A SEGMENTATION APPROACH TO LONG DURATION SEMG RECORDINGS: AN ERGONOMIC APPLICATION

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INTRODUCTION

Surface electromyography (SEMG) is a commonly used tool in the study of muscle activity due its non-invasive and representative nature. In particular, the presence of fatigue can be detected in SEMG signals when the power spectrum becomes compressed, resulting in a reduction in both the mean and median frequencies. Despite these benefits, several problems arise when SEMG is used in an ergonomic setting to detect postural muscle activity. In order to detect fatigue in postural muscles, recordings must be of long duration due to the low levels of SEMG activity present. Furthermore, low activation levels are often compounded by low signal to noise ratios (SNR), while postural SEMG activity is often masked by other electrical activity and noise (Lamotte et al, 1996). The aim of this investigation was to develop an automatic segmentation method, in order to detect postural SEMG segments. The secondary aim of the study was to search for an evolution in the power spectra of these signals due to fatigue.

METHODS

SEMG signals were collected from the cervical erector spinae muscle using a bipolar electrode configuration. The nine male subjects remained seated in a car seat over the 150-min data-collection period. Subjects' mean age, height and weight were 32.4 ± 7.6 y, 1.77 ± 0.05 m, and 75.7 ± 6.4 kg, respectively. The SEMG signals were band-pass filtered (20-2000 Hz) and sampled at 840 Hz.

The segmentation methodology used in this study was a modification of the Cumulative Sum (CUSUM) algorithm proposed in Basseville and Nikiforov (1993), which, although able to accurately detect change points in a signal, can not be used directly without a priori knowledge of the segments to be detected. The new method, termed the Modified Dynamic Cumulative Sum (MDCS), was based on the log-likelihood ratio between two instantaneous hypotheses estimated at time t. The MDCS used a double threshold in two sliding windows in order to detect changes in an auto regressive (AR) model of the original signal. The thresholds were calculated using the distribution of the Kullback-Leiber information in the signal. An example of a change detection is shown in Figure 1.

After segmentation, the signals were classified and/or rejected using a two-fold procedure. Firstly, the signals were compared to an exponential model of a SEMG spectrum to determine whether or not they contained SEMG. Secondly, the ratios between the energy levels in adjacent segments were used, in order to retain only those segments containing postural SEMG. Finally, the median frequency of each postural SEMG segments was measured, to determine the presence of fatigue.

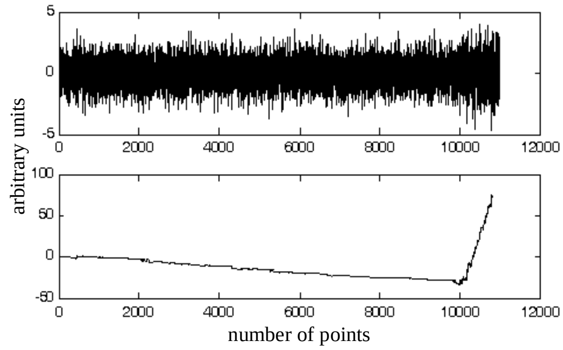

Figure 1: Evolution in the MDCS around a change point at 10,000. (a) Signal (b) Evolution of the MDCS.

RESULTS AND DISCUSSION

An example of the evolution in the median frequency of a postural SEMG signal for one subject is shown in Figure 2. The methodology used enabled the successful identification of postural SEMG signals, despite the presence of an unfavourable SNR. However, no significant evolution in spectral parameters over time was observed in the postural segments identified. Such a finding may have been due to the small number of subjects used, or that muscular fatigue was not induced during the 150-min trial.

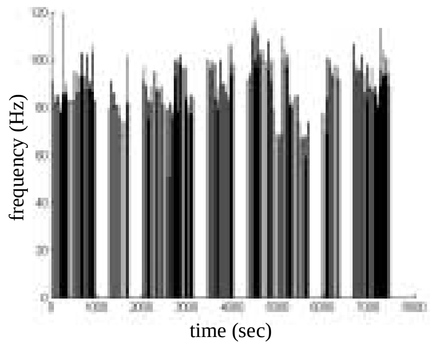

Figure 2: An example of the evolution in the median frequency of a SEMG signal over 150 minutes, after rejection of non-postural SEMG segments.

SUMMARY

The MDCS segmentation method should provide a valuable tool to tackle several methodological issues related to long-term SEMG recordings.

REFERENCES

Basseville, M. and Nikiforov, I. (1993). *Detection of Abrupt Changes: Theory and Application*. Englewood Cliffs: Prentice Hall.
Lamotte, T., et al (1996). *Ergonomics*, **39**, 781-96.