PhD offer
Effects of footwear on the biomechanics of an arthritic foot

Description of the job offer

laboratory: Center for Healthcare Engineering (CIS), lab. Sainbiose INSERM U1059

Supervision : Pr. Jérôme MOLIMARD (superviser), Pr. Woo Suck HAN, Dr. Baptiste PIERRAT

Job type: 36 month fixed term contract

Location: Mines Saint-Etienne, Campus Santé Innovation, Saint-Etienne, France

Context:

Mines Saint-Etienne is a school of the Institut Mines-Télécom (IMT), the leading public group of engineering and management graduate schools in France, under the authority of the Ministry of Industry and Digital Technologies. Mines Saint-Étienne is dedicated to education, research and innovation, transfer to industry and scientific, technical and industrial culture. The 400 employees of Mines Saint-Étienne participate in the formation of 2,400 graduate and post-graduate students in engineering.

The thesis project is in the framework of the SAINBIOSE laboratory, a joint INSERM - Jean Monnet University - Mines Saint-Etienne research unit. SaInBioSE brings together 57 faculty members and 52 PhD students in two research areas: Biology of Osteoarticular Tissues, and Vascular Dysfunction and Hemostasis. The TexMed2k team, which is part of the first research axis, involves 4 permanent staffs and 3 PhD students working on medical devices with a mechanical action on the human body (lumbar belts, insoles or shoes, compression bands, etc.).

Description of the PhD project :

Research Project – This thesis is part of the ANR INORA project, which brings together the Ecole des Mines de St Etienne, the University Hospital of St Etienne and the INRIA of Grenoble. The work will take place in a group of 9 permanent researchers, a research engineer and two PhD students specifically recruited for the project. The general objectives of this project are described below.

Medical background – Rheumatoid arthritis (RA) is the most common chronic inflammatory joint disease, with a prevalence of about 0.5%. RA is a peripheral arthritis that affects the hands and feet: foot function is compromised, which is accompanied by changes in plantar pressures and walking difficulties. The impact of RA on the foot joint can be manifested by instability, walking difficulties and, consequently, functional limitations that have a strong impact on daily activities. Foot pain and disability can be reduced with custom foot orthotics and therapeutic footwear. Although the use of insoles is generally associated with pain relief, the mechanisms involved in this treatment lack methodological evaluation. In particular, the design of the insole and its relationship to internal effects such as joint pressure and soft tissue deformities have not been studied due to the difficult nature of such studies in a clinical setting.

Medical Issue – From a medical perspective, the INORA project aims at understanding, through patient-specific numerical biomechanical models, the mechanisms of action of orthopaedic shoes and insoles in order to propose a well-founded design methodology. From a more fundamental perspective, these models will help to uncover the mechanical determinants of pain relief, which will promote long-term patient well-being.

Hypothesis – Motivated by the numerous studies demonstrating erosion and narrowing of the joint space in RA patients, we postulate that a major contributor to pain is the internal joint load (cartilage pressure) when the foot is inflamed. This hypothesis dictates the need for high-fidelity volumetric segmentation for patient-specific geometry construction. It also guides the variables of interest in the operation of a finite element (FE) model.

INORA project objectives – It aims at providing numerical tools to the scientific, medical and industrial communities in order to better describe the mechanical load on the diseased distal joints of the foot of RA patients and to propose a patient-specific methodology for designing pain-relieving insoles.

Objective of the PhD thesis – In this context, the thesis project will focus on the finite element mechanical modelling of a foot in motion, and then the optimization of the medical device (sole, shoe) in order to minimize the stresses in the critical pain areas.

Main steps

The PhD student will follow the following main steps for the realization of the thesis project:

- She/he will develop a bibliographic analysis of the field and will appropriate the methodological tools already in place in the laboratory following a previous PhD project (FE model of bare and shod foot, mesh-morphing strategy).
- He/she will build a finite element model of an RA foot on the existing base and will propose the specific adaptations necessary to the context of RA.
- He/she will develop a parametric model of insoles and propose an optimization protocol.
- She/he will participate in the follow-up of a cohort of patients with the University Hospital of St Etienne: critical analysis of the solution proposed by the podiatrists and comparison with the optimal insoles.

Missions: The candidate:

- will analyse the bibliographic context, develop the necessary methodological tools and analyse the results obtained to meet the objectives of the thesis;
- will write reports (bibliography, project follow-up report) and will disseminate his/her research results through publications in peer-reviewed scientific journals, conferences and seminars, or through knowledge dissemination activities with partners;
- may be asked to teach in the context of the training of engineering students or to participate in the supervision of master trainees or engineering students;
- will organize the management and follow-up of his/her thesis project (meetings and seminars, internal or external) in coordination with the overall INORA project.

Position Requirements

Profile of the candidate: (Prerequisite/ Diploma)

The candidate must have a master's degree or an engineering degree, with a specialization in mechanics or biomechanics. The candidate must be interested and motivated by numerical modelling.

Skills

Essential:

- Ability to lead a project and to work autonomously and in a team
- Ability to organize and manage priorities to meet deadlines
- Good command of English and French (written, oral)
- Experience in finite element modelling of a biomechanical problem

Desirable:

- Experience in programming (Python, Matlab)

Knowledge

Essential:

- Knowledge in Numerical Mechanics

Desired:

- Statistical data processing
- Programming basics

Conditions:

The position is to be filled as of 01/10/2023 for a period of 36 months (fixed-term contract).

Information and application procedures:

For any information on the position, please contact

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