2018-00884 - [EPIONE] PhD position on Statistical estimation on Riemannian and affine symmetric spaces with applications to the statistical survey of the brain anatomy

Level of qualifications required : Graduate degree or equivalent
Fonction : PhD Position
Level of experience : Recently graduated

About the research centre or Inria department

The Inria Sophia Antipolis - Méditerranée center counts 37 research teams and 9 support departments. The center’s staff (about 600 people including 400 Inria employees) is composed of scientists of different nationalities (250 foreigners of 50 nationalities), engineers, technicians and administrators, 1/3 of the staff are civil servants, the others are contractual. The majority of the research teams at the center are located in Sophia Antipolis and Nice in the Alpes-Maritimes. Six teams are based in Montpellier and a team is hosted by the computer science department of the University of Bologna in Italy. The Center is a member of the University and Institution Community (ComUE) “Université Côte d’Azur (UCA)“.

Context

This PhD will take place within the Epione team at Inria Sophia Antipolis under the direction of Xavier Pennec (Xavier.pennec@inria.fr, http://www-sop.inria.fr/members/Xavier.Pennec/), Senior Research Scientist (Directeur de Recherches) at Inria.

The Inria Sophia Antipolis - Méditerranée research center has about 600 people working in 37 research teams and 9 services to sustain research. It is localized in Sophia Antipolis, close to Antibes on the French Riviera. Within this research center, the Epione team aims at contributing to the development of what we call the e-patient (digital patient) or e-medicine (digital medicine). The e-patient (or digital patient) is a set of computational models of the human body able to describe and simulate the anatomy and the physiology of the patient’s organs and tissues, at various scales, for an individual or a population.

The PhD proposal is part of the ERC G-Statistics advance grant # 786854 (2018-2023) from the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation programme. G-statistics aims at exploring the consequences of the non-linearity of data spaces on the statistical estimation through geometry. We already know how to estimate the location (mean, median) and the concentration (covariance) of a random variable in a Riemannian manifold, or to perform simple statistical tests. There are also results for some classes of less smooth spaces, for instance lengths, for spaces of non-positive curvature. One of the objectives of geometric statistics is to unify these methods and to extend them to other non-Riemannian geometric structures. We want to include spaces with singularities and changes of dimension, in particular affine connection, quotients or stratified spaces. These geometric structures appear in practical life sciences applications, as for example diffeomorphisms (invertible transformations of space) acting on images used in the registration of medical images, phylogenetic trees or shape spaces.

Assignment

At the interface of geometry, statistics, image analysis and medicine, computational anatomy aims at analyzing and modeling the biological variability of the organs shapes and their dynamics at the population level. The goal is to model the mean anatomy, its normal variation, its motion / evolution and to discover morphological changes between normal and pathological groups. Since shapes and deformations live in non-linear spaces, this requires a consistent statistical framework on manifolds and Lie groups, which has motivated the development of Geometric Statistics during the last decade. To consolidate the mathematical bases of geometric statistics, it is now essential to explore geometric structures beyond the classical Riemannian framework. In computational anatomy, the deformable template theory considers changes of dimension, in particular affine connection, some of these groups can be endowed with a right-invariant Riemannian metric leading to affine symmetric spaces. These geometric structures appear in practical life sciences applications, as for example diffeomorphisms (invertible transformations of space) acting on images used in the registration of medical images, phylogenetic trees or shape spaces.

The PhD will explore the extension of the statistical estimation theory from Riemannian manifolds to affine symmetric spaces. This class of spaces includes non-metric spaces like Lie groups with the bi-invariant Cartan-Schouten connection. The change of paradigm from the metric to the affine connection can potentially be generalized to homogeneous spaces that have invariance connection but no invariant metric, like reductive homogeneous manifolds (Aleksseevsky, personal communication, 2017). The setting of affine symmetric spaces appears to be a very powerful non-Riemannian framework for geometric statistics where we will exemplify the impact of curvature on the non-asymptotic estimation. The second goal of the PhD will illustrate the statistical estimation methodology on dimension reduction problems for brain anatomodesy (the statistical survey of the brain anatomy). Large database of medical images are now available to study the variability of the anatomy in relation to clinical variables and outcomes at the scale of a population (1,800+ subjects in ADNI, 5,000+ images).

General Information

- Theme/Domain : Computational Neuroscience and Medicine
- Town/city : Sophia Antipolis
- Inria Center : CNRS Sophia Antipolis - Méditerranée
- Starting date : 2018-10-01
- Duration of contract : 3 years
- Deadline to apply : 2018-07-06

Contacts

- Inria Team : EPIONE
- Recruiter : Pennec Xavier / xavier.pennec@inria.fr

About Inria

Inria, the French National Institute for computer science and applied mathematics, promotes “scientific excellence for technology and society”. Graduates from the world’s top universities, Inria’s 2,700 employees rise to the challenges of digital sciences. With its open, agile model, Inria is able to explore original approaches with its partners in industry and academia and provide an efficient response to the multidisciplinary and application challenges of the digital transformation. Inria is the source of many innovations that add value and create jobs.

Conditions for application

Defence Security :
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technological potential (PPST). Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.

Warning :
you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.
in UK biobank). For complex shapes such as the brain, the classical unimodal Gaussian setting of statistical shape analysis with a few deformation modes around a mean shape model needs to be revisited. The PhD will investigate dimension reduction methods like barycentric subspace analysis (generalizing PCA on manifolds) and other generalization of PLS/CCA on the space of deformations seen as an affine symmetric space. In particular, the PhD will explore the formalization of multi-atlas methods for the segmentation of the brain based on barycentric subspaces in the space of diffeomorphisms.

References

Main activities
Main activities:
- Theoretical research in mathematical statistics and differential geometry
- Implementation of group registration and segmentation methods on large populations of brain images
- Scientific paper writing, presentations in conferences


Skills
- Master degree with strong competences in mathematical modeling, statistical learning as well as some 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).
- Strong communication abilities
- Fluent English (written and spoken)

Benefits package
- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

Remuneration
- Duration: 36 months
- Location: Sophia Antipolis, France
- Gross Salary per month: 1982€ brut per month (year 1 & 2) and 2085€ brut/month (year 3)