Université de technologie de Compiègne – Thesis proposal

Part 1: Scientific sheet	
Thesis proposal title	Advanced AI/ML and computer simulations of artificial organ-on-chip
PhD grant	Doctoral work contract based on a Ministry of Research Grant
Research laboratory	unité de recherche : Biomechanics and Bioengineering (BMBI) research team: Interactions Fluides Structures Biologiques (IFSB) web site: https://bmbi.utc.fr
Thesis supervisor(s)	Dr. Badr Kaoui
Scientific domain(s)	Biology, biomedical and health sciences Chemistry Computer science and information technologies Mathematics Physics Science and technology
Research work	Humankind is still facing serious diseases that some of them lead to dysfunctions and even to shut down of key body organs. Transplantation is yet the main reliable solution. Unfortunately, the shortage of donors and the increasing accumulation of patient recipients in the waiting list represent a very challenging problem which can be tackled by designing artificial organs. Indeed, the latter seriously represents a promising alternative. Moreover, downsizing extra and intracorporal medical devices is one of the challenging desired features. The goal of the proposed thesis is to contribute to the design of new artificial organs that could be fit into microfluidic devices and still mimic efficiently healthy organs. The thesis will use advanced AI/ML and computer simulations to investigate the interplay between the details of the microfluidic chip geometry and the performance of organ-on-chip under dynamical flow conditions to come up with accurate digital twins of experimentally studied organ-on-chip prototypes at BMBI. We will use advanced numerical methods, such as the Lattice-Boltzmann Method for the Computational Fluid Dynamics (CFD) and the Immersed Boundary Method for the Fluid-Structure Interaction (FSI). HPC simulations will be carried on multiple CPUs to screen a wide range of parameters and to conduct simulations with high grid resolutions. Due to the large number of possible parameters to be explored, we consider using Machine Learning (ML) techniques as well, and the recent trend Physics-Informed Machine Learning (PIML). Such models require a lot of computation power hence the use of parallel computing on GPUs is planned. The ML part will be developed in collaboration with Dr. Imad Rida of the C2MUST team. The developed numerical tools will be used to study blood oxygenation performance of an artificial lung-on-chip, to analyze how microflows in chips will alter glucose stimulation and insulin secretion of pancreatic islet spheroids, and to image process experimental data-set obtained for a platelet-generating bioreactor to detect whether megakaryocyte cells are attached or not to bioreactor cylinder pillars. These applications will be conducted in collaboration with Dr. Cécile Legallais of the C2B team and Dr. Anne Le Goff of the IFSB team.

Key words	Computational Fluid Dynamics, Fluid-Structure Interaction, Machine Learning, Transport Phenomena, Artificial organs, Organ-on-chip,
Requirements	Strong background in mathematics and physics, with high skills in scientific coding and computing (C/C++, Fortran, Python, CUDA, MPI, CAF). MSc in mechanical, chemical or biomedical engineering, with an interest in biomedical applications and cutting-edge technologies of computer science and engineering.
Starting time	Octobre 2022
Location	Laboratoire Biomécanique et Bioingénierie, Université de Technologie de Compiègne, 60200 Compiègne, France

Part 2: Job description	
Duration	36 months
Material resources	The simulations of the project will be carried out on local powerful machines such as PILCAM2, and others at the national and European level. The project will use advanced numerical simulations and machine learning techniques with a progressive transition from parallel computing on CPUs, GPUs to QPUs. The latter will deal with pure CFD simulations using Quantum Computing.
Contact	Dr. Badr Kaoui badr.kaoui@utc.fr Laboratoire Biomécanique et Bioingénierie, Université de Technologie de Compiègne, 60200 Compiègne, France

Please contact first the thesis supervisor before applying online on https://webapplis.utc.fr/admissions/doctorants/accueil.jsf