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ANALYSIS OF TYPE I AND TYPE II FIBER CHARACTERISTICS USING REASSIGNED SMOOTHED PSEUDO WIGNER VILLIE DISTRIBUTION

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ABSTRACT

Time-frequency distributions (TFDs) are superior in handling the non-stationarity of surface electromyography (sEMG) signals. However, the presence of cross terms makes the interpretation of TFDs difficult. Reassignment techniques are found superior to conventional TFDs in effectively reducing the cross terms along with generating a concentrated visualization of signal energy components. In this study, the suitability of reassignment technique for analyzing the fiber type characteristics of gastrocnemius lateralis (GL) and soleus (SOL) is investigated. sEMG signals are acquired from these muscles during a calf raise test and are further processed with smoothed pseudo Wigner Villie distribution (SPWVD). It is followed by reassignment technique to obtain the reassigned SPWVD. Averaged instantaneous frequency (AIF) and averaged instantaneous frequency density (AIFD) are obtained from the reassigned time-frequency matrix. The variation of these features are studied for non-fatigue and fatigue segments in both muscles. The result indicates that AIF and AIFD decreases in GL and increases in SOL signals during fatigue. Reduction of extracted features in GL might be due to the fatigue of type II fibers whereas increment of these features in SOL may be due to the augment in the firing rates of type I fibers. The extracted features are found statistically significant in one-way ANOVA test. Hence, the reassignment method and the extracted features are found effective for analyzing the fiber type characteristics of GL and SOL. The proposed method may be adopted for the fiber type analysis of different muscles.

Keywords: sEMG, fiber type, reassigned smoothed pseudo wigner villie distribution, gastrocnemius lateralis, soleus

INTRODUCTION

Surface electromyography (sEMG) is an effective technique for examining the electrophysiological modifications inside myocytes during muscle activities. These signals which are acquired non-invasively using superficial electrodes could reflect the functional state of the muscle under various neuromuscular conditions [1]. sEMG signals are informative in technical and medical disciplines. They could reveal nerve and muscle dysfunction and abnormalities in nerve-to-muscle signal transmission [2]. Moreover, sEMG signals are significant in many applications, including fatigue analysis, ergonomics, human-machine interactions, and biomechanics [3].These signals could also reflect the underlying fiber type characteristics in different muscles which may find application in athletics [4]. However, the analysis of sEMG signals needs to be done with utmost care as they are highly complex, multi-component and, time-varying in nature [5]. Recent researchers are more focused on time-frequency distributions (TFD) which are found suitable for handling the non-stationarity of sEMG signals [6].

TFD's help to generate high-resolution spectral energy distributions along with minimizing the unnecessary cross-term interference in the signal components [7]. A joint time-frequency representation (TFR) of the signal can be generated using different TFRs [8]. Wigner villie distribution (WVD) is a bilinear Cohen's class TFD that shows improved resolution relative to linear TFDs. However, this distribution is extremely sensitive to noise and generates interference components that often mask the signal terms which makes the interpretation difficult in multi-component signals. Hence,