First IUC-BOHNES Colloquium

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Round Table

DEFEATING THE SOFT TISSUE ARTEFACT IN HUMAN SKELETAL KINEMATICS RECONSTRUCTION: THE STAPAG ENDEAVOUR

Session chaired by Aurelio Cappozzo (IUC-BOHNES director)

Speakers short curriculum and abstracts of the talks

R. Dumas - IUC-BOHNES fellow - Université Lyon 1 - IFSTTAR

CURRICULUM: see BOHNES website, fellows section

ABSTRACT: Different views are found in the literature to represent the change of configuration in the skin marker positions as caused by the soft tissue artefact (STA).

First, the observation of the individual marker displacements is the most intuitive and conventionally used. The displacements are subject-, task-, and segment-dependent. The displacements seem relatively uniformly distributed even if some skin regions of higher displacements can be identified. Compensation methods based on this STA definition have been proposed (e.g., multiple calibrations, STA models driven by joint kinematics).

Second, the geometrical transformations of the marker-cluster are becoming more and more studied. They are at the basis of most optimal bone pose estimators but it is now demonstrated in several conditions that the rigid transformations are of greater amplitude compared to the non-rigid ones. Thus, it is now also stated in the literature that any least squares method applied to the skin marker positions cannot compensate for STA. Moreover, some studies reveal inter-subject pattern consistency for the rigid transformations. Such observation may help in designing new STA model architectures.

Third, proper orthogonal decomposition (or principal components analysis) has been recently applied and revealed that, for several subjects, tasks, and segments, very few modes (or components) can represent a large proportion of energy (or variability) associated to the skin markers displacements. The patterns of these modes, denoted skin envelope shape variations, can be somewhat consistent between subjects. Again, such observation may help in designing new STA model architectures.

Note that all these different views can be all embedded in a generalized mathematical representation of the STA based on a modal approach (STA is represented by an additive series of modes that can be ordered and sub-selected).

V. Camomilla - IUC-BOHNES fellow - University Lyon 1 - IFSTTAR

CURRICULUM: see BOHNES website, fellows section

ABSTRACT: not available

D. Benoit - University of Ottawa

CURRICULUM: not available

ABSTRACT: not available

K. Aminian - Ecole Polytechnique Federale de Lausanne

CURRICULUM: Kamiar Aminian received the Ph.D degree in biomedical engineering in 1989 from Ecole Polytechnique Fédérale de Lausanne (EPFL). He is currently Professor in the Institute of Bioengineering and the director of the Laboratory of Movement Analysis and Measurement of EPFL. His research focuses on methodologies for human movement monitoring and analysis in real world conditions mainly based on wearable technologies, with emphasis on gait, physical activity and sport. His research aims to perform outcome evaluation in orthopaedics, to improve motor function and intervention programs in aging and patients with movement disorders and pain, and to identify metrics of performance in sport science.

He is author or co-author of more than 450 scientific papers published in reviewed journals and presented at international conferences and holds 8 patents related to medical devices.

ABSTRACT: Soft tissue artifact (STA) is the main source of error in motion capture when using skin mounted markers or sensors and can therefore influences clinical interpretation of kinematics, particularly during gait. Even STA has been studied since many years; currently there are no robust methods to compensate this error. The main reason of this lack is probably the limited data available with STA accurately estimated. This presentation aims to provide the results obtained for the estimation of STA associated with thigh and shank during a treadmill gait in a population with sample size higher than all previous studies. We used a bi-plane fluoroscopic system to capture the kinematics of the tibia, femur and prosthesis and a stereophotogrammetric system composed of seven cameras for skin motion capture. The rigid motion of the STA was characterized for the thigh and the shank in terms of temporal and spatial distribution during gait cycle but also in terms of subject variability. The results emphasis the importance of rigid component of STA as the main source of error and show some insights useful in order to provide new perspective for robust compensation.

M. Andersen - Aalborg University

CURRICULUM: not available

ABSTRACT: "When recording human movement with stereophotogrammetry, skin marker movements relative to the underlying bone, so-called Soft Tissue Artefact (STA), has been recognised as the major source-of-error, when reconstructing the movements of the underlying bones from the skin marker trajectories measured in a laboratory-fixed reference frame. In this talk, I shall review some of our latest investigations and findings in relation to STA. These studies are been based on simultaneously recorded skin markers and bone-mounted markers for walking, cutting and one-leg hopping for six healthy male subjects for the thigh and shank in vivo. This data set provides a direct opportunity for exploring the relationship between the skin marker trajectories and the underlying bone movements, and provides a possibility for direct validation of STA compensation methods. With this data, we have 1) analysed the joint translation and rotation errors obtained from the skin markers, 2) investigated the possibility of reducing STA by introducing idealised knee joint constraints, 3) analysed the possibility of representing the relationship between the skin marker movements and underlying bone with a linear model and 4) recently described and quantified which marker motion (cluster translation, rotation, scaling and deformation) that contribute to STA for the abovementioned tasks."

M. Begon - Université de Montréal

CURRICULUM: Mickaël Begon is a M.Sc. in Sports Biomechanics and a Ph.D. in Biomechanics and Bioengineering (University of Poitiers, France, 2006), currently associate professor in Biomechanics, director of the Simulation and Movement Modelling team at the University of Montreal and researcher at the Ste-Justine paediatric hospital. His research interest is in three-dimensional multi-body modeling of the human musculoskeletal system applied to sports techniques, joint pathologies (especially shoulder disorders), and rehabilitation using dynamic orthotic devices. He is regular reviewer for journals in the field of biomechanics. He has authored or co-authored 40 archive-journal full-papers, 3 textbooks and 1 patent.

ABSTRACT: My main goal is to assess both soft tissue and bone kinematics in human movement using noninvasive techniques.

On the one hand, redundant marker sets and multibody kinematical chain combined with nonlinear least squares algorithms or extended Kalman filters are used to reduce soft tissue artefact (STA). On the other hand, soft tissue kinematics are introduced into dynamic models to better estimate joint efforts since bones represent only 10% of the skeleton mass. To reduce STA, multibody kinematical chains seem to be promising. They are also required in musculoskeletal models for estimating muscle forces. However these are sensitive to joint and segment parameters (e.g. degrees-of-freedom, length).

Recently in collaboration with A. Lundberg (Karolinska Institutet), bone kinematics of the clavicle, scapula and humerus were collected using intracortical pins and skin markers. Four subjects performed standardized movements, daily living tasks and sports activities. Several validations and model improvements have been conducted:

- estimation of joint centre location (functional vs predictive methods);

- STA reduction using optimally-weighted least squares algorithms;

- definition of the scapula-thoracic pseudo-joint using ellipsoids;

- STA reduction using the generalized mathematical representation (Dumas et al., 2014).

Also these data have been used to better understand the glenohumeral kinematics with its rotations and translations, especially the subacromial space which is related to rotator cuff injuries.