Single Channel EOG Signal Processing and Features Extraction using Virtual Instrumentation

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***Abstract*— Patient is aware and awake but body movements are restricted except for eyes, for persons suffering from severe neurological disorders. Bioelectric signals like EEG, EMG, EOG can be used by such patients to communicate with the outside world. The current research paper focuses on EOG signal acquisition using portable Myon biofeedback device and its analysis. EOG signal acquisition was carried with electrodes placed around the eye of 10 different volunteers. Pre-processing is done using cascaded stages of the notch, bandpass filters. After band-limiting the signal, 10 different features are extracted using LabVIEW software.**

***Index Terms*— neurological disorders, EOG, electrodes, LabVIEW, Features Extraction.**

I. INTRODUCTION

In our daily life activity, communication is essential for human beings to interact with the society. Differentially abled people are on the increase, thereby causes requirement of rehabilitative devices to assist these individuals to communicate with the outside world. Those suffering from severe neuromuscular disorders are perturbed from living a good quality of life. A substitute for communication without speech and hand movements is paramount to increase the quality of life for these individuals.

The eye can be considered as a rich source of information to retrieve information related to the user's activities and their cognitive processes. Huang *et al.* developed a system which controlled wheelchair based on electro-oculography (EOG) signal by detecting one type of eye movement(blink). Single Vertical channel with three wet electrodes was used for EOG acquisition. The System had a sampling rate of 250 Hz. DC level and 50 Hz power line noise was removed using differential approach. Several Features such as the peak value of the sub-segment and the duration of the blink were extracted. Thirteen different commands were generated. Thresholding algorithm was used to process these signals.[1] He *et al.* developed a single-channel EOG-based asynchronous speller. Three electrodes were used for EOG acquisition with 8 healthy subjects. The EOG signals were acquired using a NuAmps device. The data acquisition system had a sampling rate of 250 Hz. The samples were bandpass filtered to remove baseline drift and high-frequency noise. The signal was then differentiated to obtain various features like peak and valley. 73 different characters could be selected using the proposed GUI. Support vector machine (SVM) classification along with waveform detection algorithms was combined to detect the blink[2]. Wu *et al.* developed a wireless EOG-based HCI device. Two channels with 5 wet electrodes were used for EOG acquisition. The System had a sampling rate of 250 Hz. Eight different commands were generated. This system consisted of a wireless acquisition device and thresholding algorithm to classify the EOG signals[3]. Heo et al. developed a Novel Wearable Forehead EOG Measurement System for Human-Computer Interfaces. Ag/AgCl electrodes are used for EOG acquisition. The sampling rate was 256 Hz. These signals were then processed by using thresholding algorithm[4]. Lydia *et al.* developed a LabVIEW based EOG Signal Processing. Ag/AgCl electrodes were used for signal acquisition. Two channels with 4 commands were used[5].

II. ELECTRO-OCULOGRAPHY PHYSIOLOGY

Eye movement and blinking can be detected using several methods such as scleral search coils, EOG, infrared oculography and image-based methods. The EOG based methods are relatively more convenient, cost-effective and non-invasive. EOG signal finds application in the fields related to the estimation of drowsiness level to prevent an accident, as a communication aid by means of a virtual mouse, keyboard control, electric power wheelchair, Industrial assistive Robot or neuroprostheses and in the Ophthalmological diagnosis. EOG signal gives information about eye movements. The eye has a resting potential and acts as a dipole in which the front of the eye (cornea) is positive and the back of the eye (retina) is negative. The magnitude of EOG signal lies in the range of few millivolts and frequency range is dc to 50 Hz. Physiological signals suffer from interference such as power-line noise, motion artifacts, DC offset etc.

III. METHODOLOGY

The EOG analysis system is developed in LabVIEW platform. LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphical programming environment developed by National Instruments (NI), which allows high-level or system-level designs. LabVIEW constitutes a graphical programming environment that allows one to design and analyze a DSP system in a shorter time as compared to text-based programming environments. LabVIEW provides data acquisition, analysis, and visualization feature well suited for DSP system-level design[16]. The biomedical signals acquired from the human body are frequently very small, often in the millivolt range, and each has its own processing needs[11]. LabVIEW provides Digital filter design toolkits which can be configured for any design as per the requirement.

