

Human Machine Interface Using EOG Signal Analysis

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ABSTRACT: In past few decades, the number of paralyzed patients is increasing day by day. Generally paralyzed patients and others with certain disabilities cannot communicate well for their basic needs. The purpose of this work is to provide quality of life to disabled people by interfacing Electro Oculography (EOG) signals for Human Machine Interface (HMI). Eye movements are recorded through the EOG signals. Smooth pursuit eye movements will be used for eye tracking. Signal analysis algorithms are tested and developed for the perfect gaze estimation.

KEYWORDS: Text detection, Inpainting, Morphological operations, Connected component labelling.

I. INTRODUCTION

Human machine interface (HMI) becomes one of the most essential requirements for the disabled people to communicate with the world. EOG signals are used for human machine interface. Data logging of the EOG signals with the PC using the help of LabView for smooth pursuit detection of eye movements and validate the data for the appropriate gaze control of the eye movement.

Now a day's people with some disability as well as aged persons, require mobility aids to improve the quality of life. Rehabilitation engineering deals with these types of mobility aids. Rehabilitation is the biggest boon for the disabled persons. Many researchers in the world working on the Human machine interface because it serves the purpose of improvement of quality of life by using human being's own residual capacity.

Biosignals are used to convert potentials generated from the minute movements in various parts of the body and translated them into control signals for Human machine interface. For example, EMG based Robotic arm, prosthetic arm, mouse and cursor control using EEG signal etc. In the EOG signal technique, directional movements of eye are recorded and interfaced with machines. This control technique can be useful in multiple applications in HMI as well as in HCI (Human Computer Interface) and many other such applications uses EOG signals as a control signal.

The goal of this research is to develop a low cost, reliable and affordable solution for people. The system will take input from human and act according to the control signals.

II. MATERIAL AND METHODS

A. Basic block diagram of EOG based HMI system

From the Block Diagram it is clear that, the work is mainly divided into two parts:

- i. Signal Acquisition
- ii. Signal Classification

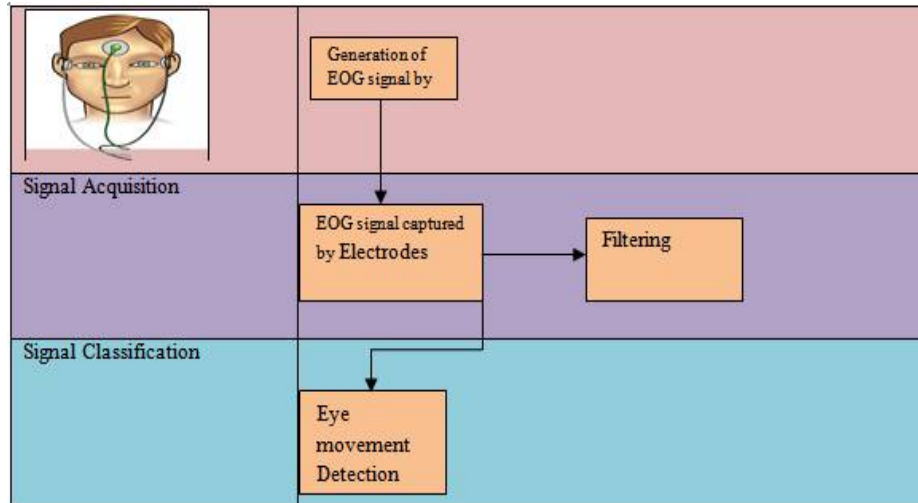


Figure 2.1: Basic Block Diagram of EOG Based HMI system

Signal acquisition part includes, acquisition of EOG signal from the person to data logging of signal to computer for further processing using Data Acquisition system. For the horizontal eye movement detection, surface electrodes are placed at the adjacent sides of the eye and for the vertical eye movement detection, surface electrodes are placed near the upper and lower side of one eye.

In the signal classification part, it includes the algorithm for the detection of eye movement after the pre-processing of EOG signal. The algorithm will give us the exact detection of the eye movement which falls into four categories of movements: right, left, up and down. Then the final task is to convert the directional movement into control signal mapping for the application of Human Machine Interface.

B. Methodology

Proposed Algorithm for Eye movement detection

Data Acquisition

EOG signals are recorded from Ag/AgCl electrodes placed on Extraocular muscle and reference electrode is placed at the center of the forehead. Figure 2.1 shows the electrodes placement system of Electrooculography.



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Data Acquisition

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X+ and X- are the horizontal electrodes which detects horizontal eye movement. Y+ and Y- are vertical electrodes which detects vertical eye movement. Z indicates reference electrode.

