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Wheelchair Movements Control Using Eog

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Abstract
The number of disabled people is rapidly increasing, with the most common cause being the inability to control limbs as a result of an accident is the immobility's root cause. The inability to move impedes the people from their daily routines as well as makes them socially isolated. We will discuss in this paper about the wheelchair prototype model where the movement is controlled by EOG, a type of electro-physiological signal, generated by eye movements. The proposed prototype's performance is evaluated on its efficiency and accuracy. The proposed prototype is cost efficient because EOG signal acquisition is very simple and economical. One of the key techniques of the method is the acquisition of EOG signals. This paper describes an effective auxiliary method for mobilization, in order to improve the standard of living of people who are afflicted with quadriplegic in particular. These people rely on others for survival on most of the time for mobility. This product includes EOG acquisition, amplification, and digitalization, and feature extraction, separation of signals, normalization and wheelchair movement control. Python is used in signal analysis and control. Python is also light, which reduces the amount of computing hardware required.

Key words: paralysis, mechanized wheelchair, electro-physiological signal, acquisition, ElectroOculoGram (EOG), digitalization, python (Computer software).

1. INTRODUCTION

The most common cause of immobility is paralysis, which can be due to damaged nerves in the body. Multiple sclerosis, spinal cord injury, stroke, serious accidents, and other conditions that cause paralysis [1] are examples. According to one study, one out of every 30 people suffers from paralysis, which equates to approximately 7.1 million people worldwide. Various aids have become available as technology and devices have advanced for the purpose

of regaining mobility functions. The use of bio-potential [2] is an effective method in the field of rehabilitation for the disabled people. Due to different factors for communication and control, electro-oculogram [3] is considered to be the most effective signal over other bio-signals. Many smart wheelchairs rely on EEG signals [4] and voice-directed movement [5] for mobilization and speed control [6].

The eye is the sight-giving organ. The cornea, iris, pupil, lens, retina, optic nerve, chloride, and vitreous are some of the components of the eye. It is a most effective method for mobilizing people and improving their quality of life. In this regard, research into Human Machine Interaction [7] is critical in terms of improving the quality of life for such patients.

An electro-oculogram (EOG) [9] measures the potential difference between the cornea and the retina during eye movements [8]. EOG can be used to control the movement of an automated wheelchair [10], as well as home appliances and other devices. Several medical systems have been developed to help patients [11] through the use of EOG. Horizontal and vertical eye movements, as well as two blinking signals [12], are used to control wheelchair movements [13].Eye movements cause the EOG signal to be produced [14]. EOG uses a silver chloride electrode to measure the electrical potential around the eye, which is then combined with an appropriate amplifier circuit and processing software to produce an HMI [15].

2. REASONS OF USING EOG

Electro-oculogram is typically used to measure eye movements [16]. The goal of our project is to control wheelchair movements with eye movements [17]. The electro-oculogram method is significantly less expensive than other methods. The electro-oculogram technique is extremely accurate. When the eye is closed, such as when sleeping, the electro-oculogram technique is used to measure it [17]. When compared to other techniques, electro-oculogram gives more accurate readings and have lower noise.

ELECTRODE PLACEMENT:

Round surface electrodes, such as silver or silver chloride electrodes (Ag/AgCl), are used to measure EOG signals. The signal is obtained by placing five electrodes around the eye. There are two for horizontal, two for vertical, and one for reference [18]. Figure 1 depicts the electrode positions.

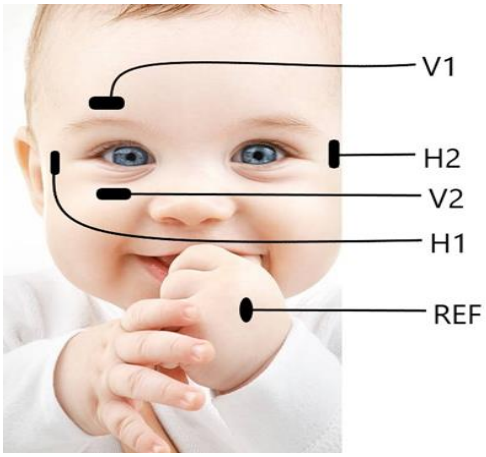

Figure 1 Electrode Placement for EOG

H1, H2 = Horizontal Channel

V1, V2 = Vertical Channel

3. METHODOLGY

The method is comprised of three major steps: signal acquisition, signal classification, and wheelchair movements.

Figure 2 Steps involved

The following are the execution steps:

1. Take an EOG signal for horizontal and vertical movement.
2. Investigation of analogue signals.
3. Signal digitization for processing.
4. Extracting features.
5. The Python platform separates the movements using the threshold [19].
6. Wheelchair movement can be personalized.

4. EOG ACQUISITION CIRCUIT:

The EOG acquisition circuit is made up of two instrumentation amplifiers, dc voltage supply units, and filter units.

InstrumentationAmplifier:
Instrumentation Amplifier is a type of amplifier that is used to amplify very low-level signals. It is essentially a differential amplifier that amplifies the difference between the input signal and the output signal.