A. *Implemented Block Schematic*

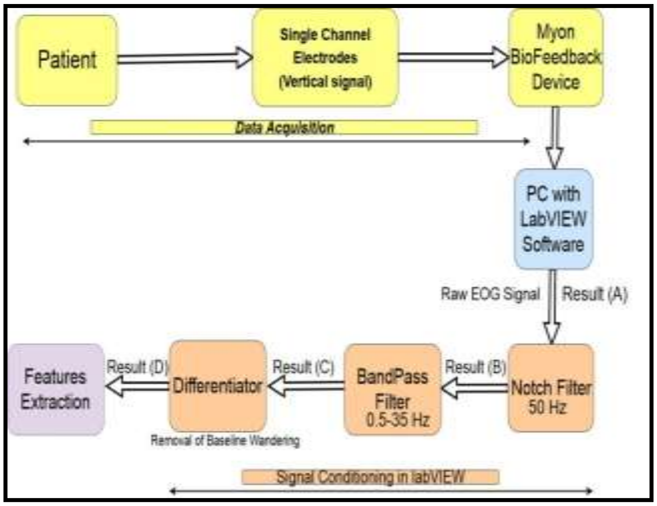


Fig. 1.Block Schematic of the EOG System

The implemented system consists of stages of Data acquisition, Signal Conditioning and Features Extraction as shown above.

B. *Data Acquisition*

Recordings of all EOG signals were carried out using a Myon biofeedback device. Disposable pre-gelled Ag/AgCl electrodes were used for EOG signal acquisition. The sampling frequency of the device is 2000Hz. Figure 1 shows placement of electrodes.

Data is collected from 5 Volunteers for about 60 seconds for a given set of commands. Those commands are: Up, Down, Blink Once, Up, Down, Blink Twice etc. A pair of electrodes was placed above and below the right Eye(anyone eye can be deployed).

C. *Signal Conditioning*

Acquired EOG signal was then passed through cascaded stages of filters. EOG signal is of low frequency. To remove 50Hz power-line noise, the signal is initially passed through the notch filter. Further, the signal is band-limited from 0.5-35Hz. Baseline wandering is removed by passing the signal through differentiator as shown in block schematic.

D. *Features Extraction*

After filtering, Feature extraction is undertaken to acquire the most significant information from the original data in-order to easily classify the eye movements.

TABLE I

EXTRACTED FEATURES

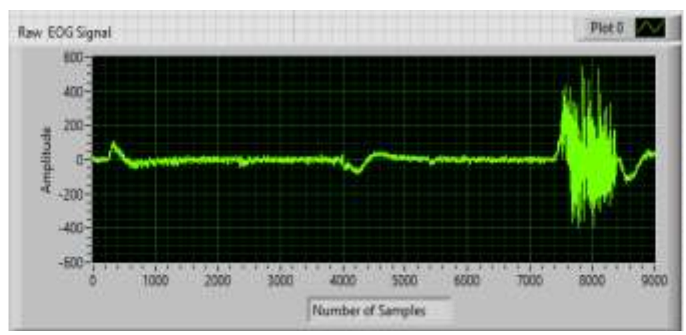
Mean	Peak Amplitude
Median	Peak Location
Kurtosis	Number of Peaks
Skewness	Sample Entropy
Standard Deviation	Variance

Fig. 2.Electrode Placement

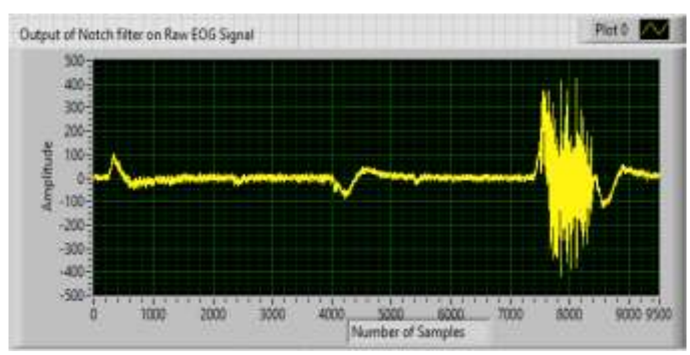
IV. RESULTS

Block schematic has clearly indicated labels as (A), (B), (C), (D) which is the output of the respective blocks.

