# Adaptive Zero-Tracking of EEG Signals For Detecting Epileptic Patients

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**Abstract** –The Analysis of EEG measurements has become a very attractive tool for noninvasive diagnosis of epileptic seizures.Although the FFT method has been widely used to analyze EEG signals, it is not well suited to the non–stationary characteristics of the EEG Signal. To overcome this limitation, a method using Adaptive filters is presented. The method is based on tracking of a single system pole of the AR model.

Keywords: EEG, Seizure, Tracking, non Stationary, AR model.

## I. Introduction

Brain activity can be measured by using electrodes placed on the surface of the skull.
Berger [3] first recorded brain waves using electrodes and was able to relate certain frequency components to the EEG waveform. Since this study, EEG Signal analysis has been widely used in the treatment of patients with epilepsy by providing a quantitative means to detect an oncoming seizure. The early warning of an epileptic seizure is essential given that the behavioral treatment of epileptic patients by conditioning or stimulation requires information regarding the exact occurrence of the seizure.
When this information is unavailable, patients way be randomly administered therapy that is laced with side effects.
Thus to diagnose patients suffering from epilepsy, A method based on an Adaptive predictor (LMS algorithm) to estimate the model parameters from which the roots corresponding to the AR part (poles) is presented.

## II. Tracking of Parameters

Time–varying AR models for the process X[n] can be written as:

$$X[n] = e[n] - \sum_{K=1}^{P} a_k[n]X[n-k]$$

where e[n] is the prediction error process and the parameter $a_k[n]$ is estimated with an adaptive predictor.
The predicted error is shown in Fig1.

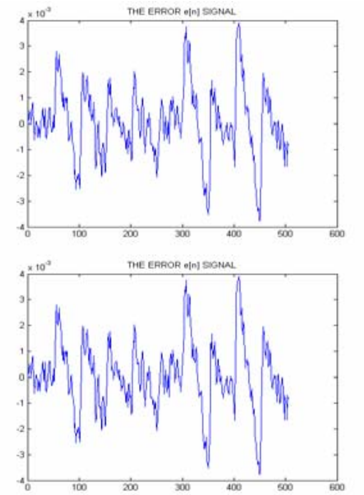



Fig1.The error e[n] signal

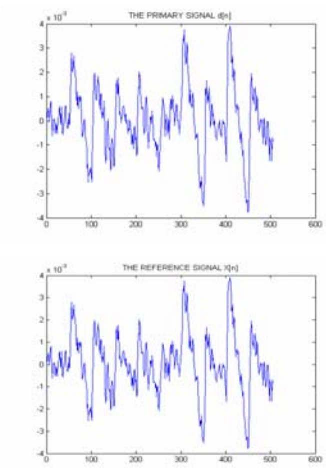
There are several algorithms that can be used as predictors.
The most common ones are the LMS, RLS and the Kalman filters. We use here the Least Mean Square (LMS) algorithm. See [4] and [5] for discussion on the tracking of EEG with the RLS algorithm and Kalman filter.
The important point in designing the LMS adaptive Zero–tracking filter is stability.
Since choosing a proper value for $\mu$ the LMS will force the poles to become bounded.
The proposed approach is based on autoregressive modeling of the EEG signal adaptively.
For each sample, the prediction coefficients $a_k[n]$ are extracted from the adaptive AR model, corresponding
to each set computed for the $a_k[n]$, the poles of the AR model are calculated. Fluctuations in the poles of the AR model are used to track any change in the statistics of the EEG signals.
This information aids in the prediction of a seizure by several seconds during the preseizure period. [6]

## III. Methods

The procedure of the seizure detection of the EEG Signals is as follows:

1. In this approach, we considered the values below:
a) The sampling rate was 100Hz.
b) The $\mu$ factor was 0.001.
c) The AR model was 15.

d) The total length of the preseizure EEG Segment Scanned according to this procedure was 60 Sec.
e) The prediction Coefficient of the preseizure EEG Signal was Calculated for 2 Sec. in length.
2. Select an Adaptive filter which calculates the prediction coefficients of the AR model by using the LMS algorithm. (The primary input of the Adaptive filter is the same as the reference input,which are shown in Fig.2).

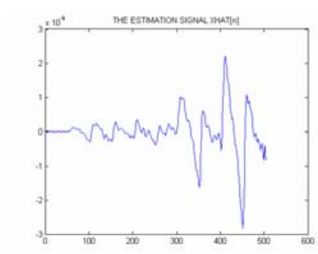



The primary signal d[n] & reference signal $X[n]$

3. for each Sample, the Adaptive filter calculates the prediction coefficients using (2.1):

$$\hat{X}[n] = \sum_{K=0}^{M-1} a_k(t) X[n-k] \qquad (2.1)$$

The AR order was 15.



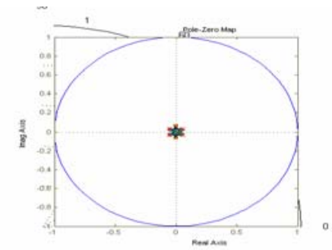

The estimation signal $\hat{X}[n]$

Thus for each sample, we obtain 15 values, each corresponding to $a_k(t)$.

4. Calculate the roots of A(z). (2.2)

$$A(z) = 1 - \sum_{k=0}^{M-1} a_k[n] z^{-k} \qquad (2.2)$$

5. The roots are considered as poles, and shown in the zero – pole plane.




The Zero – Pole plane

### IV. Results

Results reveal that the real pole become a complex conjugate pair a few seconds before the start of the seizure.
The pole pair was very close to the unit circle at the time of the seizure, as shown in fig. 3. 1.
This pole pair is called "the most mobile pole", and its trajectory was utilized to predict the start of seizure.
Results suggest the time when the real pole leave the real axis may be utilized in predicting the time of a seizure. [7]

### V: Conclusions

The seizure of an EEG signal can be efficiently discriminated by a all pole of an AR (15) model. The tracking of the model parameters can be done efficiently with the $\mu$ factor LMS algorithm.

The results show that the method can be used to predict the time of a seizure, by considering the "Most mobile pole" in the zero pole plane. By utilizing the trajectory of the poles, predicting the time of a seizure is possible.

#### References

[1] B. Jansen, "Analysis of biomedical signals by means of linear Modeling", CRC Crit Rer Biomed Eng, vol. 12, pp. 343 – 323, 1985.
[2] S. Orfanidis and L. Vail, "zero – tracking adaptive filters", IEEE Trans Acoust, speech signal processing, vol. 34, pp. 1566 – 1572, 1986.
[3] A. Nehorai and D. Starer, "Adaptive pole estimation", Trans Acoust, speeds signal processing, vol. 38, pp. 825-838, 1990.
[4] Gerch, W, and sharpe, D.R., Estimation of power spectra with finite order autoregressive models, IEEE trans, Autom. Control AC – 13: 367-369, 1973
[5] P. C. Madharan B.E. stephans, D. kligberg, and S. Morzorati, "Analysis of rat EEG using autoregressive power spectra", J. of Neurosci Meth, Vol. 40, pp. 91-100, 1991.
[6] Cioffi, J. M. and kailath, T., "Fast, Recursive Least squares tranversal filter for adaptive filtering", IEEE Trans, Acoust. Speech Signal Processing ASSP– 32: 304-337, 1984.
[7] Z. Rogowski, I. Gath, and E. Bental, "the Prediction of epileptic seizures, Biol Cybern, Vol. 42, pp. 9-15, 1981.