Chapter 50
Statistical Based Analysis of Electrooculogram (EOG) Signals:
A Pilot Study

Sandra D'Souza
Sri Chandrasekharendra Swaraswathi Mahavidyalaya (SCSVMV) University, India & Manipal Institute of Technology (M.I.T), India

N. Sriraam
Centre for Medical Electronics & Computing, M.S. Ramaiah Institute of Technology, India

ABSTRACT

The use of Electrooculogram (EOG) signals for developing Human-Computer Interfaces is increasing in the recent times. Several advantages including ease and flexibility in acquiring EOG signals have encouraged insight into EOG based research. In order to identify optimal features for EOG signals for rehabilitation applications, it is necessary to apply the statistical basis to decide the selection of best feature. This paper suggests a pilot study on non-parametric statistical based approach for analyzing EOG signals. This paper considers the detailed statistical analysis of Electrooculogram (EOG) signals. The EOG signals are acquired by considering the horizontal and vertical movements of the eye. The recording includes subjects with identified age groups with different activities. Power spectral densities based on Welch, Yule-Walker, Burg methods are estimated from the acquired EOG signals. Then non-parametric based statistical analysis is performed to show whether the gender or age of the subject influences the EOG signal obtained for different activities. The experimental results based on statistical analysis show that the raw data did not hold any significance to categorize male-female or age wise grouping. However, some features extracted set from the raw data provides useful statistical information which will be of great importance when used for selective rehabilitation.

INTRODUCTION

The human eye is described to have a definite potential between cornea and retina, with cornea having positive polarity and retina with negative polarity. It was in 1848, Emil du Bois-Reymond observed that the retina is electrically negative with respect to the cornea. Literature study shows that this potential is typically in the range 0.4-1.0 mV (Malmivuo, & Plonsey, 1995).The electric

potential changes due to movement of the eye can be measured around the eye. The technique of measuring this potential is known as Electrooculography and the resulting signal is Electrooculogram (EOG). This potential varies approximately in proportion to the displacement of the eye balls within the conductive environment of the skull (Barea, Boquete, Mazo, & Lopez, 2002).

EOG finds its application in clinical research. Biological signals like EEG, EMG have been used for developing assistive devices for physically disabled. However in recent years, the use of EOG as a basis for developing these assistive devices is gaining importance. EOG can be used as a single bio-signal or may be used along with EEG and EMG in such applications. Various eye movement characteristics have been exploited in developing them. Of specific hands-free operation of static human-computer using various eye movements (Ding, Tong, & Li, 2005), interfaces like human-robot interfaces, for assistive robots or cursor control by eye movements or for controlling an electric wheelchair finds potential examples for EOG driven applications. These systems are helpful for physically disabled with poor peripheral mobility who still retain sufficient eye-motor coordination. The EOG-based HCI is useful for severely disabled persons as well as others for controlling their eye movements for game or other entertainments. Persons with severe disabilities retain intact their eye movements, due to which eye movements could be used to develop new human computer interface (HCI) systems to help them communicate with other persons or control instruments.

It is well known fact that the physical energy used up in moving eyes is much lesser when compared to other gestures made by disabled people, like moving head, movement of limbs, speaking etc. Hence eye movements can be intelligently exploited for developing assistive devices for the physically disabled. Acquiring eye movements using EOG causes least discomfort to the patient and recording is done with least discomfort to the

subject. In patients suffering from Amyotrophic Lateral Sclerosis or illnesses where eye movement is the only intact signal, EOG based Human Computer Interaction and Brain Computer Interface (BCI) is important. Hence, research in this direction is very important. EOG based method is easy to apply and can be used for long term monitoring. Developing Human computer Interfaces or the different kinds of assistive devices for the quadriplegic, the physically impaired with intact eye control can be more advanced by in-depth research on the field of feature extraction of EOG and understanding the EOGs of different male and female subjects within varied age groups. This research work is novel in its effort in finding the significance of different features of EOG signals. Statistical results have been presented.

The main objective of the proposed pilot study is to test whether the sex or age of the subject influences the EOG signal obtained for different activities. The validation results of statistical analysis show that the raw data did not hold any significance to categorize male-female or age wise grouping. However, some features extracted set from the raw data provided useful statistical results which will be of great importance when used for selective application in future. The paper is organized as follows: The experimental components including the details of electrode placement, data acquisition and timing diagram of data collection, the methodology and analysis details, results and discussion, followed by conclusion.

MATERIALS AND METHODS

Electrode Placement

It is an interesting fact that the potential difference that occurs due to movement of the eye ball can be measured by using electrodes placed on the surface of the skin around the eyes. Hence the horizontal movement of the eyes can be recorded by electrodes placed on the canthi, and vertical

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