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Adaptive Identification of Visual Evoked Potentials, Application to Multiparametric Stimulation

A.K. Brikou*, G.V. Moustakides*
A. Bezerianos†, P. Papathanasopoulos†

1 Introduction.

The use of Visual Evoked Potentials (VEP) has become wide spread in recent years. VEP are obtained in patients with virtually all types of neurological diseases, but it is well known that certain features of the stimulus are best detected by distinct subgroups of neurons [1]. Therefore any recording may reflect only those cortical structures that are sensitive to the particular configuration of the features that comprise the VEP stimulation. Thus the study of the evoked response demands measurements over a wide range of spatial and temporal frequencies requiring long period of time.

Even though a minimum number of stimulations is adequate to produce a clarified response, there is a need of a large number of sweeps to improve the Signal to Noise Ratio, which in turn results in a substantial prolongation of the observed peaks (compare Fig. 1(a) average of 80 sweeps to Fig. 1(b) average of 580 sweeps).

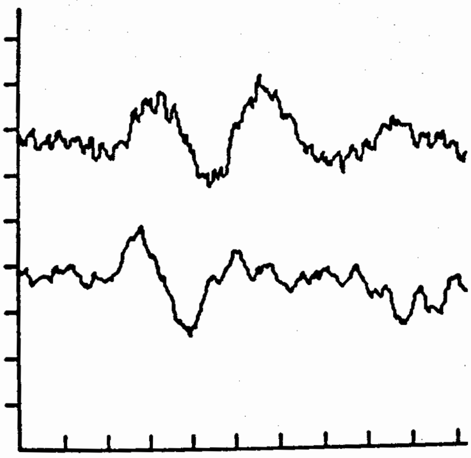
To overcome the above disadvantages a multifrequency spatio-temporal pattern protocol [2] and a novel signal processing technique are proposed.

2 Material and Methods.

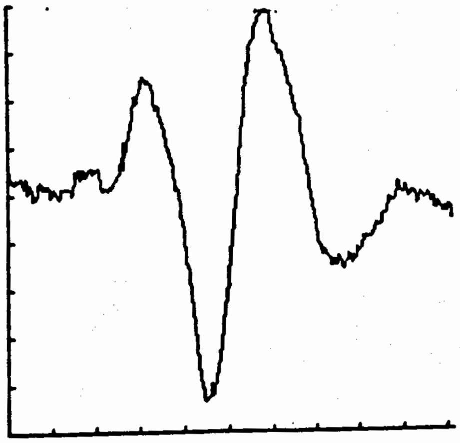
Ag-AgCl disc electrodes were attached to the scalp with collodion on the following position (10-20 System) active Oz; reference Fz; earth Fpz. Electrode impedance was kept less than 3KΩ in both active and reference leads.

A DAS16F Metrabyte acquisition board on a PC-DOS computer as host, was used to acquire the evoked potentials in parallel with a Nicolet Compact Four Electrodiagnostic system used to amplify, average and store the responses. The checkerboard was produced

*Computer Engineering Department, University of Patras, Patras 26500, GREECE.
†Medical School, University of Patras, Patras 26500, GREECE.

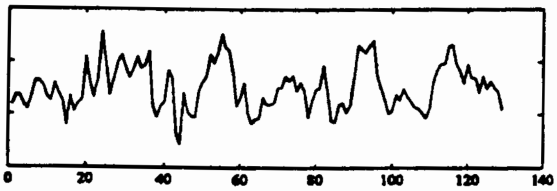


(a)

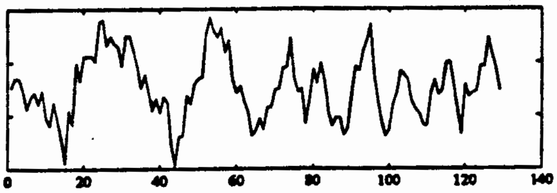


(b)

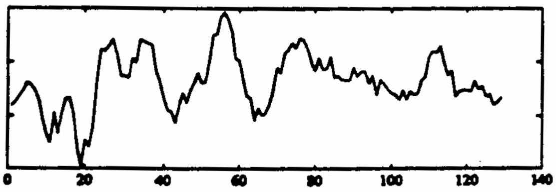
Figure 1



(a)



