APPLICATION OF AR TECHNOLOGY IN EEG ANALYSIS

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ABSTRACT

***Background**: Post traumatic epilepsy (PTE) is a key area of epilepsy research. As one of the common complications after craniocerebral injuries, little is known about the basic mechanism, especially on the formation and development of chronic epilepsy after brain injury.*

***Objective**: This paper sets to understand the mechanism of epileptic seizures and provides precise assessment of the development of epilepsy.*

***Method**: A long term monitoring and prediction platform is designed, which provides EEG monitoring and synchronous video monitoring of the seizures.*

***Result**: It shows that epileptic seizure EEG is power increase of spectrum.*

***Conclusion**: The conclusion is that under different states, the rats' reactions prove that the application of AR technology in EEG analysis can clearly show the different fluctuations of EEG.*

***Keywords**: AR Technology, Epilepsy, EEG Analysis.*

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Introduction

Post traumatic epilepsy (PTE) is a key area of epilepsy research. As one of the common complications after craniocerebral injuries, little is known about the basic mechanism, especially on the formation and development of chronic epilepsy after brain injury[1]. According to previous research, epileptic seizure model induced by cortical injection of iron ions on rats may be similar to clinic expression of PTE[2]. Based on animal models, EEG frequency of chronic spontaneous epileptiform sometimes may last for a few months and gradually develops into various forms of seizures[3].

In order to understand the mechanism of epileptic seizures as well as to offer precise assessment of the episode of seizures, we design a long term monitoring and prediction platform which provides EEG monitoring and synchronous video monitoring of the seizures. It allows better assessment of the seizures and even predictive EEG analysis[4].

One of the purposes of this research is to create a three-channel radio telemetry system which records the spontaneous EEG graphs detected from the cortical surface, e.g. the "peak" of epileptic seizures. This platform monitors the states of epilepsy for months in the iron ion induced model rats, and allows continuous recording of the EEG activities before the seizure, during the seizure and recovery after the seizure, and spontaneous video monitoring of the behaviors during the rats' seizures. Further EEG analysis is performed to assess and predict the seizures. In one of the researches, the revised Racine scale behavior classification method is used to classify the severity of rat seizures, where class 0 means no response after stimulation of epilepsy agent injection; class I means facial clonus after stimulation including abnormal expression of involuntary blinking, moving whiskers, and rhythmic chewing; class II means class I behaviors and rhythmic nods; class III means class II behaviors and forelimb clonus; class IV means class III behaviors and standing on

hind legs; class V means class IV behaviors and loss of balance, tumbling, rotation, clonus, generalized tonic clonic seizures, and even death.

In this research, by monitoring and analyzing cortical EEG signals on PTE rats induced by injection of iron ion, the power spectrum collection function of Neuro Score for the auto-regressive (AR) spectrum and fast Fourier transform (FFT) is adopted. Through comparison, it is indicated that during a certain period, the AR spectrum has better high frequency signal resolution than FFT[5]. Comparing the AR spectrum and FFT spectrum, overall AR has significant advantage in terms of power spectrum and frequency distribution over a long term monitoring of seizures. EEG analysis is conducted to understand the symptomatic characteristics during seizures for better technological support in assessing and predicting the seizures[6-8]. From a clinical perspective, complementarity between AR spectrum and FFT on EEG analysis for seizure patients should be further understood[7]. By comparing the AR and FFT on EEG power, we know that the FFT spectrum is the Fourier transform of each signal point, which has dispersed power distribution, violent spectral value fluctuations, poor variance performance, low resolution, and un-smooth spectral lines. The AR spectrum on the other hand produces smooth spectral lines, higher resolution and better variance performance[9]. AR spectral lines are similar to the FFT lines, or rather shows the trend of FFT power spectrum. On one hand, it shows that the performance of AR spectrum is better than the FFT spectrum, and on the other hand, validates the accuracy of AR models(10). In clinical application, the comparative research in EEG power spectrum can provide technical support on the clinical seizure diagnosis and treatment[11,12].

Experiment

Experiment method

This experiment uses emitter TL 10m3-F50-EEE by the three-channel physiotel®Multi Plus.

