Assistive Interactive Device using Electro-Oculography

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Abstract— Detecting eye signal with different eye movement is a difficult task. By implementing this technique as an application for the paralyzed person those who cannot make any body movement or cannot speak. Human brain mainly works on electric signals transmitting all over the body to send the information in order to operate the body parts. Even while rotating eye ball body increases or decreases the resistance near eye area. This variation in electric signals can be measured using EOG dry electrodes. A brain-computer interface (BCI) in a set of hardware devices to reach an interface human brain/computer. This new communication channel only uses brain waves; consequently, it is particularly suitable for Paralyzed person. This project will help paralyzed person to overcome their problem by communicating with doctors through EOG based device.

Keywords: Brain-Computer Interface, Electrooculogram, EOG acquisition, natural eye movement detection, Signal Conditioning

I. INTRODUCTION

Nowadays there is an increasing need for assistive technology to help people with paralyzed disabilities in order to make them comfortable to communicate with their surrounding people. Life of disable patient can make cozier with the help of Assistive Technology. Many researchers are doing research for different kind of assistive devices for disable or paralyzed patients. Due to different assistive device available the life of patients change from dependent to self-dependent that is they live autonomous lifestyle. Progress in the world of computer also make easy to develop computer handling application. Taking into consideration the increase in number of disable or paralyzed person the need of Human Computer Interface is important to make standard of living more convenient.

The Interface that provides control by using computer is called as Human Computer Interface. Various advance in embedded and sensors technology made easy to design different assistive devices. Cost effective device are develop due to advance in technology.

Human computer interface based new low cost system has designed especially for the paralyzed person with only eye motor coordination. This system provides the use of eye movement with limited motor control, which helps in communication because of its modularity and this system has various application as this device is made of low cost as shown in paper[1].

EOG based system is made with the help of cornea retinal potential. On the basis of cornea retinal potential in paper [2] presents different gestures that help speech disable person to convey that message to their colleague as shown in paper [2]. In paper [8] the virtual keyboard is presented through which patient can communicate with the doctors with the eye movement. The system made in this paper can be used to maintain the signal originality and the noise reduction. In paper [4] the different EOG signals are noticed for different person for same threshold value. For real time application use the position of electrode should be constant. In paper [5] the contact impedance of electrode with skin interface and the corresponding noise characterization has been presented.

A. *Worldwide Scenario:*

In the past days, the electrodes were embedded directly in the subject/user brain; later the signal is acquired from the user scalp. Despite the presence of several methods to acquire brain signals, the mostly used method is the electro-oculography (EOG) because of its non-invasive, portable, inexpensive behaviour and it can be used in almost all surroundings. Moreover, low cost and increasingly portable EOG equipment have been developed in the last years. There are many devices available in market as an assisting product like mind-flex, emotive, mindsets etc. But they are very expensive and thus common man can't afford those. Thus in past years many of the researchers were worked on issues related to assisting devices using bioelectrical signals. The chief application of the EOG is in the detection and measurement of eye movement. EOG based recording techniques are simple and cheaper than any other methods and can be recorded with minimal worry.

B. *Electro-Oculography:*

Electrophysiological testing of patients with retinal disease began in clinic departments, the electro-retinogram was being divided into component parts and early intra-retinal electrode studies were used to tell about which cells or cell layers gave rise to the various components. A little after the introduction of the ERG as a test of the state of the patient's retina, another diagnostic test called the "Electro-oculogram" (EOG) was introduced to the clinic (Arden et al., 1962). The EOG had advantages over the ERG in that electrodes did not touch the surface of the eye. he changes in the standing potential across the eyeball were recorded by skin electrodes during simple eye movements and after exposure to periods of light and dark. Over the years ERG recording techniques have become progressively more sophisticated in the clinics.

C. *Eye Structure:*

Vision is one of our most valued senses and during the course of each day our eyes are constantly moving. Attached to the globe of the eye, there are three antagonistic muscle pairs, which relax and contract in order to induce eye movement. These pairs of muscles are responsible for horizontal, vertical and torsional (clockwise and counter clockwise) movement.

Two specific categories exist which can be used to classify the four different types of conjugate eye movements:

1) Reflex eye movements - These provide stabilization of eye position in space during head movement.
2) Voluntary eye movements - These are conscious eye movements involved in the redirection of the line of sight in order to pursue a moving target (pursuit movement) or to focus on a new target of interest.

