Ecole Doctorale STIC

Sciences & Technologies de l'Information et de la Communication

ED STIC - Proposition de Sujets de Thèse

pour la campagne d'Allocation de thèses 2017

Axe Sophi@Stic :	BioSanté|
Titre du sujet :	Heart & Brain: linking cardiovascular pathologies and neurodegeneration through biophysical and statistical models of cardiac and brain images
Mention de thèse :	ATSI
HDR Directeur de thèse inscrit à l'ED STIC :	Maxime Sermesant

Co-encadrant de thèse éventuel :

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Laboratoire d'accueil :	INRIA

Description du sujet :

--- Project Description:

It has been shown that the insurgence of cognitive decline is strongly tied to the presence of stroke and brain vascular damage [1,2]. However, while hypertension is a major risk
factor for stroke, the relationship between cardiac abnormalities such as high blood pressure or arrhythmias, with dementia still needs to be elucidated. Indeed, the findings
associating hypertension and risk of dementia are often contradictory and non-trivially related to specific conditions, such as age and concomitance with other diseases. Among
the possible explanations of such inconsistency we ultimately identify: 1) the large variability of blood pressure measurements and other cardiovascular measurements across

the general populations and the different aging stages; 2) the poor reliability of dementia imaging markers; and ultimately 3) the lack of an established interaction model between cardiac and brain functions.

Current large clinical studies offer for the first time the chance of jointly analyzing the common variation between cardiovascular pathologies and cognitive impairment by developing computational models integrating biomedical data of both heart and brain. To give an example of the volume of data these studies entail, the Inria Asclepios group has recently gained access to cardiac and brain images of 10’000 individuals available from the UK Biobank, requiring around 30Tb of disk space for the raw data. This example of Big Data in medicine offers the potential of highlighting unknown relationships between heart conditions and brain: thanks to the development of advanced machine learning and computational modeling tools we have a unique opportunity to develop quantitative and evidence-based instruments to deepen our understanding and provide novel diagnostic tools.

This PhD project aims at developing a computational model of the relationship between cardiac function and brain damage from large-scale clinical databases of multi-modal and multi-organ medical images. The project will require 1) to use advanced statistical learning tools for discovering relevant imaging features related to cardiac dysfunction and brain damage from large datasets of medical images and clinical information; and 2) to combine these measurements within a unified mechanistic framework to understand and validate the relationship between cardiac function, vascular pathology and brain damage.

The model will provide an unprecedented instrument for the in-vivo assessment of latent neurodegenerative conditions in the general population, and will be validated with respect to established indices of cognitive decline and to specific sub-population for which the ground truth is known.

[1] Debette S, Markus HS. The clinical importance of white matter hyperintensities on brain magnetic resonance imaging: systematic review and meta-analysis. BMJ. 2010;341:c3666
[2] van Dijk EJ, Prins ND, Vrooman HA, et al. Progression of cerebral small vessel disease in relation to risk factors and cognitive consequences: Rotterdam Scan study. Stroke. 2008;39:2712,2719.

--- Main activities:

- Feature extraction from brain imaging data (anatomical magnetic resonance images), by using supervised methods based on automatic segmentation and spatial registration of brain anatomies;
- Feature extraction and analysis from cardiac-imaging data to compute features of the cardiovascular function;
- Development of statistical learning tools based on dimensionality reduction and sparse

modelling;
- Development of biophysically inspired lumped models for the integration and joint analysis of the heterogeneous biomedical data;
- Working with large-scale biomedical databases;
- Writing well-abstracted and reproducible code, creating, implementing, documenting and automatizing analysis pipelines;
- Gathering competencies on the use of novel health-care technologies in brain and cardiac disorders;
- Interact with students and researchers, and participate to the scientific life of the teams.

--- Candidate profile:

Competences in machine learning and mathematical modelling are essential, as well as knowledge in medical imaging, signal and image processing (Master 2 level). Solid
programming and IT skills are necessary (Python and C++, bash scripting, version control systems), along with strong communication abilities.

--- Contact Duration:

36 mois, prise de poste à partir du 1er octobre 2017.

--- Inria EPI:

The PhD project is within an international collaboration between Asclepios team, Université Côte d'Azur (Sophia Antipolis, FR), and PhySense Group, Universitat Pompeu Fabra
(Barcelona, ES). As part of this international research program, the candidate is expected to spend part of his working time in the two groups during the course of the thesis.

Asclepios (https://team.inria.fr/asclepios/) is a world leading research group in the field of biomedical image analysis. It is located in the tech Park of Sophia Antipolis and in Nice,
in the French Riviera, and is working on the development of novel computational methods for the analysis of biomedical images for improving healthcare and diagnosis.

PhySense (physense.upf.edu) is a research group at Universitat Pompeu Fabra, Barcelona, Spain, created to provide a platform for interdisciplinary and translational biomedical
engineering research, and having large experience in several clinical applications including neurological and cardiology problems.

The PhD project will be also carried in collaboration with international clinical partners, both in neurology and cardiology (Centre Hospitalier Universitaire de Nice, FR; Fundació
Pasqual Maragall, SP).

--- EPI webpage:

https://team.inria.fr/asclepios/

URL : https://team.inria.fr/asclepios/

English version: