Open PhD position in
Computational Brain and Cardiac Development and Remodelling

A PhD position is available at the BCN-MedTech Research Unit (https://www.upf.edu/web/bcn-medtech/), Department of Information & Communication Technologies (DTIC) of the Universitat Pompeu Fabra (UPF), Barcelona, Spain, in close collaboration with IDIBAPS and BCNatal - The Fetal Medicine Research Centre (https://medicinafetalbarcelona.org) of Hospital Clínic de Barcelona, starting October 2019.

PhD project: The Heart-Brain axis, or There and Back again: the journey towards brain development traverses vascular territories

The heart and the brain are arguably the two most fascinating and important organs of the human body. Scientists have been studying these organs for centuries but mainly at an individual organ level. There is a need for a more systemic approach to study the physiology of some neurological and cardiovascular processes that remain not well understood, even with the current deluge of medical data and tools available nowadays. A good example involves brain development, especially in abnormal conditions such as after insults during pregnancy (Intra-Uterine Growth Restriction, IUGR). There are plain and numerous evidences on the effect of IUGR on the cardiovascular system and in the brain of these infants, but they have never been studied together. The aim of this project is to create a computational modelling platform, linking heart and brain systems, to test the influence of mechanical forces originating from vascular anatomy, haemodynamics and metabolic characteristics on brain development in normal and abnormal conditions. This research will open up opportunities for understanding systems-based mechanisms of other conditions affecting heart and brain such as congenital heart disease, schizophrenia, autism, neurodegenerative diseases or neurocardiology applications.

The first task will involve the development of a model of neurological development coupling brain mechanics (Fig. 1) with a multi-scale model of blood circulation and metabolism. Local forces will arise from anisotropic tissue surrounded by fluid and skull as well as pulsatile forces through vessels and their acute and chronic remodelling. Blood circulation models from the heart to the brain will provide regional flow and pressures at different scales, whereas metabolic exchange models will be included to describe oxygen and nutrients diffusion from vasculature to brain tissue. In a second phase of the project, parametric studies will be performed to identify the most relevant characteristics for normal and abnormal brain development. Mesh-less numerical techniques will be explored. Robust verification and validation experiments of the developed computational models will be implemented, both for each sub-system individually and globally. A thorough sensitivity analysis of the parameters will be achieved to determine the ones having the largest influence on brain development and how cardiovascular deficiencies can induce abnormal neurodevelopment. A unique clinical database of IUGR cases available at Hospital Clínic de Barcelona, including brain and heart data from the same cases, will be used to personalize, validate and guide the modelling work. The combination of physiological modelling and machine learning techniques to analyse this data is planned.

This project is strongly interdisciplinary, joining clinical, biomedical and technical expertise. The PhD candidate will be surrounded by a team including experts, postdocs and junior researchers from different disciplines (engineering/physics, biomedical/experimental), available in the hosting research group (PhySense, part of the BCN-MedTech research unit at UPF) and from our collaborators (P. Saez, Universitat Politècnica de Catalunya; D. Rueckert, Imperial College London; M. Sermesant, M. Lorenzi, Inria, France; O. Coulon, Aix-Marseille Université; Pr. B. Bijnens, Dr. F. Crispi, Dr. E. Eixarch, Hospital Clínic de Barcelona; M. Vázquez, Barcelona Supercomputing Centre; V. Borrell, Instituto Neurociencias Alicante; S. Safaei, G. Talou, P. Hunter, Auckland Bioengineering Institute).

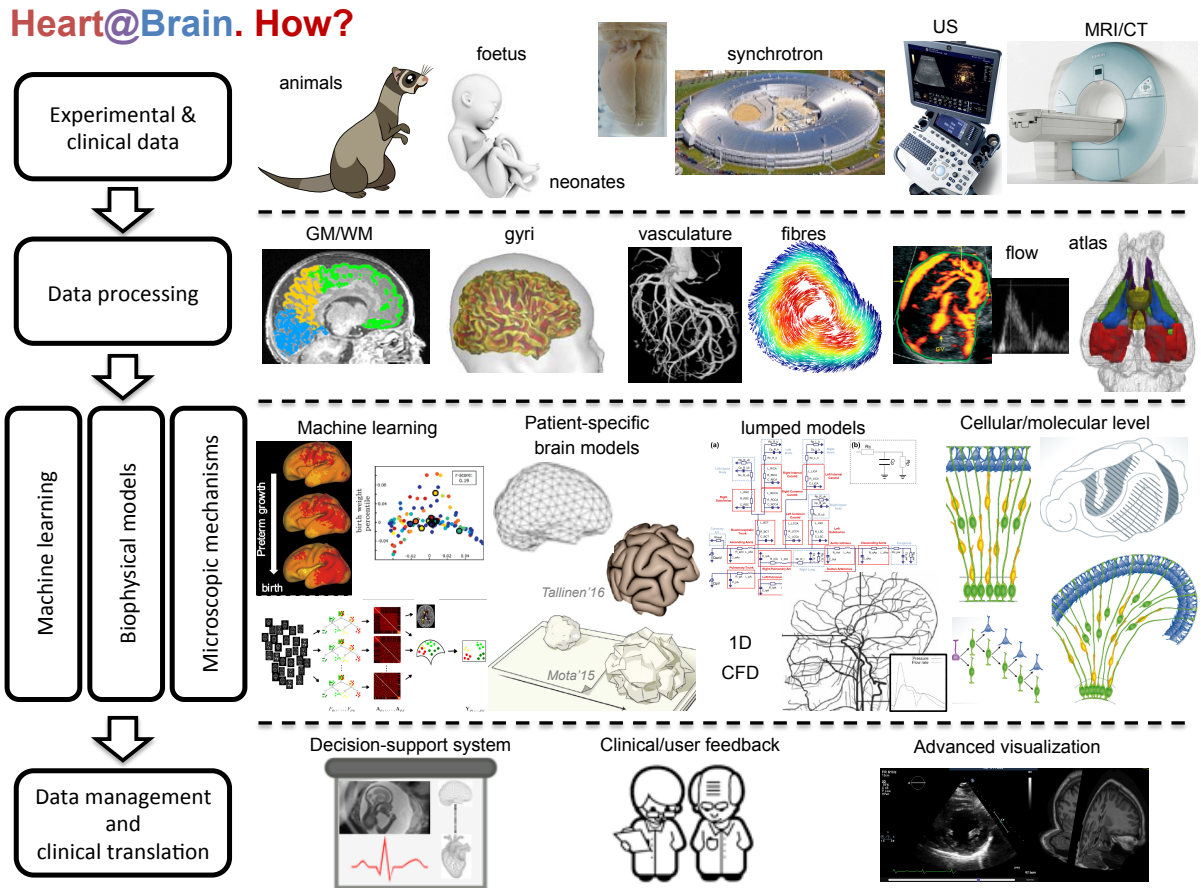

Fig. 1 Scheme with several of the (possible) methodological steps for heart-brain modelling.

Workplace

The main supervisor of this PhD is Oscar Camara, Associate Professor at the Department of Information and Communication Technologies of the Universitat Pompeu Fabra (DTIC-UPF, https://www.upf.edu/web/etic), and leader of the PhySense research group. The DTIC at the UPF is the first Spanish ICT department that has been awarded with the María de Maeztu grant (excellence in science and innovation accreditation, 2016-2019) on data-driven knowledge extraction (https://www.upf.edu/web/mdm-dtic), and the Spanish university department with the largest number of ERC grants (15, including 6 Advanced ERC Grants). PhySense was recognized as an Emerging Research Group by the Government of Catalonia in 2014 and it is currently composed of 21 members, including 6 postdocs, 10 PhDs and 3 software developers. In September 2016, the group was one of the founding members of the BCN-MedTech unit (https://bcn-medtech.upf.edu/), a Research Unit at UPF that holds more than 200 I+D projects, 95 external collaborations, 1000 high-impact publications, 19 patents and 61 PhD Thesis. It recently (2018) obtained the TECNIO certification from the Catalan Government, given to research centres with proven record of technology transfer.

The PhD will be performed in close collaboration with clinical researchers from Hospital Clínic de Barcelona, experts in both cardiovascular and brain-related development and remodelling: IDIBAPS, supervised by ICREA Research Pr. B. Bijnens; and The Fetal Medicine Research Centre at the Maternity Hospital; supervised by Dr. F. Crispi, Dr. E. Eixarch and Pr. E. Gratacós). Researchers from prestigious international institutions will also be involved in the project (see above), enabling the possibility of short stays during the doctorate.

Profile of the candidate

We are looking for highly motivated young researchers with a Master degree (or equivalent) in Biomedical Engineering, Physics, Mechanical Engineering, Applied Mathematics, Computational Science, or related disciplines, willing to study and do research at the leading edge of biomedical engineering. Experience in computer sciences and having proven programming skills would be of importance. High motivation is the only essential pre-requisite; our top-quality research standards demand hard work, which only strong motivation and commitment can ensure. Nevertheless, candidates already familiar with (continuum) mechanics, ideally in medical applications, would have a faster start of the project. Review Tallinen et al. paper (Nature Physics, 2016; https://www.seas.harvard.edu/softmat/downloads/Brain-morph.pdf) as a good example on what it should motivate and not scare you (code available: http://users.jyu.fi/~tutatall/codes.html).

Candidates must have excellent teamwork and communication skills and be enthusiastic about collaborating with a diverse range of international partners. We expect them to be fluent in English as it will be the language used to interrelate with the different partners. Interest in clinical translation is essential since meetings with clinicians will regularly take place. Female applicants are explicitly encouraged to apply and will be treated preferentially whenever they are equally qualified as other male candidates.

More information on the requirements for a PhD position at the Universitat Pompeu Fabra can be found on https://www.upf.edu/web/etic/doctorat and http://www.upf.edu/doctorats/en.

Conditions

An initial training plan will be set up by selecting the best opportunities in the PhD programme of UPF and available initiatives within our collaborators. Clinical training will be organized depending on the needs and background of the researcher. BCN-MedTech offers an ideal working environment, mainly due to the large critical mass of experienced senior investigators in diverse areas of biomedical engineering, junior postdoctoral researchers and an international team of talented young PhD students; there is always someone that can help! In addition, the extensive network of collaborations, including clinical and large infrastructure partners, gives us a privileged access to unique data, software and technological facilities. The maximum score usually obtained in individual national and international fellowships evaluating the institution repeatedly demonstrates the excellent training environment of BCN-MedTech.

Initially, this PhD will be funded by a DTIC-UPF fellowship, which is associated to a teaching load of 60 hours per academic year (https://www.upf.edu/web/etic/predoctoral-research-contracts), which is a good opportunity for PhD students to get familiar, from the beginning of their career, with teaching activities. The teaching topics are chosen depending on the PhD background, preferentially in the biomedical engineering BSc and MSc degrees we manage (https://www.upf.edu/en/web/etic/bachelor-degree-biomedical-engineering-2016). Supervising practicum internships as well as BSc and MSc thesis is also possible. The first year starts with around 1000 euros gross monthly salary, which is progressively increased during the PhD. You won't get rich, we know; unfortunately, this is valid for most pre-doctoral students worldwide. Nevertheless, we encourage and support our students to apply for individual fellowships, which are usually better paid (https://www.upf.edu/web/phdfunding). Complements can be discussed.

Deadline and contact information

Applicants should send a curriculum vitae and a motivation letter describing their research interests to Oscar Camara <oscar.camara@upf.edu>. Deadline: 9th of April 2019.