D. Scientific Principle:

The movement of each eyeball in its orbit is caused by the contractions of six voluntary muscles attached to the surface of the eyeball. Four of the six muscles run straight from origin termed as recti muscles: the superior rectus, the inferior rectus, the medial rectus, and the lateral rectus. The remaining two muscles are attached to the eyeball surface called as the superior oblique and the inferior oblique, Contractions of the recti muscles are controlled by way of motor pathways in the brain

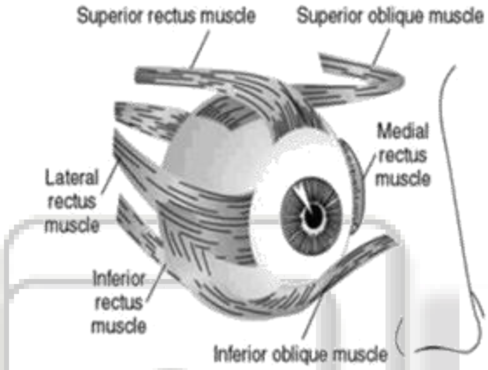

Fig. 1: The Muscles Controlling Eye Movement

And three pairs of cranial nerves. Voluntary eye movements are initiated and controlled in the motor cortex of the frontal lobes. Cortical activity associated with motor control of the extra ocular muscles can be detected and recorded using conventional electroencephalographic techniques. Electrooculography (EOG) is the measurement and interpretation of electro-oculogram, which are the electroencephalographic tracings obtained while the person, without moving the head, moves their eyes from one point to another.

E. Electrodes Placement:

The placement of electrodes is shown in the figure below. We are using disposable ECG electrodes for our experimental setup due to availability and the low price. The acquisition system employs Ag - AgCl surface electrodes for signal pickup which requires application of sufficient electrolyte gel to reduce the skin impedance

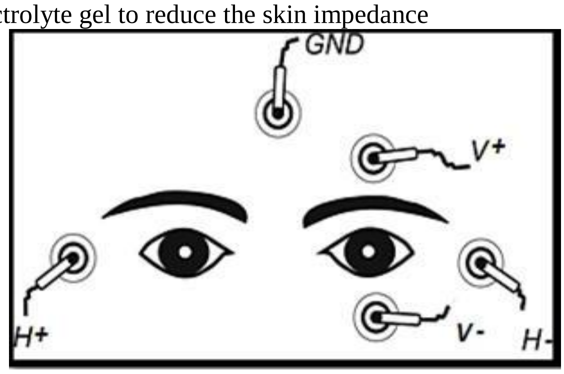

Fig. 2: Electrodes Placement

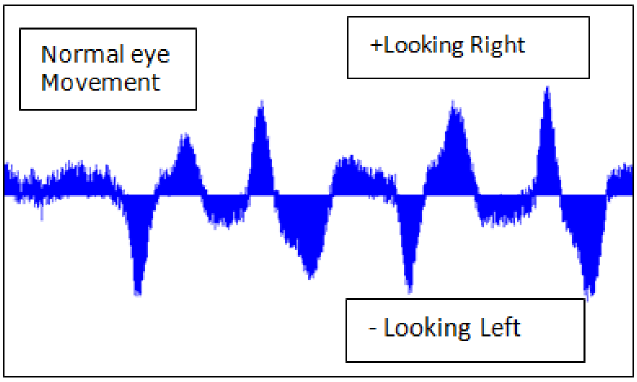

Fig. 3: Resulting Eye Signal

II. METHODOLOGY

In the proposed system signal amplification circuit is used for amplifying the eye signal in in order to remove the noise or error. The basic building block for acquisition of EOG signal. Instead of using Instrumentation amplifier in our system we are using AD620 due to its best result and availability in market. For measuring signal the three electrodes are used which are place to the left, Right and center to the eye. Positive electrode of horizontal channel was placed on the right side of the canthus of right eye while, negative electrode of horizontal channel was placed on the left side of the canthus of left eye. The reference electrode (Ref) was placed on the forehead.

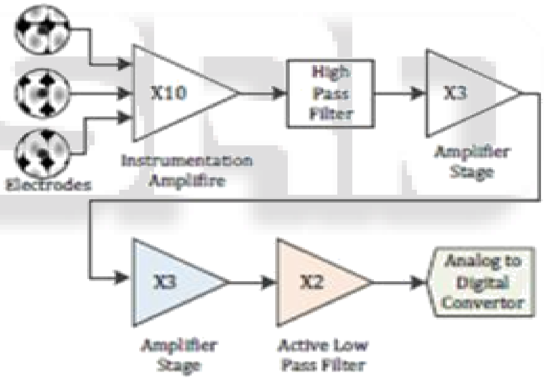

Fig. 4: Basic Building Blocks for Acquisition of EOG Signal

Instrumentation amplifier is use to amplify the low level signal up to enough voltage level. As discussed earlier like all biological signals the EOG has very low amplitude of around 0.05 mV to 3.5 mV. 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. As we know that EOG signals' frequency from 0 to 40 Hz; and generally as discussed filter of band 0.01 to 50Hz is designed. To remove power line noise notch filter of 50Hz frequency is designed. We are using only low pass filter

