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METHOD FOR SUPPRESSION OF ELECTRICAL STIMULATION ARTIFACT IN ELECTROMYOGRAPHY

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1 INTRODUCTION

The use of Functional Electrical Stimulation (FES) to promote rehabilitation in people with neurological diseases consists of electrically inducing the contraction of muscles that otherwise would be weakened or paralysed as happens with the Tibialis Anterior in people with Drop Foot. A bio-inspired method for controlling FES devices is the application of controllers that use neuromusculoskeletal models that map the Electromyography evoked by stimulation (eEMG) to joint torque or angle and to determine the proper stimulation to apply to the user [1].

One issue with using eEMG with FES are the stimulation artifacts that contaminate the EMG signal and need to be filtered to give the M-wave, the electrical signal that reflects muscle contraction and is used to drive said models. Some methods for artifact removal have been presented in the literature [2,3] but rely on characteristics of the signal that are not robust to all stimulation conditions/setups. Here we present a more heuristic approach that uses simple but known characteristics of the signal to detect and suppress the stimulation artifacts in a wider range of conditions.

2 METHODS

The filtering strategy here presented follows a strategy adapted from Liu et al. [3]. Our strategy consists in the following steps and is illustrated in Figure 1:

1. Apply a Savitzky-Golay Filter to the raw data;
2. Compute the difference (residue) between the filtered and raw signals;
3. Full-wave rectify and filter the residue with a low-pass filter (moving average);
4. Use the location of the first peak of every M-shape event present in the resultant signal to create the regions where the artifacts are contained, by placing a pre-defined window centred in such peaks;
5. Remove the artifacts and interpolate the signal to get the reconstructed, artifact free, M-waves.

To locate the artifact, information about the stimulation frequency (f_{stim}) is also used as we assume that the artifacts happen once every $1/f_{stim}$ seconds.

To test this method, we applied a Pseudo-Random Binary (PRB) stimulation signal at 20Hz to the Common Peroneal Nerve of a healthy subject. EMG signal was collected from the Tibialis Anterior using the Delsys Trigno system and processed off-line in an “online-like” manner in Matlab 2021a. This was done by considering packets of 59 samples (13.5 ms of data) at a time, emulating the streaming capabilities of the Delsys system. These packets would be buffered and processed in bundles of three.

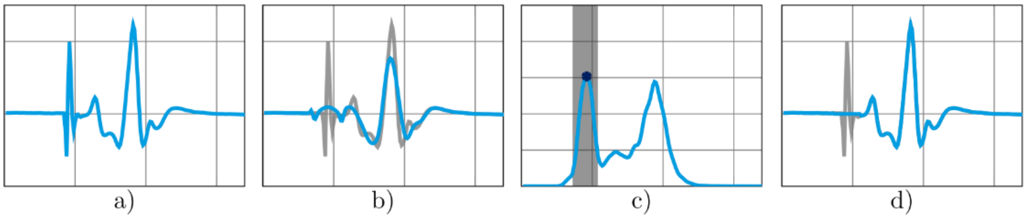

Figure 1 –Filtering process: a) raw data with both the artifact and the M-wave present; b) Savitzky-Golay Filter applied to the raw data; c) Residue between filtered and raw data is full-wave rectified, low-pass filtered and the first peak of the M-shape is used to create the exclusion region; d) the artifact is removed from the raw data and the final signal is interpolated to get an artifact-free M-wave.

3 Results

Figure 2 –Filtering of an EMG signal contaminated with artifacts from a 20Hz stimulation. One can see the raw signal (in grey) overlapped by the filtered signal (blue)

The result of the filtering process of the PRB stimulation signal applied to the subject is presented in Figure 2. The method was able to remove the artifacts without changing the shape of the M-wave, thus without losing any important information. This was done regardless the amplitude of the former and even when the amplitude of the latter is higher than the artifact.

4 Conclusion

A new method for suppressing stimulation artifacts in EMG with real-time application was presented. This new method works despite the amplitude of the stimulation signal or evoked M-wave and represents a more robust tool to deal with such artifacts when using controllers for FES devices based on neuromusculoskeletal models driven, in part, by the evoked M-wave. This will ultimately help in the development of more bio-inspired devices that will result in a more natural and efficient rehabilitation process.

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