PhD student position in biomechanics / ultrasound imaging / musculoskeletal modelling

Title: Comprehensive personalisation of musculoskeletal models using ultrasound imaging (ULTRAMOD)

Context: Musculoskeletal modelling has become in the last decades an alternative to invasive measurement methods to quantify musculo-tendon forces and related contributions to progression, support and balance, but also contributions to joint loading during dynamic tasks such as gait. However, the clinical application of such an approach remains limited due to a need for personalisation of the related models. Indeed, the recent literature has clearly demonstrated the necessary of defining models with subject-specific parameters to ensure valuable accuracy in force estimations. Usually, this personalisation is performed using MRI, CT-scan or biplanar radiography. Indeed, medical imaging provides many useful geometrical information (e.g. muscular insertion sites, position of anatomical landmarks) to personalise the models. However, the development of a systematic approach employing such costly, invasive and/or irradiating protocols is hardly possible for evident ethical issues.

An alternative to these traditional approaches is to use a 3D ultrasonic system. This method consists of coupling a conventional ultrasound probe to a position sensor (e.g. based on a motion capture system). The resulting device is called freehand 3D ultrasound system. Using such a tool, each pixel of the 2D ultrasound images (i.e. B-scans) can be located in the 3D space of the motion capture system. This allows defining anatomical landmarks such as joint centres, but also the reconstruction of volumetric data. Furthermore, ultrasound imaging has already been used in musculoskeletal modelling to characterise musculo-tendon properties such as muscle fibre length and pennation angle during static and dynamic tasks. This approach has been recently promoted for musculoskeletal model personalisation, and as also the potential to bring new knowledge about experimental measurement errors for which musculoskeletal models can be sensitive to.

Objectives: The present project aims thus contributing in the field of clinical biomechanics by developing an integrated approach to achieve a multi-level ultrasound-based musculoskeletal model personalisation. This approach will be applied to a musculoskeletal model resulting from the scientific collaboration between the teams supervising this new project. Such a contribution will benefit to the development of advanced numerical models of humans, and more specifically to the development of medical applications, especially in the fields of orthopaedic surgery and rehabilitation medicine. The objective of this project is threefold and will focus the use of a lower limb musculoskeletal model to study normal gait as a starting benchmark case before targeting pathological cases:

Firstly, musculoskeletal models can be sensitive to measurement errors. The primary error using marker-based motion capture is called soft tissue artefact (i.e. motion of the skin, fat and muscles relative to the underlying bone). By quantifying the displacement between anatomic landmarks (observed by ultrasound) and cutaneous markers (observed by the motion capture system), a corrective method will be determined. Such a development will not only benefit for musculoskeletal modelling, but for all applications that use marker-based motion capture.

Secondly, the use of anatomy-based joint kinematic models has demonstrated its effectiveness to improve musculoskeletal models accuracy. However, while many models have the potential to be personalised, few of them have been explored in this way. The interest of ultrasound for the determination of several joint centres has already been pointed in the literature and will be extended to other joints. Furthermore, several studies have evaluated the capability of ultrasound in measuring muscle lever arms. Even if this application is limited to superficial tendons, it has the potential to provide quantitative information about the validity of generic musculoskeletal models in replicating these lever arms.

Thirdly, several ultrasound-based methods have been employed to measure muscle parameters (e.g. pennation angle, muscle fibre length). These methods will be gathered in an integrated approach to complete the multi-level ultrasound-based musculoskeletal model personalisation proposed in this project.

Required skills: The successful candidate will have skills in solid mechanics (i.e. kinematics, rigid multi-body dynamics), programming (at least Matlab). Ideally, the candidate should have had a first experience in the field of biomechanics, or even in musculoskeletal modelling, and / or medical imaging. An interest in the field of rehabilitation is strongly recommended.

Work places:

- Laboratoire d'Analyse du Mouvement et de la Posture (LAMP) of the Centre National de Rééducation Fonctionnelle et de Réadaptation – Rehazenter (Luxembourg)
- Laboratoire d'Analyse du Mouvement of the Centre de Réadaptation Pierquin in the l'Institut Régional de Réadaptation (IRR) de Nancy (France) / Université de Lorraine

Recruitment: The candidates must send by email to Florent Moissenet: florent.moissenet@rehazenter.lu and Christian Beyaert: christian.beyaert@univ-lorraine.fr before May 21st before midnight:

- A CV
- A one-page motivation letter signed by the candidates, explaining why their skills, knowledge and experience make them a particularly suitable candidate for the given position
- Master's results and the master's classification (semesters 7-8 & semester 9)
- An abstract of their master thesis.

The selected candidate will then be contacted by 11 June to prepare an application at the BioSE doctoral school of the University of Lorraine (full procedure available here: https: / /www.adum.fr/as/ed/proposition.pl?site=biose). The successful candidate will be auditioned between June 25 and July 6 at the University of Lorraine (Nancy, France) to obtain the thesis grant.

Start of the project: The start of the project will be conditioned by obtaining this thesis grant sand will start at the earliest in October 2018.