A New EEG Signal Processing Technique for Discrimination of Eyes Close and Eyes Open

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ABSTRACT

Earlier difficulties have been observed in generating control sequences for prosthesis as well as other applications when using biological signals such as EEG. This paper deals with a new methodology of using EEG and discriminating between close/open state of the eyes. Digitized signal of duration 3 seconds had been divided into 8 segments and a digital band pass (BP) filter (Butterworth) implemented to extract the noise from alpha rhythm. The output of the band pass filter for each segment is used as a weightage factor for the same segment before filtering and signal of the each segment was processed by fast fourier transform (FFT) and power spectra analysis. By comparing the frequency of peak power before and after processing for each segment of eyes closed and eyes opened, the results show that the two states of the eyes have been clearly discriminated.

Key words: EEG,EEG analysis,power spectrum,prosthetic control.

INTRODUCTION

Electroencephalogram (EEG) depicts the state of mind and the brain activity. EEG has been purposefully applied to generate command for controlling external devices. In the past several investigators have applied autoregressive (AR) technique for extracting features from EEG. Jansen [1] used AR modeling for feature extraction. In this approach the EEG was ***a priori*** segmented in short time segments, the resultant of AR parameters for each segment used as a features for classification of that segments. As the segment length increases the model order increases and varies with the class of EEG segment. EEG has several distinct visual classes, hence difficulties arise in selection of the model order in practice. Lower order models may be biased because of the absence of truly non-zero parameters and higher order models depict too much variation in superfluous parameter and increase the computational cost. To identify and extract variables from the raw EEG therefore present a problem . Before feature selection signal needs preprocessing using level and frequency discriminators. Extraction of meaningful features from the different segments of the EEG signal have enabled to discrimination between different states of eyes. Earlier it had been reported that EEG during eyes open/close state can be differentiated by power spectral analysis of EEG [2]. In continuation with the earlier studies here in this paper a new methodology for differentiating EEG features in the eyes close and eyes open state is presented.

SUBJECTS AND METHODS:

a) Subjects: A total of six subjects,five male and one female, right handed volunteers in the age group of 21 to 37 years 30± 6.35 with no prior history of nervous system disorder, drug abuse or psychiatric conditions participated in the study. Electroencephalography was done in the clinical neurophysiology laboratory of the Department of Physiology, All India Institute of Medical Sciences New Delhi having a EEG chamber with Faraday cage for isolation. The temperature in the cabinet was maintained at 22 °C. Luminosity in the room was controlled remotely from outside for each subject. It is important for the subject to be in a comfortable position to avoid muscle artifacts. During the placement of electrodes, subjects were informed about the purpose of study Ag-AgCl cup electrodes were placed on the scalp according to the international 10-20 system [3] with the electrode kept below 10k-ohm,the EEG was recorded from four sites. These bipolar connections were

1) Fz-Oz ; 2) C1-C5 ; 3) C2-C6 ; 4) O1-O2.

The points chosen for our experimental study were based on two criteria:

a) Wide coverage of brain structure: from frontal to central to occipital and also on both hemispheres.
b) Area to be known to produce different types of EEG wave forms such as beta waves from frontal areas and alpha waves from occipital areas.

b) TASK

All studies on subjects were conducted in the morning and the EEG on all the subjects were recorded in three to four sessions on different days. Before initiating the study each subject was asked to relax for ten to fifteen minutes in the experimental laboratory and all the staff members working in the laboratory were specially instructed to maintain calm so as to avoid any distractions. The protocol consists of two successive phases that is eyes closed and eyes opened. Initially EEG was recorded for ten to fifteen seconds for each platform of eyes it was found that the subjects were showing signs of tiredness and hence recording time was reduced to 5 seconds which was free from artifacts observed in longer traces by visual inspection. Subjects were asked to avoid eye blinking , eye movements and body movement during the recording. Commands were communicated to the subject remotely.

c) DATA ACQUISITION AND ANALYSIS

The EEG's were amplified, filtered (upper frequency cut off 35 Hz) on Grass electroencephalograph model 8-10C machine. Data was then taken on the cassette recorder (RC-60) and simultaneously recorded on paper at the speed of 30mm/s. On a separate channel, a marker provided coded time information. The EEG signal was digitized at a rate of

100 Hz for the duration of 3 seconds. Experience from our earlier studies [2] indicated that desired information may be extracted from alpha (8-12 Hz) band and therefore a fourth order Butterworth band pass filter was used. The designed filter had roll off -3dB and stop band attenuation-6dB,the order of the filter was determined by using the buttord function from matlab library. Signal was then digitized using 12 bit ADC (PCL-207) and 256 sample points has been chosen, these points were further divided into 8 segments with each segments having 32 points. Power spectrum on each of the segment was obtained by fast fourier transform (FFT) and then frequency at peak power (Fpp) found out, next the same segment was processed through a band pass (BP) filter and the out put of the BP filter was used as a weightage factor for the same segment before filtering. Multiplying the preprocessed signal by the weightage factor new values were found out. The FFT was done for these new values and the frequency for peak power (Fpp) was again estimated using Dynalog LABTECH software. A change in peak power frequency before (Fppb) and after (Fppa) correction i.e. subtracting Fppb from Fppa has been tabulated (Table 1).

RESULTS AND DISCUSSION

A representative graph is shown in Fig. 1. Table 1 shows the output peak power and frequency in the two states of eyes closed and opened. Table.1.a shows decrease in frequency in 8th segment for eyes closed. This has occurred at last part of 3 seconds epoch. Such changes have been seen in all 6 subjects ,occurring once or more. Table 1.b shows occurrence of frequency shift(increase at 4th and 7th segments) after correction. This positive frequency shift of 6.25 Hz was again common for all 6 subjects. The most significant feature that has been identified is that in any subject the change in peak power frequency was $\pm$6.25 Hz when eyes were opened and closed or vice versa. Therefore this frequency shift has been used to discriminate between the states and generate a trigger command for the prosthesis or any other external device.

A.EYES CLOSE

segments of eyes close	frequency shift (with correction)		peak power	
	Decr.	Incr.	Bef.corr.	Aft.corr.
1	-	-	4.9162	0.3597
2	-	-	27.265	0.8157
3		12.5	15.771	1.8654
4		12.5	24.022	1.2973
5	-	-	6.170	0.4669
6	-	-	18.095	1.0879
7		12.5	22.409	1.3174
8	6.25		18.407	1.2616

B.EYES OPEN

segments of eyes close	frequency shift (with correction)		peak power	
	Decr.	Incr.	Bef.corr.	Aft.corr.
1	-	-	15.783	0.82177
2		3.125	1.0026	0.02099
3	-	-	1.6886	0.0355
4		6.25	2.703	0.11492
5	-	-	3.0101	0.12225
6		3.125	2.1775	0.03186
7		6.25	5.3251	0.57737
8	-	-	12.107	0.25379

Table-1 Represents of peak power against frequency shift.

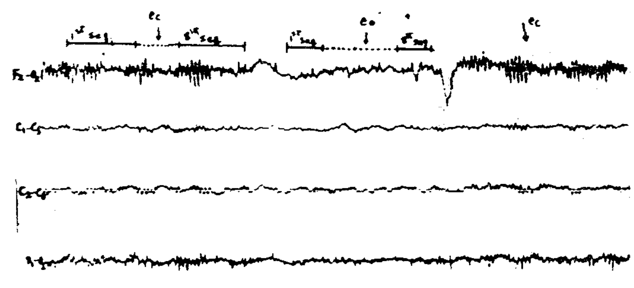

Fig. 1 Effect of Eye close and Eye open

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