control signal to the motors for activation and control action of the prosthetic robotic arm. The microcontroller is programmed using Embedded C language.

A regulated power supply of 12 V is given to the motors through relay and 5 V is given for the microcontroller. A 230 V / 50 Hz step-down transformer is used as power source.

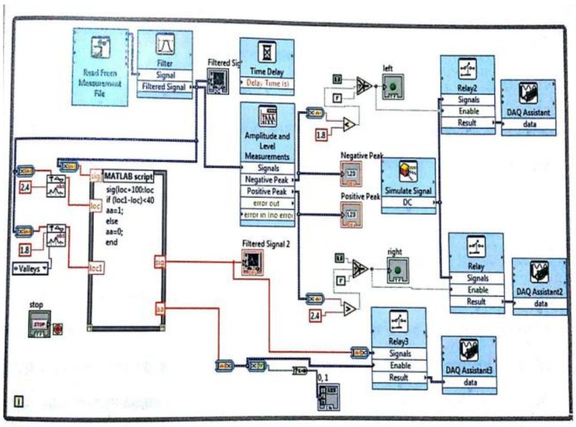
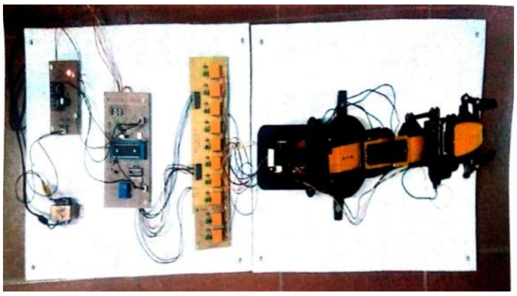


Figure.3 VI created in LabVIEW

The photograph of the entire setup is given below :



IV. RESULTS AND DISCUSSION

The EOG signal was obtained for three persons by placing electrodes in HL and HR (Horizontal Left and Horizontal Right) positions and Forehead as reference and auricular point for ground.

The EOG signal waveform obtained from end output of VI created for one subject taken for the right, left ocular movements and a blink signal is as given below :

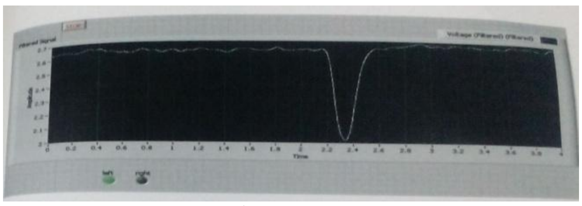


Figure.4 Left eye movement signal

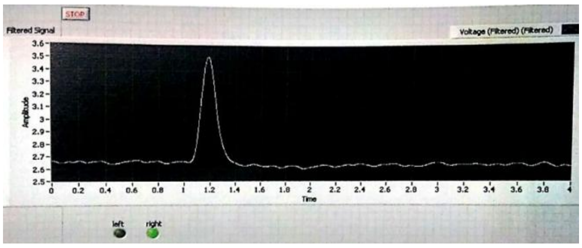


Figure.5 Right eye movement signal

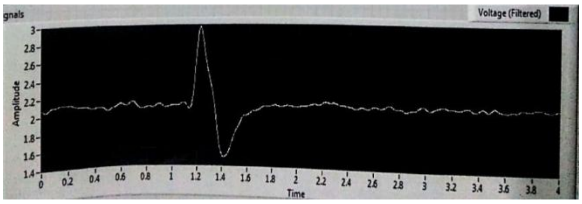


Figure.6 Blink signal

The threshold values for the left and right eye movements and blink signal that are given as control signal for activation of the robotic arm are as follows:

Subject	Direction of Eye movement	Threshold
1	Left	2.3
	Right	3.2
2	Left	2.3
	Right	3
3	Left	2.5
	Right	2.7

V. CONCLUSION

A low cost robotic arm was thus designed and activated using EOG signal. Eye movements require minimum effort and allow direction selection, has increased response. Also, progressive illness that affects the motor system often leaves the ocular movements preserved for a relatively long time. This remains the main reason for the users to choose an EOG based system design as a more reliable HMI.

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