T02: EMG signal processing

ESTIMATION OF MOTOR UNIT CONDUCTION VELOCITY DISTRIBUTION BY MULTI-CHANNEL M-WAVE DECONVOLUTION

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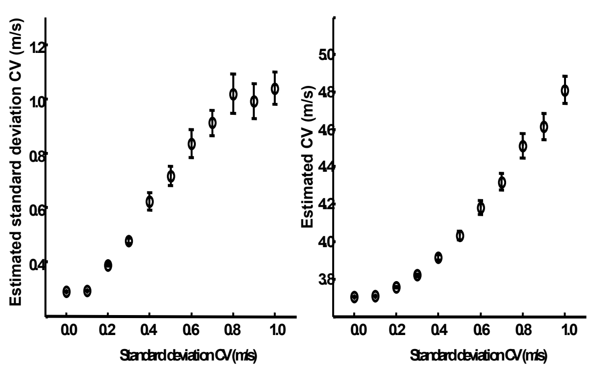
Aims: We propose a method for estimating the distribution of motor unit conduction velocity (CV) from M-waves recorded with a linear electrode array.

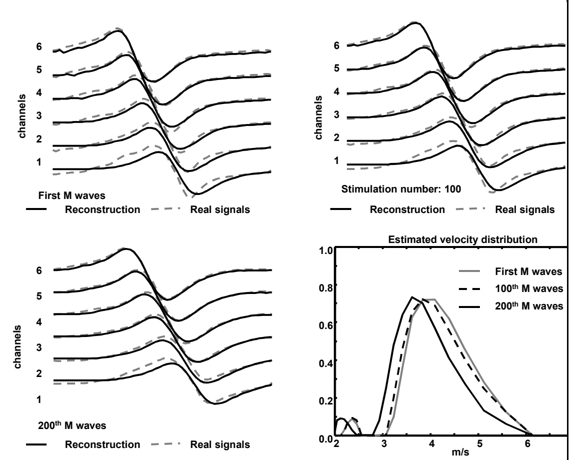
Methods: An M-wave was modelled as the summation of delayed and scaled (in amplitude) versions of the same waveform. Thus, the compound potential can be related to the single action potential by a convolution operation. Neglecting the spread of the end-plates, the delay associated to the detection of each action potential is inversely related to its velocity of propagation. The determination of the distribution of the delays given the M-wave can be obtained by the inversion of the convolution operator applied to the single action potential to obtain the M-wave (deconvolution). Deconvolution is an ill-posed problem which requires the use of a regularisation technique. Tikonov regularisation method was used in this study. The method was generalised to the case of a multi-channel detection system. The estimated solution was obtained by minimising, in the least square sense, the error in the reconstruction of the data. Both penalisation of L_2 norm of the solution and of its derivative were tested. Furthermore, an algorithm for imposing positivity of the solution was implemented, based on Landweber iteration method. The resulting delay distribution was finally restricted to physiological delays. The regularisation parameters were chosen by the L-curve method.

Results: The developed method was applied to simulated (using a simulation model of surface EMG signals with multi-layer, cylindrical description of the volume conductor) and experimental signals (from transcutaneous electrical stimulation of the biceps brachii muscle). The method proved to be sensitive to changes in the standard deviation of the CV distribution (Figure A) in simulated signals, although the estimates presented a bias, especially for low standard deviation values. Figure B shows the application of the method to representative experimental signals.

Conclusions: A M-wave deconvolution method was developed generalising Tikonov regularisation to a multi-channel detection system. The method may detect relative changes in the spread of conduction velocity of the motor units and can thus be applied in fatigue studies.



RESULTS ON SIMULATED SIGNALS. ESTIMATED STANDARD DEVIATION AND MEAN CV (AVERAGE ± SD, OVER 100 SIMULATIONS) AS A FUNCTION OF THE STANDARD DEVIATION IMPOSED IN THE MODEL.



EXAMPLE OF APPLICATION TO EXPERIMENTAL SIGNALS