Acquisition, analysis and interpretation of bioelectric and EMG signals

Coordinators: prof Marco Gazzoni and prof Roberto Merletti

Objective: to present the methodologies for acquisition, analysis and interpretation of bioelectric (in particular myoelectric) signals, considering their features from a physiological point of view. Analysis includes the signals processing in the time-domain, frequency-domain and their interpretation by means of modeling.

Topic	Lecture topics	Teacher	Hours
Mathematics and physics of physiological electrical signals	Review of math and basic physics of signals. Signals in space and in time. Fourier expansion of a signal and concept of amplitude and power spectrum. Concept of bandwidth of a signal. Concept of filter.	Roberto Merletti	7
	Basic electrophysiology. Origin and informative content of the main bioelectric signals: ECG, EEG, sEMG, nEMG. Modeling of signal generation	Roberto Merletti	4
	Physiological signals in space (over the skin/chest) and in time. Spatial filter. Bipolar and multichannel array sEMG.	Alberto Botter	3
Detection of bioelectric signals Analysis of bioelectric signal and surface EMG	Transducer, sensor. Conditioning and amplification of a signal. The electrode as a transducer. Sampling and A/D conversion of bioelectric signal.	Giacinto Luigi Cerone	4
	Power line interference, noise and movement artefacts. ECG interference. Focus on sEMG.	Giacinto Luigi Cerone	3
	Demo. Tips and tricks: “how should bioelectric signals (sEMG) be properly detected”. Reduction of power line interference, noise, movement artefacts, ECG interference.	Roberto Merletti, Taian Vieira, Marco Gazzoni	3
EMG Signal quantitative variables	Processing and feature extraction. Temporal features of sEMG. Muscle activation intervals. Muscle activation level. Estimation of muscle fiber conduction velocity.	Taian Vieira	2
	Spectral features of sEMG and their physiological significance.	Taian Vieira	2
	Myoelectric manifestations of muscle fatigue.	Marco Gazzoni, Taian Vieira	3
	Factors influencing sEMG in isometric and non-isometric contractions (Heterogeneous spatial distribution of sEMG. Identification of innervation zones etc..).	Marco Gazzoni	3
	Decomposition into fundamental patterns (synergies) (Non Negative Matrix Factorization).	Andrea D’Avella	4
Clinical applications	Clinical examples of applications. Examples of common mistakes and misinterpretations. Identification of poor signal quality. Gait analysis, control of prosthesis and exoskeletons, spasticity assessment and other applications in sport and occupational medicine.	Isabella Campanini, Andrea Merlo,	10
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Instrumental analysis of motor performance **Coordinators: prof Carlo Frigo and prof. Manuela Galli** **Objective:** to present technologies useful for assessment of motor performance of subjects with motor impairment. Technologies will be introduced after an overview of applied biomechanics.		
Topics	**Teacher**	**Hours**
Basics of applied biomechanics	Carlo Frigo	14
Basics of biomechanical data processing	Manuela Galli	7
Torque measure: isometric, isotonic and isokinetic dynamometers	Nicola Maffiulettti	4
Neuromuscular assessment in motor functions: EMG	Nicola Maffiuletti	3
Arthrogenous muscle inhibition: twitch interpolation technique	Nicola Maffiuletti	4
Balance: static and dynamic posture assessment. Systems for data acquisition and clinical data analysis	Davide Cattaneo Elisa Gervasoni Rita Bertoni Maurizio Petrarca	11
Movement analysis: kinematics (spatio-temporal parameters, joint angles,…)	Manuela Galli	14
Movement analysis: kinetics (internal and external joint torques, ground reaction forces and COP, mechanical energy)	Carlo Frigo	7
Gait Analysis (standardized protocols, models, joints kinetics and kinematics, EMG, quality assessment, clinical cases): clinical cases	Roberto Gatti Maurizio Petrarca Maria Gr Benedetti Luigi Piccinini	14
User-friendly devices for motor performance analysis in clinical practice (IMU, and wearable systems. Instrumented clinical test: iTUG, i10-minutes walking test, i6-minutes walking test, etc..)	Matteo Zago Federico Temporiti	17
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Technologies for therapeutic exercise **Coordinators: prof Maria Chiara Carrozza and prof Roberto Gatti** **Objective:** to present technologies used in physiotherapy planning. The module is designed to introduce the devices after a literature review about their application, efficacy and posology.		
Topics	**Teacher**	**Hours**
Neurophysiology of motor control and motor recovery	Riccardo Fesce, Francesco Bolzoni	21
Rehabilitation Engineering and Tele-rehabilitation Robots and systems for Rehabilitation Exoskeletons and device for rehabilitation Clinical trials and assessment of bio-robots for rehabilitation Machine learning and algorithm for control	Maria Chiara Carrozza, Stefano Mazzoleni, Simona Crea, Chiara Arienti, Andrea Mannini	28
Use of cognitive facilitation in rehabilitation Rehabilitation with augmented or immersive virtual reality systems Mechanical Peripheral Stimulation	Roberto Gatti Andrea Turolla Raffaello Furlan	21

Rationale of balance training: Balance rehabilitation with robotic systems Balance rehabilitation with stabilometric platforms	Davide Cattaneo Elisa Gervasoni Rita Bertoni Maurizio Petrarca	14
Electrical stimulation systems: applications of TMS in rehabilitation; applications of tDCS in rehabilitation; functional electrical stimulation systems	Francesca Baglio Antonio Caronni Simona Ferrante	7
Advanced prosthetics and control of upper and lower limb	Christian Cipriani Francesco Clemente Leonardo Cappello Simona Crea	12
Continuity of care: telerehabilitation	Fabrizio Natali	7
User-friendly devices for motor rehabilitation: biofeedback on force, ROM and sEMG; use of Apps; Other tools (es. Movies with motor content, etc.)	Paola Adamo, Johanna Jonsdottir	7
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