CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 CONCLUSION

Our method of approach to EEG evaluation offers a new possibility of its analysis. The representation of the EEG time series as a superposition of the damped sinusoids is closer to our understanding of this process, than the assumption that it consists of a large number of harmonics, as implied in Fourier method. In the present method EEG rhythms are obtained directly without a need for fitting the model to the FFT spectrum. Spectral estimates obtained by AR method have superior statistical properties to the FFT method, but even bigger advantage is connected with the parameterization of the signal.

Independent component analysis (ICA) (Rosipal et al. 1998) is a powerful tool for separating signals from their observed mixtures. The majorities of these methods adopt a truly blind approach and disregard available a priori information in order to extract the original sources or a specific desired signal. This could by possible by the application of a suitable form of the independent component analysis transform for the extraction of and information bearing signal. In this contribution they are proposed a fixed point algorithm which utilizes a priori information in finding a specified signal of interest from the sensor measurement.
In the year 2001, Gharieb and Cichocki proposed the approach of the classification and tracking of the EEG waves. In this approach, an adaptive recursive bandpass filter is employed for estimating and tracking the center frequency associated with each EEG wave. The main advantage inherent in the approach is that employed adaptive filter only requires one coefficient to be updated. This coefficient represents an efficient distinct feature of each EEG specific wave and its time function reflects the nonstationarity of the EEG signal. The signals are passed forward and backward through the filter to avoid phase distortion. Due to above mentioned length process, this technique not more suitable for the detection of sleep spindles.

The sleep spindle is a defining property of stage 2 NREM sleep. In 2002, (Miroslaw et al. 2002) developed the software which not only detects spindles but also visualizes the distribution of spindle intensity across EEG channels. They apply the novel procedure of wavelet mapping to study the influence of focal epilepsy on spindle distribution. In wavelet mapping technique, selection of suitable wavelet with respect to spindle activity is more crucial.

Parametric description of EEG time series have been widely used, but the parameters of AR model, which are represented as the output of the analysis, lacked the physiological meaning. On contrary, the parameters proposed by our research have a clear interpretation. The representation of the parameters of the impulse function of the EEG time series: frequencies of oscillations with the associated decay factors in the complex S plane seem to be a good way of describing the nonlinear changes of the EEG signal. This kind of analysis offers high reduction of data to few parameters of a clear physiological interpretation. These parameters are also optimal from the point of view of information theory since they are obtained by the method having the properties of maximum entropy.
Detection of sleep spindles using the surrogate data method proposed in this thesis gives accurate results when applied to test the significance of power spectral amplitudes. It is based on solid statistical principles and overcomes some weaknesses in previous methods for the same purpose. The approach proposed in this study is able to provide, thanks to the use of an efficient procedure to identify nonlinear characteristics, the surrogate data that mimic possible changes through time in the properties of a given time series. This approach permits application of the surrogate-based test for nonlinearity to a wider class of null hypothesis, including nonstationary behaviors.

Various Fourier transform-based frequency methods for data analysis have been applied to sleep EEG for more than two decades. However, the use of higher order spectral techniques (i.e., normalized bispectrum) which may detect and measure the interactions between frequency components of the EEG has only been investigated in a few cases (sleep spindle). Both the time and frequency domain experiments show that: 1) spindle activity may not uniformly dominate all regions of brain; 2) during the spindle activity frontal recordings still exhibit rich mixtures in frequency contents and couplings. On the other hand, data from the posterior region of the head exhibit a poor couplings but demonstrate dominancy to spindle activity, which confirms some other recent (second-order statistics based) studies (Marc et al. 1992); 3) evidences suggest that sleep spindle activity ought to be envisaged by having at least second-order nonlinearity.

One of the important uses of the bispectrum is detecting quadratic phase coupling effects. This information is actually infused in the third moment sequence of a process. For a process consisting of sinusoids in white Gaussian noise, the third moment sequence satisfies the third order recursion with a finite set of improved surrogate data sets. The resulting bispectrum estimates are superior to known methods in detecting phase coupling effects
for short length data. This fact has been consistently borne out by many simulation experiments. To mitigate this problem, the improved surrogate data method is used to detect the QPC type of nonlinearity. In conclusion, bispectral analysis is a powerful tool to detect QPC and has been applied successfully to evaluate QPC types of nonlinear effects in human electroencephalogram (EEG) recordings. The frequency domain method, based on normalized spectrum and bispectrum describes frequency interactions associated with nonlinearities occurring in the observed EEG.

6.2 FUTURE WORK

The present work provides several additional recommendations for continuing the research on the same area. First, generating the null hypothesis distribution for the test statistic is a very time-consuming process. The application of chi square distribution theory mitigates this problem. Secondly, when the original data with length L need to be zero padded to length N (N > L), the improved surrogate data still have the same power spectra with the original data, the improved surrogate data need to be normalized by L, instead of the real data length N. Significant nonzero bispectra at frequencies with low power are thus effectively masked by frequencies with high power. This problem could be mitigated by using bicoherence as the test statistics since it is normalized across power. Third, when the improved surrogate data set is generated using improved ziggurat method, it does not generate random numbers effectively in tail regions because Matlab does not execute greater than 500 function calls. Finally, the discrimination power of our statistical test is unclear. This can be determined empirically by repeating the test many times on different realization for the data. This issue can be considered for our future research.