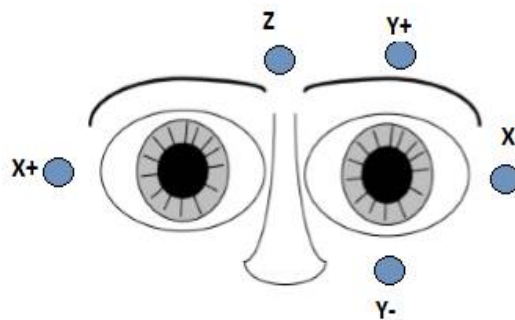


Figure2.2: Electrooculography electrode placements

First EOG signal data is acquired by following the calibration cycle. Sequence of the calibration cycle is as follows:

- I. Only for **horizontal** movement: To and fro eye movement between **center** and **right**
- II. Only for **horizontal** movement: To and fro eye movement between **center** and **left**
- III. Only for **vertical** movement: To and fro eye movement between **center** and **up**
- IV. Only for **vertical** movement: To and fro eye movement between **center** and **down**
- V. **Mixed** movements: To and fro eye movement between **center** and **right most top**
- VI. **Mixed** movements: To and fro eye movement between **center** and **left most top**
- VII. **Mixed** movements: To and fro eye movement between **center** and **right most down**
- VIII. **Mixed** movements: To and fro eye movement between **center** and **left most down**

We have created flash file moving the dot according to these calibration cycle and calibration data signal is acquired which is used for further processing.

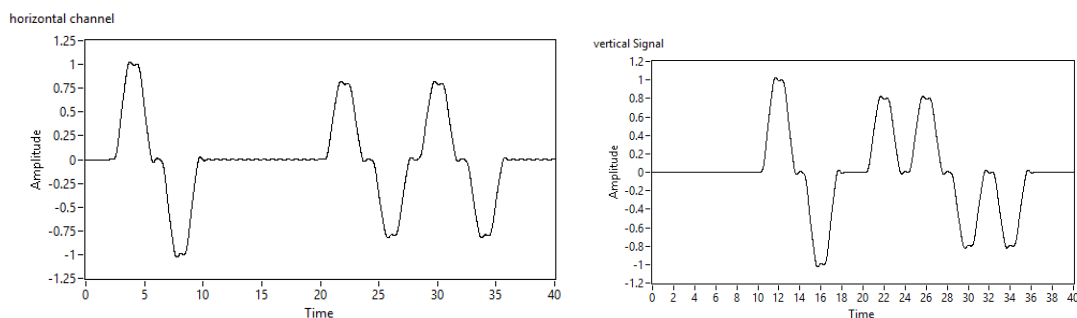


Figure2.3: Acquired calibrated EOG signal

Pre-processing

The median filter performed denoising best; it preserved edge steepness of smooth pursuit eye movements, retained EOG signal amplitudes, and did not introduce any artificial signal changes. So we can distinguish between saccadic and smooth pursuit eye movement. For baseline drift removal we apply, level nine 1-D wavelet decomposition using Daubechies wavelets. This method removes the baseline wandering.

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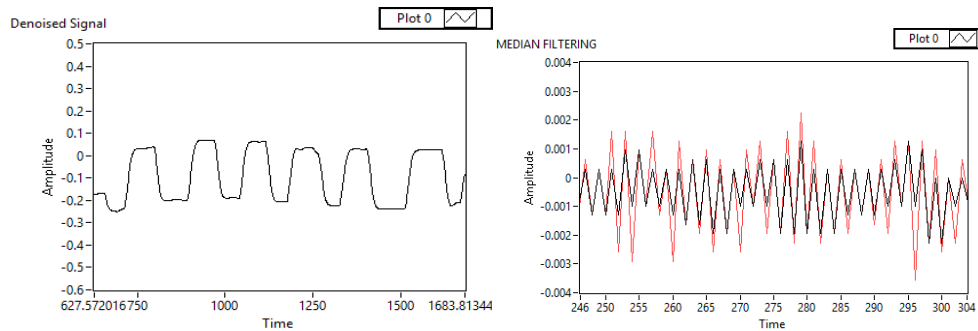


Figure2.4: Filtered EOG signal

Feature extraction

After pre-processing, useful features from the signal need to be identified for the classification of movement. Here we work on the time domain features of the signal, and identify three useful features. Mean, maximum and minimum. By applying windowing technique in time domain, we can get these three features.

Classification

To detect various eye movements Fuzzy classification is proposed here. Sequence of the steps for the Fuzzy classification is as follows:

Fuzzification: The process of associating crisp, or numerical, input values with the linguistic terms of the corresponding input linguistic variables is called Fuzzification. Mamdani Fuzzification method is used here.

Linguistic Variables: Here our input and output linguistic variables are EOG Signals in terms of voltage and angular movement in terms of degree respectively

Membership Functions: Membership functions are numerical functions corresponding to linguistic terms.

Implementing a Linguistic Control Strategy: After a fuzzy controller fuzzifies the input values of a fuzzy system, the fuzzy controller uses the corresponding input linguistic terms and the rule base to determine the resulting linguistic terms of the output linguistic variables.

