Simulation of Surface EMG Signals for a Multi-layer Volume Conductor with Triangular Model of the Muscle Tissue

T01: EMG modeling

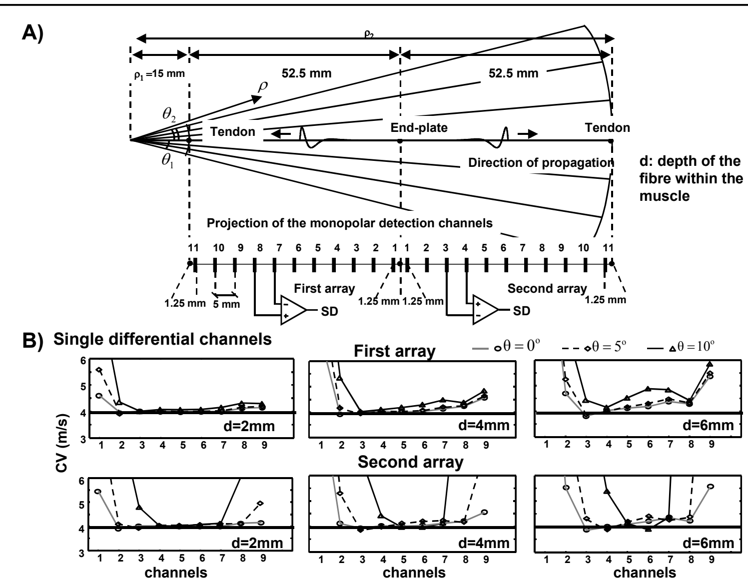
SIMULATION OF SURFACE EMG SIGNALS FOR A MULTI-LAYER VOLUME CONDUCTOR WITH TRIANGULAR MODEL OF THE MUSCLE TISSUE

Mesin L.
LISiN, Dept. of Electronics, Politecnico di Torino, Torino, Italy.

AIMS: Surface EMG signal simulation has important applications in testing algorithms for parameter estimations and in interpreting experimental EMG data. This study analytically describes surface EMG signals generated by a model of a triangular muscle, i.e., a muscle with fibres arranged in a fan shape. Examples of triangular muscles in the human body are the deltoid, the pectoralis major, the trapezius.

METHODS: A model of triangular muscle is proposed. It is a sector of a cylindrical volume conductor (with the fibres directed along the radial coordinate). The muscle conductivity tensor reflects the fan an-isotropy. Edge effects have been neglected. A solution of the non-space invariant problem for a triangular muscle is provided in the Fourier domain. An approximate analytical solution for a two plane layer volume conductor model is obtained by introducing a homogeneous layer (modelling the fat) over the triangular muscle. The results are implemented in a complete surface EMG generation model (including the finite length of the fibres), simulating single fibre action potentials.

RESULTS: The model is not space invariant due to the changes of the volume conductor along the propagation of the action potentials. Thus the detected potentials at the skin surface change shape as they propagate. This determines problems in the extraction and interpretation of parameters. The influence of the in-homogeneity of the volume conductor in CV estimation is addressed. Different fibre depths, electrode placements and small misalignments of the detection system with respect to the fibre have been simulated. The CV estimate is largely biased when the depth of the fibre increases, when the detection system is not aligned with the fibre and close to the innervation point and to the tendons. CV estimates with bias less than 10% were obtained only in the case of superficial fibres (less than 4 mm depth within the muscle), aligned with the detection system (less than 5° misalignment), far from the end-plate and tendons. Values with more than 50% bias were obtained in the worst simulated conditions (channels close to the innervation region or tendons, misalignment 10°, 6 mm depth of the fibre within the muscle).



A) MODEL OF TRIANGULAR MUSCLE. TWO ELECTRODE ARRAYS ARE SIMULATED. B) ESTIMATED CV AS A FUNCTION OF THE DETECTION ARRAY AND POSITION OF THE MUSCLE FIBRE.

CONCLUSIONS: In a triangular muscle surface EMG signal variables are largely affected by the volume conductor and by the fibre arrangement.