First IUC-BOHNES Colloquium

Rome, January 26-27, 2015

RESEARCH VISION AND FUTURE PROJECTS IN THE AREA OF NEUROMUSCULOSKELETAL BIOENGINEERING

Speakers and short abstracts of the talks

G. Rao - IUC-BOHNES fellow - Aix-Marseille University

In the last few decades, neuromusculoskeletal bioengineering has dramatically increased its scope of application with connections -to name but a few- to robotics, health sciences (diagnosis, equipments & treatments), ergonomics, neurosciences, or sport equipments.

On the one hand, increasingly dedicated lab equipments, protocols, and modeling techniques have been developed to precisely and adequately characterize the different features of the human movement (joint kinematics, external forces acting over the environment, energy transfers, muscle forces and activities,…), generating huge amount of data. These data are usually studied through specific time points of the dataset (maximum, mean, amplitude values…). On the other hand, data reduction techniques and/or global analysis methods are available (PCA-derived methods, synergy extraction, solutions coming from dynamical systems physics,…) that preclude the above limitations.

Moreover, as it is well understandable, studying (for example) cycling in a laboratory environment can generate results far from those expected in the field. To this aim, dedicated portable recording devices are now commercially available and can be used outdoor daily.

The aim of our group is thus to apply biomechanical modeling techniques together with data reduction techniques using field-acquired (i.e., real life situation) data to sport activities (indoor team sports, running, cycling, climbing…) in order to improve sport equipments as well as training or rehabilitation protocols.

L. Chèze - IUC-BOHNES fellow - Claude Bernard Lyon 1 University

Gait analysis & musculoskeletal modelling towards clinical applications

The recent and future research projects of our team aim reducing the gap between the kinematic and musculoskeletal models developed and their applications in the clinical field. In this context, an original database of biomechanical parameters of young healthy children gait (under 7 y.o.), has been built and a regression model taking into account both age and gait speed allows superimposing reference targets on the pathologic pattern of each parameter (joint angles, moments, power) in order to better understand the dysfunction or evaluate the treatment effect.

The estimation of muscle forces during activities of daily life is another issue, essential to assess the joint contact forces, and thus help improving the diagnosis and monitoring of neurological and orthopedic diseases. The 3D musculoskeletal model of the lower limb, including ”anatomical constraints” (i.e., surface contact condition, ligament length constancy), has been developed and the joint contact forces at the knee, computed during gait, have been validated using experimental data from instrumented prosthesis.

The next step will be to facilitate the adaptation of the model to a specific patient (e.g., using medical image) and better defining the optimization criterion to take into account for different pathologies.

S. Fioretti - IUC-BOHNES fellow - Polytechnic of Marche University

The research topics in the field of Movement Analysis that Ancona research unit will address in the next years are: *i*) The application of statistical methods (Principal Component Analysis) to analyze, in a retrospective manner, the association between the fall history of a wide sample of older adults without dementia and the values of PCA parameters derived from posturographic data; *ii*) The study of the Pisa Syndrome in Parkinson disease developing an appropriate measurement protocol using kinematic, dynamometric and EMG instrumentation; *iii*) The assessment of natural variability of surface EMG signals from lower-limb muscles during free walking, in order to develop a reference frame in terms of onset-offset muscular activation and occurrence frequency. Muscle co-contractions will be assessed to. The methodology used will be the Statistical Gait Analysis that allow to analyse numerous (hundreds) gait cycles; *iv*) Analysis of balance by means of dynamic perturbations. To this purpose a moving platform able to translate will be used in association with kinematic and EMG instrumentation.

The bio-engineering personnel involved will be: Sandro Fioretti, Associate Professor; Elvira Maranesi, PhD, Postdoctoral Researcher; Francesco Di Nardo, PhD, Graduated Technician; Federica Verdini, PhD, Graduated Technician; Alessandro Mengarelli, PhD student.

Collaborations in course are with: Neurorehabilitation Clinic of UNIVPM, Ancona, IT; Department of Electronics and Telecommunications, Turin Polytechnic, IT; Motion Analysis Laboratory – AUSL Reggio Emilia, IT; Regional Hospital of Lugano and Mendrisio, CH; Movement Analysis Laboratory of Geriatric Hospital, INRCA (IRCCS), Ancona, IT.

U. Della Croce - IUC-BOHNES fellow - University of Sassari

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P. Bifulco - IUC-BOHNES fellow - University of Naples Federico II

Our research in neuromusculoskeletal field regards the study of the physiological mechanisms of the motor and sensory system to investigate the features of the pathophysiology of movement disorder. In particular, we focus on biomechanics of upper arm movement during specific motor tasks with robotic assistance and on gait analysis using conventional camera-based and wearable sensor systems to describe the kinematic, kinetic, and muscle activation patterns of movement.

This research aims to assess the mobility-related disability, to understand impairment and recovery mechanisms from both biomechanical and neurophysiological perspectives with the final aim to develop a quantitative kinematic assessment of human movement, useful to implement rehabilitative strategies patients oriented.

Another research of our group is the intervertebral kinematic analysis of the spine.

The research aims to develop analytical techniques in vivo, in particular for the analysis of the cervical region, using sequences of fluoroscopic images (X-ray low dose), the only technique still used for clinical use. This method can help clinicians in the pre- and post-operative evaluation of prostheses implanted in place of the intervertebral disc. The research aims also to a quantitative noise assessment and, finally, to develop methodologies for three-dimensional analysis, by integrating techniques such as digital fluoroscopy and CT.

G. Vannozzi - IUC-BOHNES fellow - University of Rome Foro Italico

The aim of the laboratory is to contribute to the accumulation and dissemination of knowledge on the functions of the human locomotor apparatus and to their application. This is done using the conceptual and operative tools that are currently used by bioengineers. Specific research objectives are pursued taking into account different populations in terms of gender, age, initial motor abilities, health status and risk factors, with the goal of maximizing performance, personal safety, prevention of any type of limitation, or within a cultural and educational framework, and, more broadly, to contribute to the maintenance/improvement of human life quality.

Main research themes involve, but are not limited to**:** *i*) High Resolution Movement Analysis, aimed at improving methods and models to obtain an accurate 3D reconstruction of the musculo-skeletal system movement in the laboratory system reference; *ii*)Wearable Inertial Sensors for Mobility Assessment, aimed at solving methodological and application issues to support the use of inertial sensors clinical movement analysis, motor development in children and analysis of mobility in adults people; *iii*) Minimum Measured Input Models, with the aim of developing quantitative methods for assessing an individual motor capacity and to identify the relation between associated impairment and disability starting from a minimum number of measured variables; *iv*) Sports Biomechanics, contributing to sport research in studying performance and to understand the factors that influence the risk of injury or performance. Performance indexes are generated using a neuromechanical approach to evaluate normal and disabled athletes; *v*) Data Mining and Knowledge Discovery in biomechanical databases: since quantitative analysis of motor acts may provide a huge amount of information to analyse, the investigation, development, and application of appropriate "data mining" algorithms are proposed for the characterization of human movement during selected motor tasks and for the classification of specific sub-groups of interest.

S. Conforto - IUC-BOHNES fellow - University of Rome RomaTRE

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E. Di Stanislao - IUC-BOHNES fellow - ITOP

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