(b)



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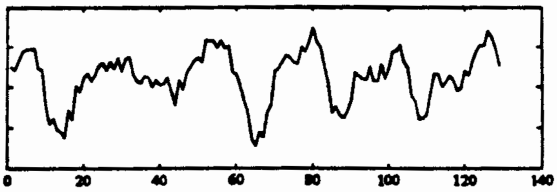

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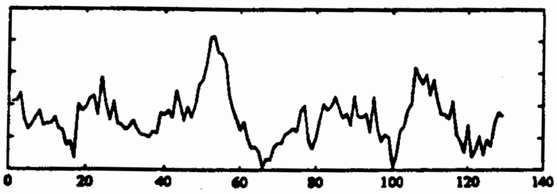
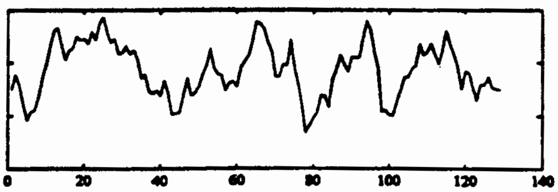


(e)



(f)

Figure 2

by a digital video pattern generator on a 12" black and white monitor. The checksize of the stimulus was 52.5' and the visual field subtended $14° \times 10°$. The luminance of the bright checks was 192 cd/m^2 and of the dark ones 12 cd/m^2.

With the use of the acquisition board, a continuous acquisition of the the evoked potentials was performed with a sampling frequency of 500Hz. The stimulus frequency was 2Hz.

The basic problem of the classical processing techniques is the fact that they do not perform very well in cases of signals that have time varying characteristics. In Signal Processing a whole field was developed to deal with this problem and the schemes that were derived, known as Adaptive Schemes, seem to give a satisfactory answer to the problem in most cases [3,4]. In the last years these methods were also applied to the problem of VEP [5,6,7].

With this work a novel processing method is proposed based on adaptive identification techniques. A combination of two models is used to describe the acquired signal. Specifically an Autoregressive (AR) model is used to model the EEG, while a Linear Regression (LR) model to model the evoked potential. A Recursive Least Squares (RLS) type algorithm is used to continually identify the parameters of the models and estimate the useful part of the recorded signal. An AR model of size 5 for the EEG and a LR model of size 2 seemed to yield satisfactory results.

3 Obtained Results.

The processing was basically used to improve as much as possible the signal to noise ratio during every single sweep, aiming at a significantly smaller number of sweeps for the averaging process in order to obtain a clear signal. In Fig. 2(a-f) we can see the results of averaging 80, 40, 20, 10, 5 and 2 processed sweeps. It was observed that by averaging 10 processed sweeps the resulting signal in most of the cases yielded a quite acceptable signal where one could clearly identify the classical peaks. Fig. 3 present eight such sets of 10 sweeps that were processed by our algorithm and consequently averaged. (In Figures 2 and 3 positivity is upwards).

4 Conclusion.

A novel processing method based on AR modeling of the EEG and Linear Regression modeling of the Evoked Potential, is proposed for improving the Signal to Noise Ratio in the Evoked Potential signals. The method achieves a signal with acceptable quality, by averaging 10 processed sweeps, thus significantly reducing the patient exposure time.

