Multiscale Modelling and Simulation Lab., MSME UMR 8208

Open PhD position

Model-based modelling of ultrasonic wave propagation at bone-implant interfaces

Context. The use of implants is now widespread in dental, maxillofacial or orthopedic surgery. However, the risks of failure, which are often very difficult to anticipate, still occur and can have serious consequences. The stability of the implants strongly depends on the quality of the newly formed bone tissue in an interphase between the bone-implant. However, existing techniques do not allow a reliable evaluation of the biomechanical properties of the interphase, nor to carry out a reliable clinical follow-up of bone healing. Non-destructive testing ultrasonic methods are very interesting for evaluating the properties of this interphase and following its evolution during healing. In clinical practice, the techniques associated with these methods aim to quantify the mechanical and micro-architectural characteristics of this interphase during the so-called osseointegration process.

Objective. The aim of this thesis is to develop robust numerical methods allowing to describe the interaction between the ultrasonic wave field and a rough surface of an implant which is totally or partially in contact with the bone tissue. We will first derive enhanced mechanical models to study the multiscale dynamic behaviour of the bone-implant interface. Next, model order reduction technique for finite element simulation of wave propagation problem in the considered multi-physics and strongly heterogeneous medium will be developed. Then, model-based machine learning approaches will be employed to enable the real-time simulation of this large-scale system.

Required skills. Master (or equivalent) degree in mechanics, applied mathematics, or a similar domain; Good knowledge in mechanics, acoustics, numerical simulation and programming; Interested by biomedical engineering, even no specific skills in this field are expected; Ability to work in a multidisciplinary, creative environment and interact with experts from different areas; Fluent knowledge of written and spoken English, French is an advantage.

Work context. The PhD candidate will work within the Biomechanics team of the Laboratory of Multiscale Modelling and Simulation (MSME, UMR 8208 CNRS) at the University Paris-Est Créteil (located about 10 km from Paris centre). The team is one of the recognized leaders in the research domain. This PhD programme will be part of the project DynImplant, funded by “Agence National de la Recherche “ (ANR) in collaborating with the University Sorbonne Paris Nord, CHU Nantes and the start-up WaveImplant (www.waveimplant.com). Strong interaction with experimental scientists (CHU Nantes), applied mathematicians (University Sorbonne Paris Nord) as well as biomedical engineers (WaveImplant) will be expected to validate the proposed methods.

The PhD candidate may also have opportunities to participate to national/international conferences and/or benefit visiting doctoral fellowships in universities abroad during her/his PhD program.

Keywords. Biomechanics; Bones, Implant; Ultrasound imaging; Finite element, Reduced-order model; Machine learning.

Salary. The net salary will be about 1800 €/month. This salary may be complemented by assisting to some teaching tasks.

Application. Send your CV, motivation letter, last 3 year transcripts and references with contact information (preferably before 30/04/2023) to:

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