Chapter 6
Classification of EMG Signals Using Eigenvalue Decomposition-Based Time-Frequency Representation

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ABSTRACT

Electromyogram (EMG) signals are commonly used by doctors to diagnose abnormality of muscles. Manual analysis of EMG signals is a time-consuming and cumbersome task. Hence, this chapter aims to develop an automated method to detect abnormal EMG signals. First, authors have applied the improved eigenvalue decomposition of Hankel matrix and Hilbert transform (IEVDHM-HT) method to obtain the time-frequency (TF) representation of motor unit action potentials (MUAPs) extracted from EMG signals. Then, the obtained TF matrices are used for features extraction. TF matrix has been sliced into several parts and fractional energy in each slice is computed. A percentile-based slicing is applied to obtain discriminating features. Finally, the features are used as an input to the classifiers such as random forest, least-squares support vector machine, and multilayer perceptron to classify the EMG signals namely, normal and ALS, normal and myopathy, and ALS and myopathy, and achieved accuracy of 83%, 80.8%, and 96.7%, respectively.

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INTRODUCTION

The muscular system is responsible to generate the force for the movement of the body and providing the shape to the body. Nerve impulses are responsible for the movement of the muscles. These impulses originated in the brain and travel through the peripheral nervous system to a specific location in the body. Neuromuscular disorder (NMD) is a disorder which interrupts the communication path between the nervous system and the muscles (Kandel et al., 2000; Anthea et al., 1993). Motor neuron diseases, disorders of neuromuscular transmission, neuropathy, amyotrophic lateral sclerosis (ALS), and myopathy come under the category of NMD (Karpati et al., 1970). Myopathy is a disease which affects the skeletal muscle tissue directly. It affects the functioning of the muscles. However, neuropathy is related to the disease that causes damage to the nerves which is involved in the muscular control (Yousefi et al., 2014). The ALS is also a type of NMD which can also be responsible for the death of the patient (Mishra, et al., 2016, February). The commonly found symptoms of ALS are respiratory failure, atrophy, and weakness. It may have serious impact on the functioning of motor neurons. With the time, it may result in the paralysis. Hence, in time diagnosis and proper treatment are of prime importance. Electromyogram (EMG) is a common tool utilized by the clinician for the diagnosis of the NMD.

In general, neurophysiologists utilized the properties of motor unit action potentials (MUAPs) to assess the NMDs (Nikolic & Krarup, 2011). Hence, MUAPs have an important role in the diagnosis of the NMDs. The MUAPs consist a complex structure which makes the manual assessment, a difficult task. Moreover, the accurate manual detection of the abnormalities present in the characteristics of MUAPs requires a lot of skills and experience. Hence, the detection accuracy of these abnormalities may not be sufficient to take the further step. Therefore, it is required to perform computer aided analysis of MUAPs using signal processing techniques.

Several computer aided methods are available in the literature for the analysis of normal and NMD EMG signals. In (Pattichis & Elia, 1999), the time domain measures, cepstral coefficients, autoregressive (AR) coefficients, and AR spectral measures are computed from the MUAPs for the analysis of normal and diseased EMG signals. In (Fattah et al., 2012), time and frequency domain-based features such as zero crossing rate, autocorrelation, and Fourier transform are suggested for the detection of the ALS patients. The interference pattern analysis is found useful in studying the muscle activity (Fuglsang-Frederiksen, 2000). A method for ALS detection based on short time Fourier transform (STFT) is proposed in (Doulah et al., 2012, May). In (Pfeiffer, 1999), a sequential Baysen algorithm-based approach is used to analyze the EMG signals. An AR method and wavelet neural network-based approach is utilized for the discrimination of different classes of EMG signals (Subasi et al., 2006). The principal component analysis (PCA) based method is proposed