Approach of Thought Control using Electro-Oculogram Signal for Different Eyeball Positions

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Abstract— In this era of science and technology anything can be controlled with mind activities especially for the differently able persons. This paper depicts the approach of implementing mind controlled work. Electro-oculogram (EOG) is an electrical potential that can be detected using bio-electrodes and it is linearly proportional to eyeball movement. This technology is based on the principle of recording the Cornea-Retinal potential (CRP) which is the resting potential between the cornea and the retina. EOG signal gives the way to allow the handicapped, especially those people with only eye-motor co-ordination to live more independent lives implementing the thoughts arising on their mind.

Key words: Biomedical Signal Processing, Eyeball Movement Analysis, Eletro-OculoGram (EOG), Cornea-Retinal Potential (CRP), bio-electrodes

I. INTRODUCTION

Electro-oculography is a technique for measuring the cornea-retinal standing potential that exists between the front and the back of the human eye. The resulting signal is called the electro-oculogram. Primary applications are in ophthalmological diagnosis and in recording eyeball movements. Unlike the electro-retinogram, the EOG does not measure response to individual visual stimuli[1].

To measure eyeball movement, pair of pre-gelled bio-electrodes are placed either above and below the eye or to the left and right of the eyes. If the eye moves from center position towards one of the two electrodes, this electrode detects the positive side of the retina and the opposite electrode detects the negative side of the retina. Consequently, a potential difference occurs between the electrodes. Assuming constant resting potential, the recorded potential is the measure of the eye’s position. EOG signal is based on the dipole within the eye. It is basically the electrical signal produced from the potential difference of the cornea (positively charged) and the retina (negatively charged). There is a steady corneal-retinal potential from the back of the eye to the front of the eye. This steady dipole may be used to measure eye potential by placing surface electrodes around the eyes. When the eyes are looking straight, the electrodes are spaced equally from the eyes will be at right angle with the eye’s electric field which will result in output to be zero. Due to the movement of the eyes, there is a direct current voltage shift experienced which gives the EOG signal.

The most important factor that makes EOG far better than other bio-signals is a linear relationship of EOG signal over the eyeball movements.

II. METHODOLOGY

A. Block Diagram of the EOG Signal Acquisition Model:

Fig. 1: Block diagram of EOG signal acquisition model

Amplification gain is needed while working with bioelectrical signals. In order to obtain an EOG signal, differential amplifiers are tools perform as an electronic filter that amplifies the difference between two voltages[2]. INA118 is used which is an instrumentation amplifier and one of the best options out there for biomedical systems. For this, 3-op amp is designed in such a way to make it powerful tool with high gain and high CMRR (Common mode Rejection Ratio), making it a perfect solution for this purpose. The 110db CMRR of INA118 at a gain of 1000 removes some noise by eliminating common signals that go in both inputs. Noise reduction is a process of removing unwanted perturbation of a signal which is not needed. Low-pass filters in an EOG circuit are needed in order to block higher frequencies. A low pass filter is one that passes low frequency signals but attenuates signals with frequencies higher than the determined cutoff frequency[4].

There is a resting potential between cornea and retina of the eye. This potential varies depending on several factors such as light, eyes’ size, skin conductivity, etc. After amplification process, the resting potential is well amplified, but it is something which is not wanted on the EOG signal. In this work, the system is able to read the eye’s horizontal movements and it’s therefore measured as a signal with a slope. For removing this unwanted DC offset and to be able to read only the slope in the waveform, a small capacitor is added. Current is defined as the capacitance times the rate of change of the voltages that passes through a capacitor, hence when the derivative of the constant potential is zero, that is, the derivative of a constant value is = 0. Thus, the capacitor is going to be equal to zero.

The voltage follower enables to connect higher source impedance device than the EOG output’s impedance which is useful to connect a meter or any other device used for troubleshooting. It is used with a gain of zero.

An operational amplifier needs an offset so that it can work correctly while working with positive and negative voltages. By adding a simple offset, it would make the reading unstable because of the fact that the resting potential in the electrodes is not constant, but depends on several environmental factors[3]. For this dual polarity op-amps are needed which is positive and negative voltage with respect to virtual ground. For lower costs and complexity, 7805 voltage regulator is added to eliminate the need for dual power supply.
With Lab view, the eye movements using electro-oculography (EOG) is easily detectable. It is a biomedical technique based on picking up signals from electrodes which are placed around the eyes. Users who can’t manipulate a mouse or track pad with their hands can move a cursor on a computer monitor with the help of the EOG signal interfaces [Fig.1].

**Fig. 2: Schematic diagram of EOG signal acquisition**
The detection unit consists of two electrodes. In this case, pre-gelled electrode has been used [Fig. 3].

**Fig. 3: Pre-gelled Electrodes**
A pair of electrodes detects the signal from the desired location on the skin surface [Fig.4]. The two electrodes placed at the active portions of the surface to reduce the noise. A conducting gel or paste is required to improve the electrical contact between the skin and electrodes for reusable electrodes.

Some advantages are:
- High efficiency: the sorting speed can be very high.
- High precision: the margin of error can be reduced to great extent.
- Good quality and low failure rate with long life.
- Reliable operation and maintenance.

**III. RESULTS**
An Electro-oculogram or EOG is the resulting signal of the potential difference caused by eye movements. The voltage difference is measured between the cornea and the retina. The resting potential ranges from 0.4mV to 1mV and a pair of electrodes are commonly used to detect this signal, but the voltage difference when there’s an eye movement can be as small as micro volts. Depending on the eyes’ position, different waveform graphs[Fig.4,5,6] are obtained. Therefore, the recorded signal is either negative or positive when moving the eyes.

**Fig. 4: Graph of slow eyeball movement**

**Fig. 5: Graph of eyeball movement towards left eye**

**Fig. 6: Graph of eyeball movement towards right eye**

**IV. CONCLUSION**
Utilizing the bio signals achieved from the eyeball movement, processed with digital control system the total idea can give a perfect impact on the social matters regarding handicapped, helpless people to improve their special ability for a better life.

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**REFERENCES**