Instrumentation amplifier specifications:

- High precision with high input impedance, low cost, low DC offset, low noise, and very high open – loop gain.
- High CMRR: greater than 100 dB
- Create a virtual ground as a reference to provide constant positive and negative voltage.
- Amplification of the difference between two electrodes by removing common-mode noise.

The amplifier used is the AD620 [20] i.e. shown in figure 3, which is more suitable for bio-signals than other amplifiers. The AD620 is a low-cost, high-accuracy instrumentation amplifier with a single external resistor that can be used to set gains ranging from 1 to 10,000.

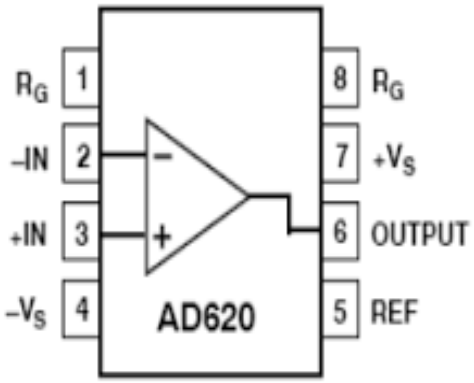

Figure 3 EOG - Instrumentation Amplifier

DC voltage supply:

- A voltage divider is used to create a virtual ground in a DC voltage supply.
- To avoid the loading effect, the OP-Amp LM358 [21] is used as a buffer.
- Creating a virtual ground as a reference to provide constant positive and negative voltage.
- Capacitors are used to filter the output ripple effect.
- Capacitors have a low power consumption (0.02W).

Filter units:

The filter unit is made up of an active high pass and an active low pass filter, both of which are powered by the LM741 op-amp [22] shown in figure 3. The Active High Pass Filter attenuates frequencies below the cut-off frequency while passing signals above it. It's just a passive filter section followed by a non-inverting operational amplifier. The Active Low Pass Filter attenuates frequencies above the cut-off frequency while passing signals below it. A DC-coupled high gain electronic voltage amplifier is an LM741 operational amplifier. Inside, there is only one op-amp.
As a comparator, an operational amplifier integrated circuit (IC) compares the two signals,

inverting and non-inverting. This IC's primary function is to perform mathematical operations in a variety of circuits.

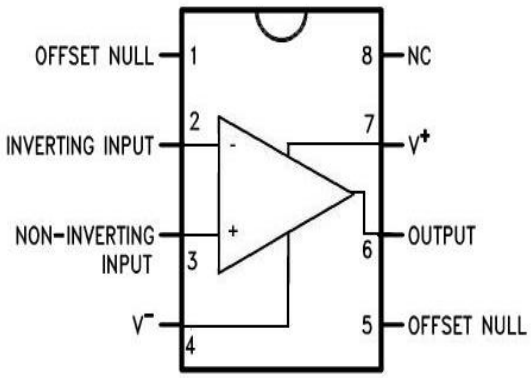

Figure 4 Filter for noise reduction - LM327

SIGNAL CLASSIFICATION

Setting threshold values allows the above-mentioned circuit's signal to be classified. The values obtained during signal analysis are used to calculate these thresholds. The voltage peak values of the signals are shown in Figure 5.

DIRECTION	POSITIVE PEAK(mV)	NEGATIVE PEAK(mV)
RIGHT	460 - 480	310 - 325
LEFT	440 - 450	350 - 370
UP	515 - 550	220 - 270
DOWN	490 - 510	315 - 290

Figure 5 Signal classification (mV)

WHEELCHAIR MOVEMENT

The signal acquired from the movement of eye is very low and it is amplified using the amplification circuits consisting of instrumentation amplifiers [23]. Further to combat the trade-off between gain and noise, another hardware filter LM741 is included in the circuit. Finally, we get a clear waveform of EOG.

This waveform is fed into the Raspberry Pi [24], the waveform is normalized as to operate the motors. An H-bridge driver circuit [25] is utilized to control the movement of the motors in the wheelchair setup. A 12v battery is equipped to quench the power necessary for the motors to pull the load.

A separate circuitry which converts the given input to desirable (Pulse Width Modulation) PWM [26] is embedded to the setup. The input is taken from the EOG waveform.