Experiment subject

The male SD rats (200-300 g, n=30) are used. The management of experiment animals follows the lab animal management rules published by the Ministry of Science and Technology of the PRC.

Radio telemetry system

This research adopts Dataquest A.R.T. data simulation software by DSI-Transoma Medical. The EEG data captured from the emitters is sent to the input exchange matrix. The data simulation software runs the data and outputs calibrated simulation signals from the digital signals by the receiver.

Results and discussion

AR spectrum analysis on iron ion-induced PTE rats

As in Fig 1, this experiment uses AR spectrum for the EEG analysis, and provides spectrum analysis method to predict the seizure episodes. Before the abnormal behavior is captured by the video monitoring, the AR spectrum analysis shows abnormal changes in existing EEG spectrum. The 1-25Hz EEG frequency band is collected, and the EEG analysis defaults 20s as a data band. It is observed that during the seizures, all frequency bands increase. Before seizure, the low frequency dominates, while through AR spectrum analysis there might be a long warning period during which high frequency content is on the rise.

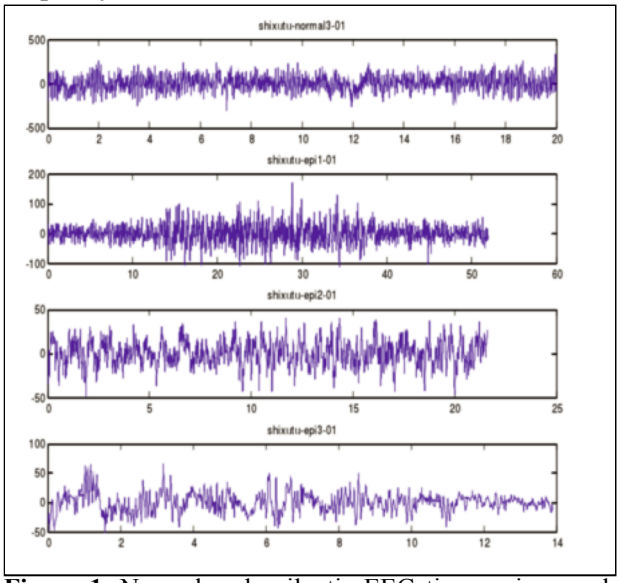

Figure 1: Normal and epileptic EEG time series graph left occipital region Y/ μV; X/n.

Behaviour of ferrous chloride modelled rats

1 to 60 minutes after injection of iron ion, the PTE model rats develop behavior of paroxysmal dull eyes, motionless and wet dog shakes, followed by voluntary behaviors such as repeated rigid nods and chewing, facial cramps, spasms, unilateral forearm tremors, and continuous nods. Rats then have forelimb aggravated tremors, then lose of balance and outburst of whole body tonic clonus. Two rats die of sever seizures. After the seizure, the rats regain the consciousness and are back to free activities such as eating. Small focal seizures are common. Some rats have muscular tension and hump-

back postures. Normal rats demonstrate normal behaviors such as eating.

In the sham-operation group, after regaining consciousness, activities such as eating are reduced. And most of the rats do not have seizures. But they sometimes conduct behaviors such as long staring. spams and trembling.

EEG analysis

As in Fig 2 and Fig 3, the AR spectrum of marked 20120530 seizure model rat has longitudinal axis unit of navut square, each grid for 20n V^2. The longitudinal axis unit of the EEG graph is μV, each grid for 100μV. The upper horizontal axis is the time axis, each grid for 1 second; the longitudinal axis unit of the AR spectrum is Hz, ranging from 0Hz to 25Hz, each grid for 1Hz.

