Detection of Rhythmic Synchronized Double Neuronal Discharges*  

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Abstract— Bursting neurons play an important role in motor pattern synchronization and neuronal communication resulting in the ability to coordinate muscles across large anatomical distances. We developed an expert system to detect and assess such synchronization among multiple double-firing neurons.

I. INTRODUCTION

In this research, we investigate the underlying neuronal bursting behavior in human Central Pattern Generators (CPGs) revealed by rhythmic surface electromyographic (sEMG) activity [1]. The Discrete Wavelet Transform (DWT) has long been used to explain motor unit recruitment by selecting a mother wavelet similar to the Motor Unit Action Potentials (MUAPS), such as Daubechies 3 (db3) [1], [2], where high scale subbands have served to single out the spiking neuronal events, and lower scale subbands are mainly comprised of high-frequency noise [1]. However, the periodicity of the DWT and variability in the return times of bursts may cause the multiple MUAPS be misaligned with the mother wavelet during the spiking events (e.g. burst #2 of Fig. 1), or half aligned (e.g. burst #3 of Fig. 1), compared to a relatively better alignment that occurs in burst #1 of Fig. 1.

Thus, we developed a system [3] that delays the DWT multiple times and increases the waveform matching between raw sEMG signal and its 8-level sub-signal to provide time-localization and characterization of spiking events.

This research was supported by the EpineurEnergetics Foundation and approved by the Institutional Review Board (IRB) of the University of Southern California (USC). The techniques developed in this paper are covered by US Provisional Patent Application No. 62/608,474.

Prior to electrode placements, volunteers had signed the Informed Consent Form drafted by the investigators and approved by the IRB of USC. R. Martin del Campo is with the Electrical Engineering Dept., USC, Los Angeles, CA 90089 USA (corresponding author; phone: 213-361-4850; e-mail: mat737@usc.edu).

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II. METHODS

Four-minute recordings of sEMG data were collected at a sampling rate of 4,000 Hz from volunteers with different states of health, who had four reduced-noise tripolar sEMG electrodes placed along their paraspinal muscles and aligned with the fibers at cervical, thoracic, lumbar, and sacral positions*. To solve the mentioned shift variance issue, we designed a set of expert rules that consist of nested conditional statements each within a for loop (with index representing the chronological appearance of each burst) that computes the minimal error between the local maxima of a delayed DWT sub-signal and a smoothed (Savitzky-Golay filtered) sEMG signal. This process resulted in delays at which this waveform matching is located on the Pareto front.

III. RESULTS

The delays \( \theta_1=5 \text{ ms for D}_8 \) burst #1', \( \theta_2=14 \text{ ms for D}_8 \) burst #2'', and \( \theta_3=24 \text{ ms for D}_8 \) burst #3''' were found on the Pareto front, thus providing a better match (Fig. 2).

![Figure 2](image_url)  

Figure 2. Zoom around each burst with its 8-level sub-signal: The DWT has been delayed the amount of time that the expert system found on the Pareto front for each burst, recovering the morpholgy of D8 bursts #2 & #3.

IV. DISCUSSION & CONCLUSION

The entire spiking events are best reconstructed from two relatively high and successive D8 coefficients (each spanning \(~60 \text{ ms})

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