[Proceeding] Estimation of monopolar signals from spincter muscles and removal of common mode interference

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ESTIMATION OF MONOPOLAR EMG SIGNALS FROM SPHINCTER MUSCLES

Luca Mesin

LISN, Dept. of Electronics, Politecnico di Torino, Torino, Italy

1. INTRODUCTION

Surface electromyogram (EMG) is usually recorded by means of spatial filters with vanishing sum of weights. More information could be extracted from monopolar signals measured with respect to a reference electrode away from the muscle. Under some assumptions, surface EMG detected along a line parallel to the fiber path has zero mean value in space at all time. This property is a constraint which can be used to estimate monopolar signals from single differential (SD) EMG signals and is satisfied in the case of a circumferential electrode array surrounded by a circular muscle.

2. METHODS

The problem of estimating monopolar signals \( \hat{m}(t) \) from SD \( \hat{s}(t) \) is not well posed. Indeed, there are infinite solutions, as an arbitrary function of time \( f(t) \) can be added to the monopolar signals without affecting the SD signals.

\[
\hat{s}(t) = \hat{m}(t) + f(t) - (m_0(t) + f(t) - m_0(t))
\]

SD signals from an array of N electrodes can be expressed in terms of monopolar signals as follows:

\[
\begin{bmatrix}
0 & 1 & \cdots & 0 \\
1 & 0 & \cdots & 0 \\
\vdots & \vdots & \ddots & \vdots \\
0 & 0 & \cdots & 1
\end{bmatrix}
\]

Matrix \( A \) cannot be inverted as it has a vanishing eigenvalue, associated to an eigenvector with constant entries. Nevertheless, the pseudoinverse of matrix \( A \) can be evaluated and monopolar signals can be estimated as

\[
\hat{m}(t) = A^\dagger \hat{s}(t)
\]

Under the assumption that the volume conductor is space invariant, the monopolar surface EMG detected along a curve parallel to the fiber path has zero mean value in space at any time.

3. RESULTS

Application to simulated SFAPs

Additive white Gaussian noise

Amplitude variation

Variation of the amplitude of 200 Hz interference

Energy of the noise error

Application to simulated noise free MUAPs and interference signals

4. CONCLUSIONS

Under the hypothesis of space invariance of the volume conductor, monopolar signals detected along the direction of the muscle fibers with an array covering the entire spatial support of the potential distribution have vanishing spatial mean at any time. This provides a constraint for estimating monopolar SD signals from sphincter muscles.

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