T01: EMG modeling

AN ANALYTICAL MODEL FOR SURFACE EMG GENERATION IN VOLUME CONDUCTORS WITH SMOOTH VARIATION IN CONDUCTIVITY

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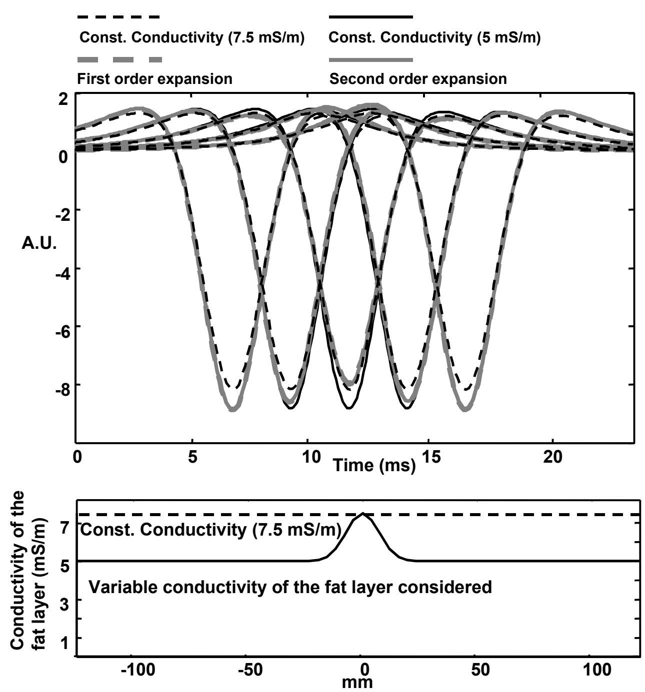
AIMS: In this study we provide an analytical description of a non-space invariant volume conductor for surface EMG signal generation. The volume conductor presents a variation in conductivity along the direction of the muscle fibres. This may reflect the practical situation of tissues with different conductivity properties in different locations or of transitions between tissues with different properties.

METHODS: The volume conductor comprises planar layers representing the muscle and subcutaneous tissues. The muscle tissue is homogeneous and anisotropic while the subcutaneous layer is inhomogeneous and isotropic. The inhomogeneity in the subcutaneous layer is modelled as a smooth variation in conductivity along the muscle fibre direction. The problem is studied in the two-dimensional Fourier domain with spatial angular frequencies corresponding to the longitudinal and perpendicular direction with respect to the muscle fibres, in planes parallel to the detection surface. Regular perturbation theory was applied, representing the solution as a series expansion. This leads to a set of Poisson's problems, for which the source term in an equation and the boundary conditions are determined by the solution of the previous equations. This set of problems is solved iteratively, obtaining approximations of higher order at each step. The series expansion is truncated for the practical implementation, leading to an approximate solution.

RESULTS: The model was implemented in Matlab and showed high convergence rate. A second order expansion indeed provided an approximation with negligible error with respect to higher orders (Figure). A smooth change in the simulated conductivity of the subcutaneous layer determined a perturbation in the shape of the surface potential in the direction of source propagation (Figure). The perturbation dependsed on the position of the source, thus the model is not space invariant.



REPRESENTATIVE SIMULATION OF SINGLE FIBER ACTION POTENTIALS GENERATED BY THE PROPOSED MODEL IN CASE OF HOMOGENEOUS VOLUME CONDUCTOR AND IN CASE OF GAUSSIAN VARIATION OF CONDUCTIVITY OF THE SUBCUTANEOUS LAYER, WITH ZERO ORDER, FIRST ORDER, AND SECOND ORDER EXPANSIONS.

Conclusions: The proposed model constitutes a new approach for surface EMG signal simulation with applications related to the validation of methods for information extraction from this EMG signals.