Defuzzification: Defuzzification is the process of converting the degrees of membership of output linguistic variables within their linguistic terms into crisp numerical values. Centre of area Defuzzification method is used here.

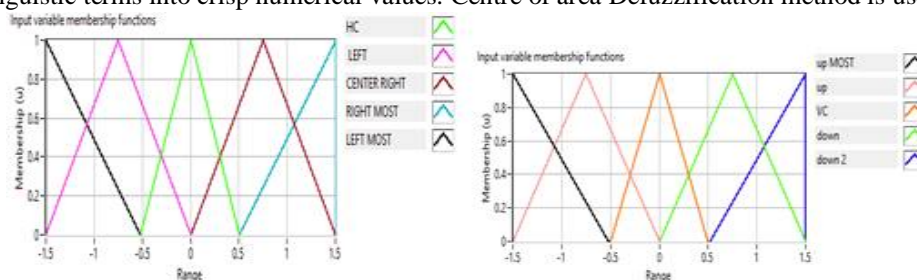


Figure2.6: Fuzzy membership functions for Input variables

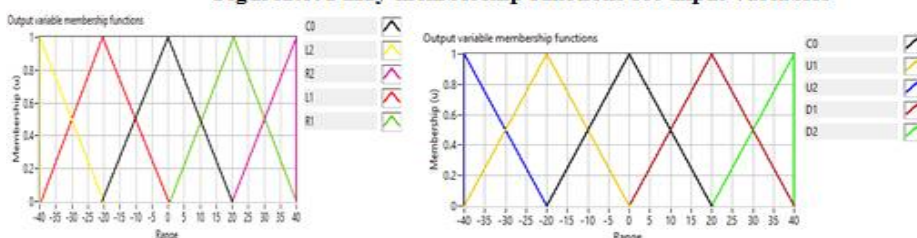


Figure 2.7: Fuzzy membership functions for Output variables

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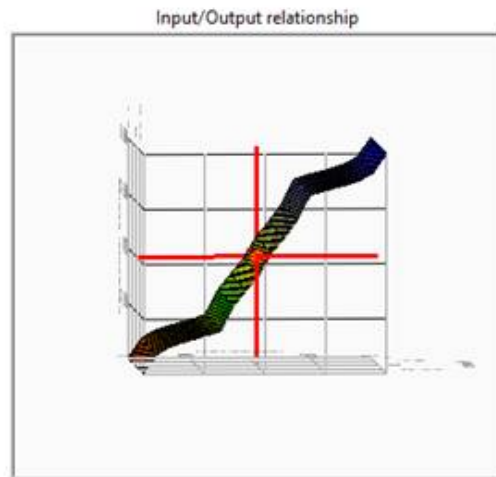


Figure 2.7: Fuzzy input output relationship curve

III. RESULTS AND OBSERVATIONS



Figure 3.1: Output signal of Horizontal channel

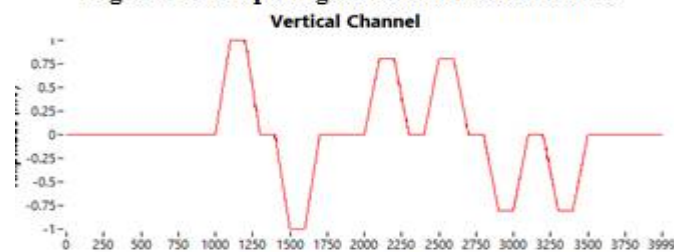


Figure 3.3: Output signal of vertical channel

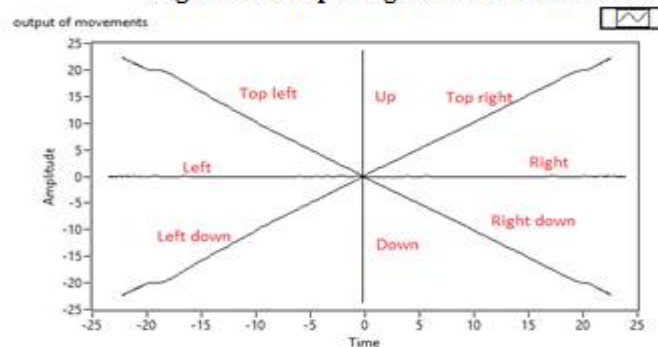


Figure 3.3: Output graph of movements

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Figure 3.1 shows the output signal of horizontal channel recorded according to the calibration cycle. Figure 3.2 shows the output signal of vertical channel. From both the signals, we can say that when there is only horizontal movement of eye vertical signal remains tends to DC signal and vice versa. Figure 3.3 shows the output graph of movements. There is total 8 eye movements: right, left, up, down, top right, top left, right down and down left.

IV. CONCLUSION

From the above, we can say that rehabilitation is a very wide area of application which is very helpful to the society. Human machine interface becomes one of the most essential requirements for the disabled people to communicate with the world. By combining rehabilitation and Biosignal approach, we can definitely improve the quality of life over all.

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