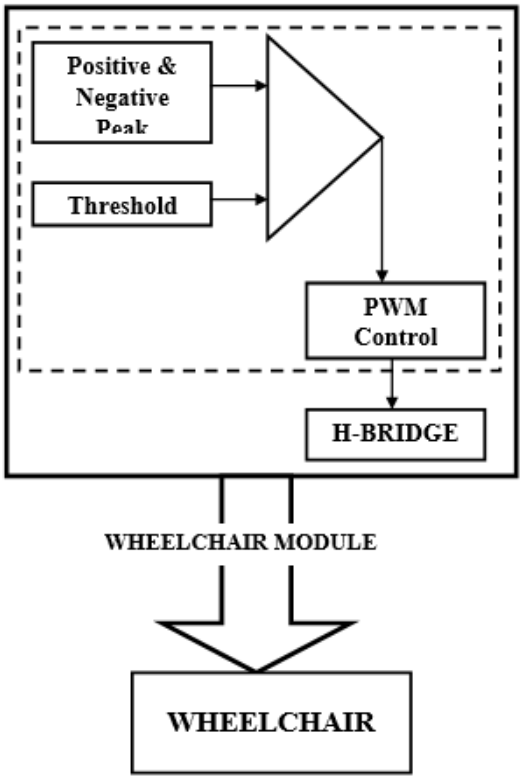

Figure 6 Wheelchair module

A positive and negative threshold defined peak detection algorithm is coded in python [27]. The output is appropriately converted into PWM that enables the navigation in the wheelchair. The speed of the wheelchair movement can be controlled based on a predefined eye moment pattern that will be taught to the user during the training phase.

5. BLOCK DIAGRAM:

Figure 7 depicts the project's block diagram. The electrodes must be properly positioned. The EOG signal is then obtained from the eye movements by using the electrodes on the surface. Following that, the signal went through the amplification and filtering stages. The signal is then routed to the instrumentation amplifier AD620, which is followed by the filter units (high pass filter and low pass filter) for amplification and noise reduction. The Analog to Digital converter converts this analogue signal to digital values. The analog signal is then fed into the MCP3008 [28] (Analog to Digital converter). Following the conversion of the signal, the digital values were passed through the raspberry pi. Analyzing digital values to classify

horizontal and vertical eye movements. The python software is used to classify the signals by setting certain threshold values. After classification, this is fed into the wheelchair module as input. The wheelchair module follows, which controls the wheelchair's movements.

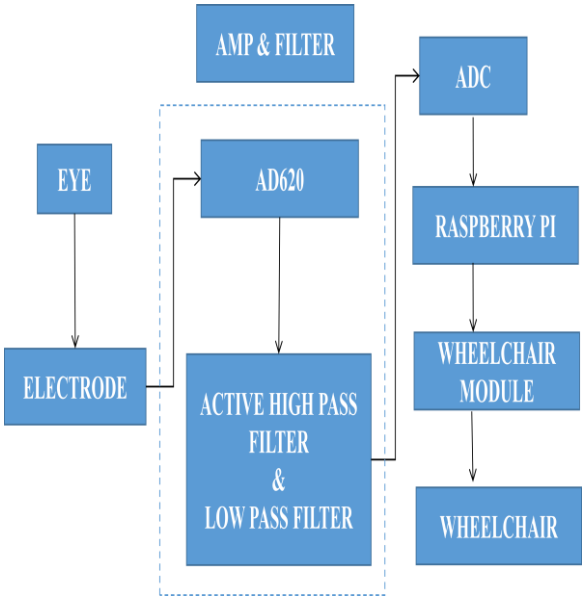

Figure 7 Block diagram

6. RESULT AND DISCUSSION:

The EOG signal was very informative in tracking the movement of the eyeball. A dual instrumentation amplifier with low nose and high precision was used in the circuit to extract the meaningful EOG data leaving out the noise introduced. The natural artifacts were studied and nullified in the amplification unit. Thus obtained bio-signal

was given a shift in amplitude such that the negative value is clamped using a simple circuit. This made further processing using raspberry possible. Through an analog to digital convertor, the data is fed to the raspberry pi which instantaneously analyzed the deviation in the bio-signal. A threshold as explained was set which differentiated the various movements. These direction informations were fed into a motor driver circuit of the wheelchair unit. Appropriate amplification along with the motor control unit was simultaneously used to control the wheelchair navigation. To access various other options such as the speed control patterns were programmed such that blinking thrice followed by right eye movement will increase the speed abs similar such conditions were programmed and successfully validated in the prototype model.

Waveform obtained

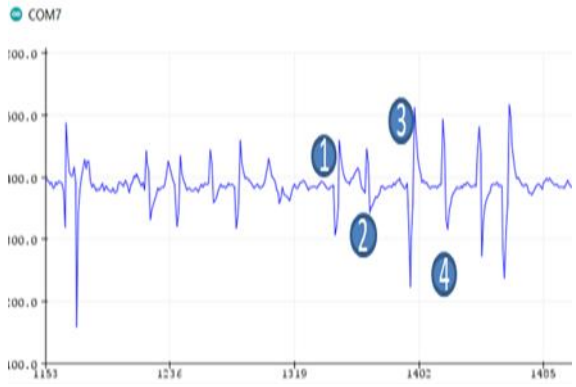

Figure 8 waveform recorded

1. Rightward 3. Upward

2. Leftward 4. Downward

These waveforms are classified using the recorded amplitude mentioned in figure 5.

7. CONCLUSION

Patients with conditions that affected their limbs often relay on another person for their movement. The proposed system curbs this inefficiency by simply using a couple of electrodes and an electronic setup through which a wheelchair can be controlled. This system can be used various other purposes, a future scope is studying the EOG in detail and create precise patterns with which the pi will be trained to perform various activities including the control of prosthetics.

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