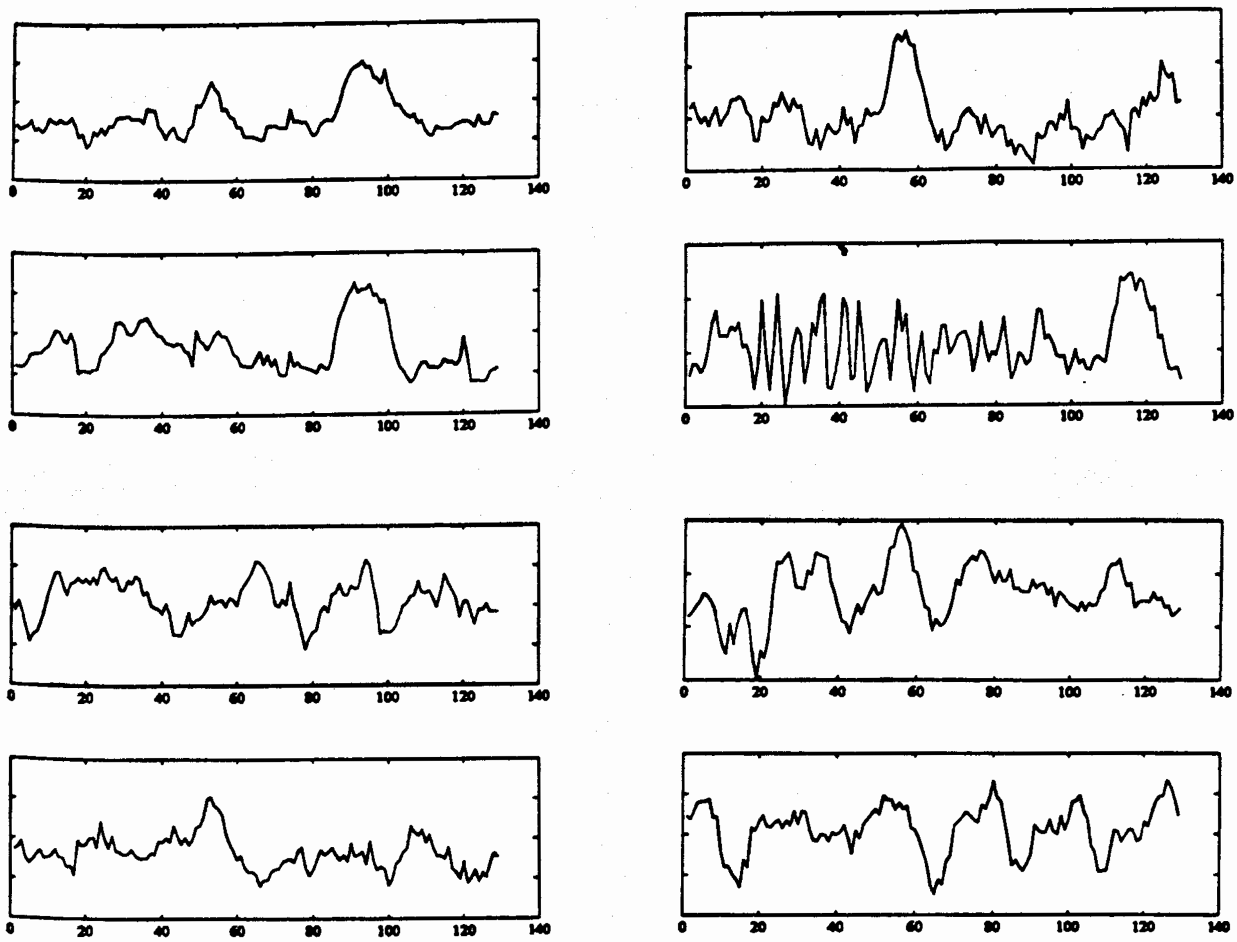


Figure 3.

REFERENCES.

[1] Sestokas A.K., Lamkuhle S., Kratz K.E., "Visual Latency of Ganglion X and Y Cells", *Vis. Res.*, Vol. 27, pp. 1399-1408, 1987.

[2] Bezerianos A.G., Papathanasopoulos P.G., "A Programmable Digital Video Pattern Generator for Basic Research and Clinical Applications", *Vis. Res.*, Vol. 31, pp. 1563-1572, 1991.

[3] Ljung L., " System Identification theory for the user", *Prentice Hall*, 1985.

[4] Widrow B., Stearns S. D., " Adaptive Signal processing", *Prentice Hall*, 1985.

[5] Cerutti S., Bersani V., Carrara A. and Liberati D., " Analysis of visual evoked potentials through Wiener filtering applied to a small number of sweeps", *Ibid.*, Vol. 9, pp. 3-12, 1987.

[6] Cerutti S., Baselli G., Liberati D. and Pavesi G., " Single sweep analysis of visual evoked potentials through a model of parametric identification ", *Biol. Cybern.*, Vol. 56, pp. 111-120, 1987.

[7] Liberati D., Bertolini L., Colombo D. C., " Parametric method for the detection of inter- and intrasweep variability in VEP processing", *Med. & Biol. Eng. & Comput.*, Vol. 29, pp. 159-166, 1991.