III. CIRCUIT DESIGNING

For the acquisition and the amplifier circuit, there are many instrumentation amplifiers are available in the market, conventionally the instrumentation amplifier used is the IC 741, but as the EOG signals are concern the frequency as well as the voltage difference is so small that it is difficult to achieve the amplification with conventional 741 instrumentation amplifier, thus we have simulated the results by using different instrumentation amplifiers which are used in the biomedical instruments such as INA126, INA122, INA118, AD620 etc. so in our design we have used the AD620 instrumentation amplifier IC which is three op-amp design with a good accuracy, whose output is amplified with just the single external resistor.

A. *Signal Acquisition Process:*

In general, the signal (or data) acquisition process has 3 steps.

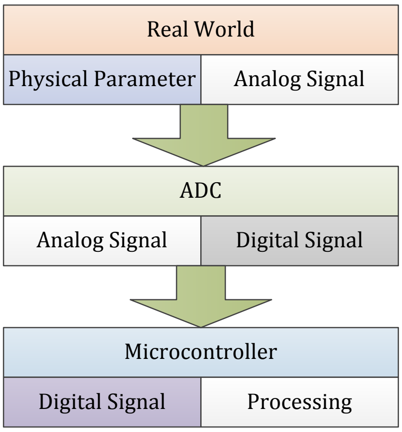

Fig. 5: Signal Acquisition Process

1) In the Real World, a sensor senses any physical parameter and converts into an equivalent analog electrical signal.
2) For efficient and ease of signal processing, this analog signal is converted into a digital signal using an Analog to Digital Converter (ADC).
3) This digital signal is then fed to the Microcontroller (MCU) and is processed accordingly.

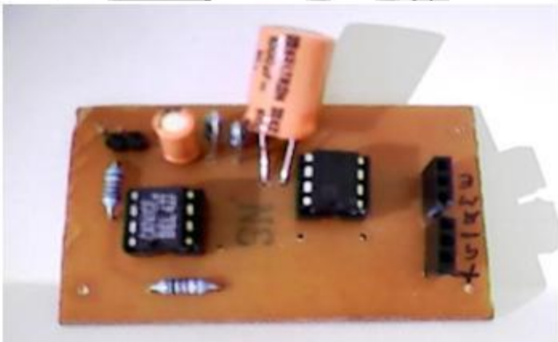

Fig. 6: Amplification Circuit

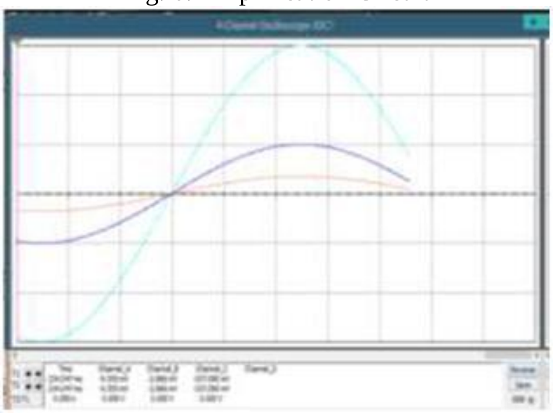

Fig. 7: Simulation of AD620 Amplification Circuit

The circuit is implemented on the breadboard and the results are observed with the help of the Oscilloscope, the inputs are generated with the help of two signal generator and the working of circuit is verified, the output is the amplified version of difference of two inputs. The basic RC filtered output is also noticed.

IV. RESULT AND CONCLUSION

The implemented system is useful for those people who are unable to do task on their own. This system would help to lead an independent and comfortable life for those of differently-able people along with the normal ones having a feeling of equality. The disabled, in particular, have serious problems with their own Activities of Daily Living (ADL), for which some assistive devices or systems would be very useful to improve their quality of life.The main objective of this study is to analyze the different eye movements of user and based on the study, predicting the direction respectively. A new device which comprises of dry EOG electrodes can be designed as a future work with the help of design using AD620 acquisition and filter circuit as discussed in the paper, making a step forward in the way to obtain a commercial EOG interactive device. The filer circuit can also be designed which will again improves and smoothen the results.

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