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Sampling, noise-reduction and amplitude estimation issues in surface electromyography â˜†

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Abstract

This paper reviews data acquisition and signal processing issues relative to producing an amplitude estimate of surface EMG. The paper covers two principle areas. First, methods for reducing noise, artefact and interference in recorded EMG are described. Wherever possible noise should be reduced at the source via appropriate skin preparation, and the use of well designed active electrodes and signal recording instrumentation. Despite these efforts, some noise will always accompany the desired signal, thus signal processing techniques for noise reduction (e.g. band-pass filtering, adaptive noise cancellation filters and filters based on the wavelet transform) are discussed. Second, methods for estimating the amplitude of the EMG are reviewed. Most advanced, high-fidelity methods consist of six sequential stages: noise rejection/filtering, whitening, multiple-channel combination, amplitude demodulation,

smoothing and relinearization. Theoretical and experimental research related to each of the above topics is reviewed and the current recommended practices are described.

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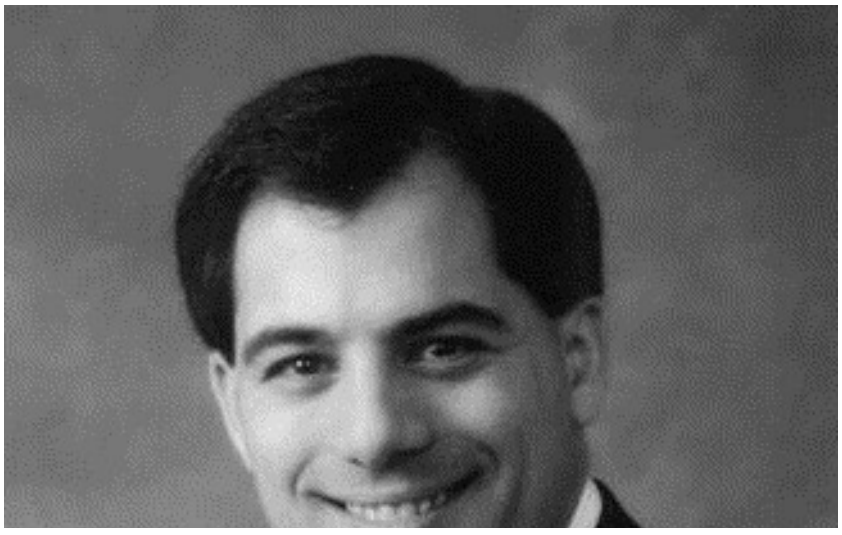
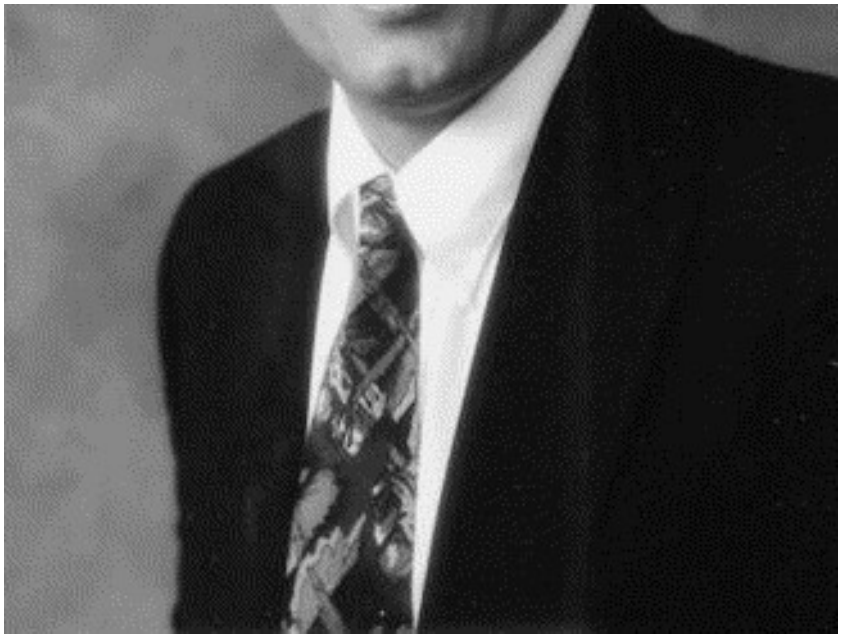
Keywords

Artefact rejection; Electromyography; EMG; EMG amplitude; Measurement noise; Noise ; Surface EMG





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Edward (Ted) A. Clancy received his BSc degree from Worcester Polytechnic Institute (WPI), and his SM and PhD degrees from Massachusetts Institute of Technology (MIT), all in Electrical Engineering. He has worked in industry for medical instrumentation and analysis companies interested in EMG, EEG, ECG and blood pressure, and the defence industry (aircraft instruments and radar). He is Assistant Professor of Electrical and Computer Engineering, and of Biomedical Engineering at WPI. He is a lecturer at MIT and Professor AssociÃ© at Laval University (Quebec, PQ, Canada). He is interested in signal processing, stochastic estimation and system identification, particularly as applied to problems in medical engineering and human rehabilitation.

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Evelyn Morin received a BSc in Physiology from the University of Toronto in 1981 and an MScE and PhD in Electrical Engineering from the University of New Brunswick in 1984 and 1988 respectively. Since 1988, she has been at Queen's University, Kingston, Ontario, Canada, where she is currently an Associate Professor in the Department of Electrical and Computer Engineering and the School of Physical and Health Education. She is also a member of the Ergonomics Research Group at Queen's. Dr Morin's research interests are in the area of EMG signal acquisition and processing and human performance assessment, in particular during load carriage.

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Roberto Merletti graduated in Electronics Engineering from Politecnico di Torino, Italy and obtained his MSc and PhD from The Ohio State University. He is Associate Professor of Biomedical Instrumentation at the Department of Electronics of Politecnico di Torino and Director of the Laboratory for Neuromuscular System Engineering in Torino, Italy. He has been Associate Professor at the Department of Biomedical Engineering and at the NeuroMusculat Research Center of Boston University. His research focuses on surface electromyography, myoelectric signal processing, electrical stimulation and neuromuscular control.

â˜† This paper by Clancy et al is the second paper published from a consensus conference held in Northern California in 1998 [Marconi Research Conference 1998â€"Estimating Muscle Load Using Surface EMG Amplitude, David Rempel, ed, Ergonomics Program, University of California, Richmond, CA]. The conference attendees addressed the question, â€œUnder what circumstances can surface electromyography be used to estimate upper extremity and neck muscle load during the performance of precision tasks?â€ The purpose of the papers was to provide guidelines to the ergonomics community in the application of surface electromyography to evaluate tools and tasks.

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