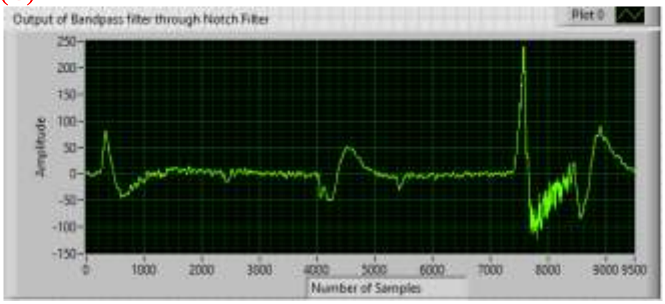
(A)



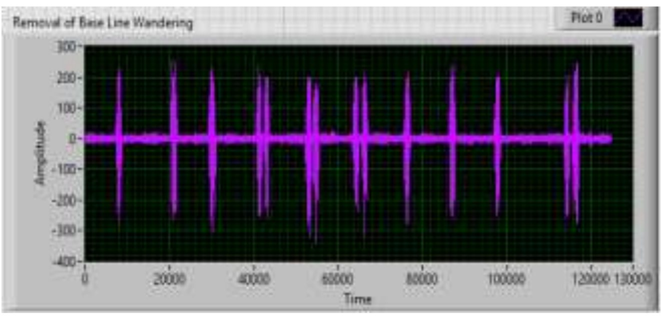
(B)



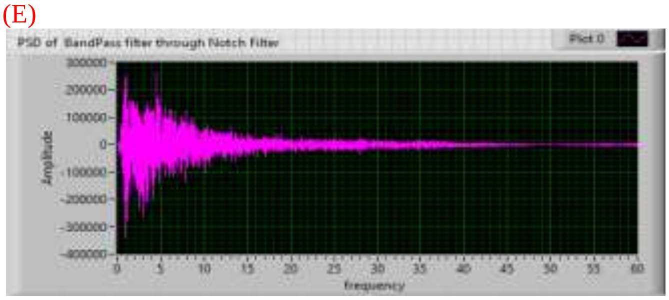
(C)



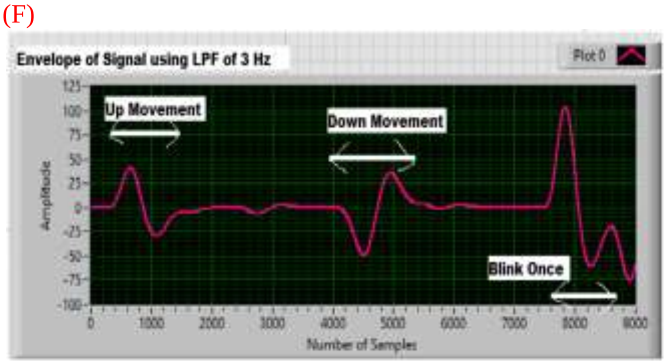
(D)



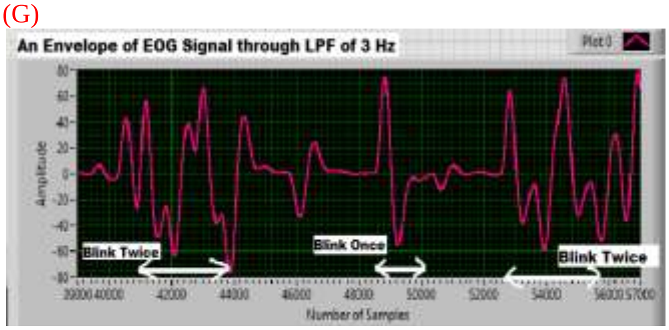
(E)



(F)



(G)



Upward or Downward movement of an eye corresponds to Vertical Movement. As seen from the result (F), Up Movement initially has as a positive peak, which is then accompanied by a negative peak. The amplitude of initial positive peak is higher than that of the negative peak. For the downward movement, the case is exactly the opposite. If the subject looks straight then dc level appears. Blink EOG signal is also attainable from vertical channel. Blink signal in comparison with up movement has the highest peak but time span is short which makes them distinguishable. Result(E) shows that maximum information content is present at lower frequencies.

V. CONCLUSIONS

The EOG Data is acquired using electrodes through Myon Biofeedback device. This collected data is signal conditioned in LabVIEW using Bandpass Filter, Notch filter, and Differentiator. The Features extractions are carried out on filtered data which will be useful for classification of signals as an extended work.

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