Neurostimulation artifact removal algorithms to improve control of a tactile feedback prosthesis

F Just[1, 2], R Reho[1, 3], EJ Earley[1, 4], M Ortiz-Catalan[1, 2, 5]

[1]Center for Bionics and Pain Research, Mölndal

[2]Department of Electrical Engineering, Chalmers University of Technology, Göteborg

[3]University of Genoa, Genova

[4]University of Colorado Anschutz, Denver

[5]Bionics Institute, Melbourne

Introduction

To achieve reliable bidirectional control of a multifunctional upper limb prosthesis by the end user, tactile feedback to the brain is essential. One approach to providing tactile feedback is to implant electrodes around residual nerves, allowing for direct nerve stimulation based on sensor information from the prosthetic device. Furthermore, modulation of the stimulation is necessary to achieve a more natural sensation and richer information. However, the proximity of the nerve electrodes to the muscular electrodes can cause electric artifacts during stimulation, which degrade the quality of the electromyographic (EMG) signal and reduce the reliability of the myoelectric control.

Methods

We propose a novel algorithm for removing modulated stimulation artifacts by using a statistical model-based approach due to strictly limited memory within a self-contained embedded prosthetic system. The algorithm adapts the filter based on the modulated amplitude of the stimulation, allowing the relative artifact template to be subtracted from the EMG signals. Offline analysis of recorded EMG signals containing modulated stimulation artifacts was conducted to train the algorithm and evaluate its performance in artifact removal. To assess the algorithm's real-time performance, it was implemented on an embedded prosthesis controller, and experiments were conducted with a participant implanted with intramuscular electrodes for myoelectric control and nerve cuffs for tactile feedback.

Results

The experimental results demonstrate that the proposed filtering algorithm partially removes offline the modulated stimulation artifacts and helps to restore the original EMG signal for control. The improved signal quality enhanced the performance of the neural network classification for myoelectric control during standardized online motion tests by 38% (from 8/25 to 11/25 correct classifications with 5 possible classification classes).

Conclusion

The algorithm can filter modulated stimulation artifacts partially, to enable more reliable myoelectric control and tactile stimulation simultaneously. However, further research is needed to reach a more reliable classification accuracy.