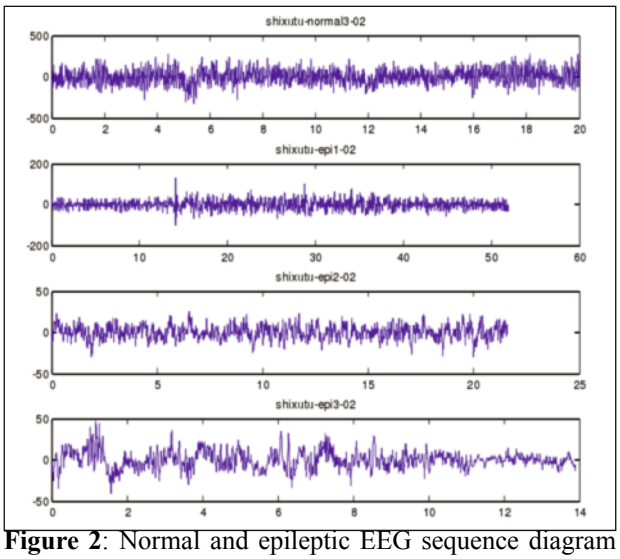

Figure 2: Normal and epileptic EEG sequence diagram of right occipital region Y/ μV; X/n.

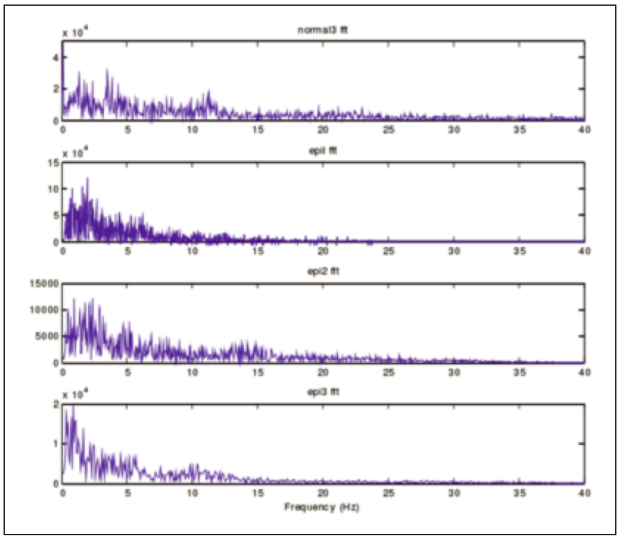

Figure 3: The left frontal region FFT power normal and epileptic patients' spectrum.

The monitor shows 30 seconds data. For each 20s, a AR spectrum is generated.

In the figs, channel 3 (Label:EEG2) is the original EEG wave form of normal rat 2, channel 1 is the AR spectrum of normal rat 2, and channel 4 (Label:EEG1) is the original EEG wave form on the ferrous chloride modeled rat 1 marked 20120530, and channel 2 is AR spectrum of model rat 1. The video record shows rat 2 and rat 1 are both in normal conditions, while rat 1 does not have seizure. From the comparison, we see that seizure model rat 1 demonstrates much more clusters of spindle shaped waves compared to normal rat 2. The visual inspection method is time and manpower consuming and hard to quantify. For the two rats, 20 second data is selected for AR spectrum analysis. Compared for normal rat 2, it is noticed that in AR spectrum of seizure model rat 1 has peak shift to the right and increased high frequency content, among which the most significant increase is on 6Hz to 15Hz content. The low frequency content decreases from the level of normal control rat, but within a moderate range. The AR spectrum for normal rat 2 conform to the AR spectrum features of most normal rats: the peak is furthest to the left, with dominating 0 to 5Hz waves and seldom any Sigma or Beta waves. The seizure model rat 1 has a peak value at 80n V^2 between 10 Hz to 10.5 Hz. The normal rat 2 has peak value at 70n V^2 between 0 Hz and 0.5 Hz. The original EEG waves of two rats peak at around 100μV.

The EEG AR spectrum of seizure model rats has longitudinal axis unit as micro-volt square, each grid for 1μV^2. The unit of original EEG waves is m V, each grid for 200 μV, and larger grid for 1m V. The upper horizontal axis is time axis, each grid for 2 seconds (unit: second). The horizontal unit is time axis, each grid for 1 second (unit: second). The horizontal axis unit for AR spectrum is Hz, ranging from 0 Hz to 25 Hz, each grid for 1Hz. The monitor shows 60 seconds data. For each 20 seconds, a spectrum is generated. Channel 1 (Label:EEG4) is the original EEG wave form of seizure model rat, channel 2 is the AR spectrum. The simultaneous video record shows that the rats are in the phase IV seizures. In the control group, the frequency spectrum collected concentrates under 10 Hz.

