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Comparison of STFT and wavelet transform methods in determining epileptic seizure activity in EEG signals for real-time application☆

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Abstract

Electroencephalography (EEG) is widely used in clinical settings to investigate neuropathology. Since EEG signals contain a wealth of information about brain functions, there are many approaches to analyzing EEG signals with spectral techniques. In this study, the short-time Fourier transform (STFT) and wavelet transform (WT) were applied to EEG signals obtained from a normal child and from a child having an epileptic seizure. For this purpose, we developed a program using Labview software. Labview is an application development environment that uses a graphical language G, usable with an online applicable National Instruments data acquisition card. In order to obtain clinically interpretable results, frequency band activities of δ, θ, α and β signals were mapped onto frequency–time axes using the STFT, and 3D WT representations were obtained using the continuous wavelet transform (CWT). Both results were compared, and it was determined that the STFT was more applicable for real-time processing of EEG signals, due to its short process time. However, the CWT still had good resolution and performance high enough for use in clinical and research settings.

Keywords: EEG; Wavelet transform; STFT; Epileptic seizure

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1. Introduction

Spectral analysis and signal decomposition continue to find wide use in a multitude of engineering disciplines. The basic idea in signal decomposition is to separate the spectrum into its constituent subspectral components and then process them individually, based on the application [1]. Electroencephalogram (EEG) is widely used clinically to investigate brain diseases. Since EEG signals contain a wealth of information about brain functions, there have been many attempts to apply spectral analysis techniques to EEG signals classification in brain abnormalities. To use this information in medical researches and illness diagnosis, spectral analysis of signals must be performed with spectral analysis methods and it is necessary to make automation [2]. The system shown in Fig. 1 was realized for this purpose.

Epileptic seizure may start at any period in life, under certain conditions it may also start nearly almost after birth. The first epileptic seizure is seen before 20 years, especially in the first 3 years and before adolescence time in three-fourth of all epilepsy patients [3]. Nowadays, EEG is accepted as the most economic and harmless technology in diagnosing this widespread illness. In most of the events it is used in determining that point in brain which causes the epilepsy, during the diagnosis if the abnormal excitation of nerve cells is decreased or not, and how fast it is decreasing.

EEG signals are not deterministic and they have no special formation like electrocardiogram (ECG) signals. Because of this, in the analysis of EEG signals, statistical and parametric analysis methods are used (such as time–frequency analysis, self relation, crosswise relation, wavelet transform). These methods provide imaging of frequency band at the moment of epileptic seizure. They also provide the determination of the time of frequency rhythm analysis of periodic EEG signals. Since their statistical properties are dependent on time and space, EEG signals are treated as complex signals. But these signals may be decomposed into typical sample periods analytically. Furthermore, if the temporal characteristics of EEG signals are taken into consideration, it will be seen that they are not stable as it is clearly seen from Fig. 11(a) [4–7].

Spectral analysis of the EEG signals is performed using the short-time Fourier transform (STFT), in which the signal is divided into small sequential or overlapping data frames and fast Fourier transform (FFT) applied to each one. The output of successive STFTs can provide a time–frequency representation of the signal. To accomplish this, the signal is truncated into short data frames by

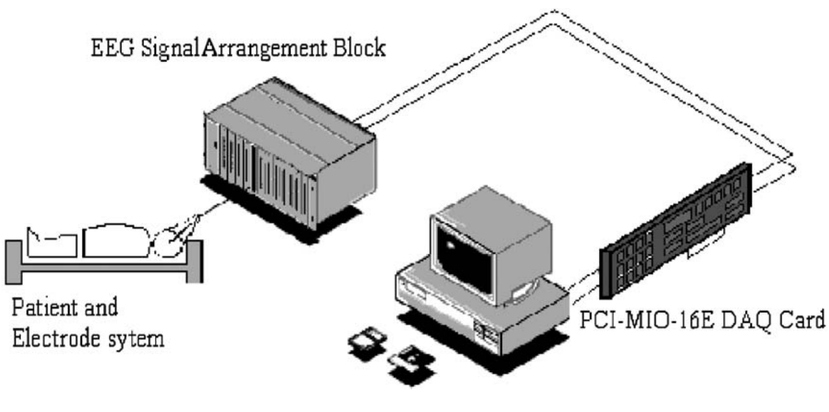

Fig. 1. EEG signal acquisition and processing system.