In Fig 4 of PET model rat, the behaviors of seizure are observed often, and transferred to higher frequency in the corresponding channel (> 10 Hz). The seizures are monitored through the behaviors or EEG data.

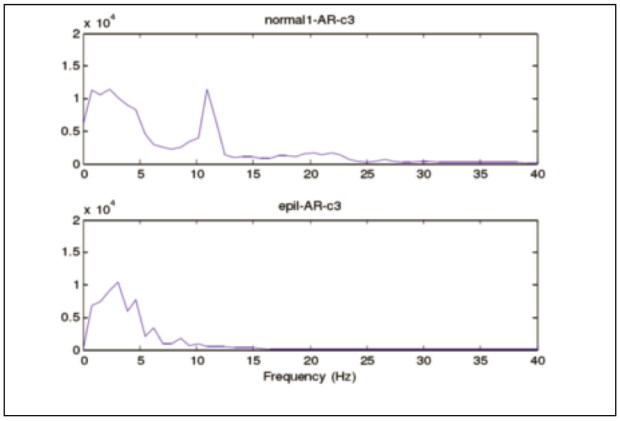

Figure 4: Normal people and patients with epilepsy left central EEG AR spectrum.

For the longer term monitoring of chronic spontaneous epilepsy seizures (prediction), compared to shorter time AR analysis (e.g. 20 seconds), the power distribution of frequency or the total amplitude over shorter time have significant changes, which facilitates automatic detection of seizures.

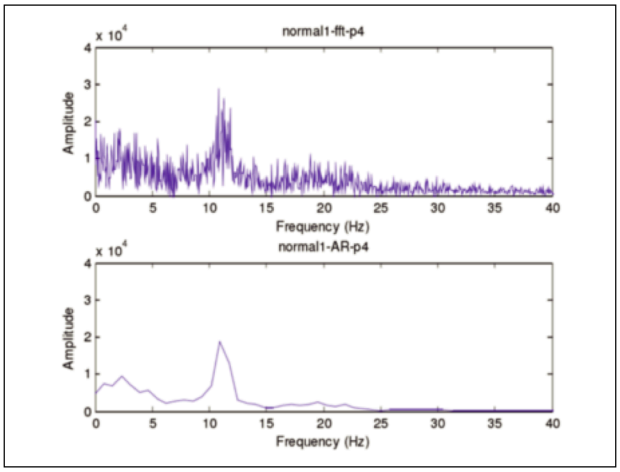

Figure 5: Normal people and patients with Epilepsy EEG AR spectrum right vertex.

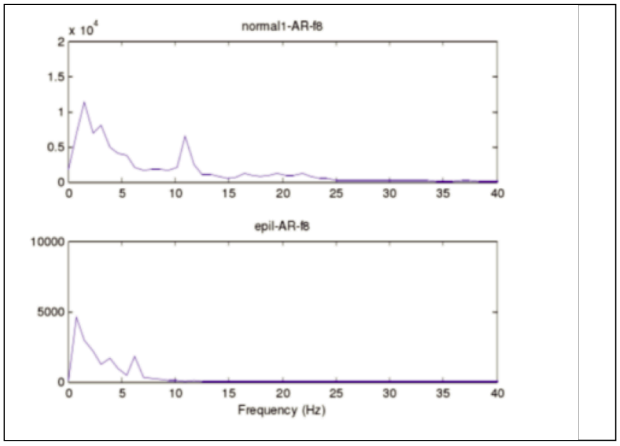

Figure 6: Normal and epileptic patients with right temporal EEG AR spectrum.

In fact, the power amplitude and relative stable static episodes, the EEG seizures is a 1000 times power increase of spectrum. See details in Fig 4, 5 and 6.

Conclusions

Through programming, there are many ways for automatic pattern recognition of rat seizures to identify the features of seizure behavior, such as from the peak value shift, comparing area under the AR spectral curves of the normal and seizure periods, and comparing spectral value of the high frequency band. These can be automatically obtained with the help of algorithms and software to realize automatic detection. The rat reaction under varied conditions prove that the AR technology can clearly show the fluctuation of signals in EEG analysis.

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