Offer #2025-09173

PhD Position F/M Generative approach for modelling longitudinal trajectories of medical images including anomaly detection

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

Context

Studying the evolution of pathologies using medical imaging data is an important aspect of many clinical fields. These analyses are useful not only for early diagnosis, but also for personalized therapeutic monitoring of patients and assessment of the effectiveness of proposed treatments. To address this issue, this thesis proposes an approach that combines two mathematical disciplines: Riemannian geometry and Bayesian statistical models.

Assignment

Geometric representation of images: shape space and LDDMM in a generative statistical framework

Initially, we will use differential geometry tools, in particular the Large Deformation Diffeomorphic Metric Mapping (LDDMM) framework. This methodology enables medical images and their deformations to be represented as points in a shape space with a Riemannian manifold structure. It is also useful for detecting anomalies: LDDMM can be used to construct a healthy reference close to the patient, comparable to the real image, and to display lesions such as residuals not explained by the diffeomorphic elastic deformation. Based on the first deterministic model proposed by Vianney Debavelaere and Tom Boeken during their theses, we will build a generative statistical model enabling a multi-scale population analysis: population variables showing the most frequent lesion locations in the population and individual variables enabling the model to be customized. The introduction of latent variables into these mixed-effects models makes it possible to model the inter-individual and spatial variability present in the images.

Stochastic approximation algorithms such as MCMC-SAEM (Monte Carlo Markov Chain - Stochastic Approximation Expectation Maximization) will be used to estimate the model parameters. The model will then be able to generate images that faithfully simulate the patterns observed in the data.

A theoretical study of these models will be proposed.

An analysis of digestive cancer data will be carried out.

Longitudinal dynamics and evolution of lesions: picewise models of evolution

The analysis will be extended to the modelling of longitudinal trajectories of images containing lesions, in order to meet two major clinical constraints. The longitudinal nature makes it possible to follow the evolution of the disease over time from successive images of the same patient. However, trajectories are not always diffeomorphic: the appearance or disappearance of anomalies - caused by treatment or the emergence of new lesions - makes it necessary to introduce piecewise continuous trajectories into our model.

A theoretical study of these models will also be carried out.

An analysis of digestive cancer data will be carried out, followed by tests on data acquired as part of the MediTwin project.

Main activities

The aim of this thesis project is to develop a robust mathematical framework ranging from detection to statistical modelling, in order to build a model capable of analyzing longitudinal imaging data presenting anomalies. This model will contribute to a better understanding of the evolution of pathologies, while opening up clinical prospects for diagnosis and personalized monitoring.

Skills

Compétences techniques et niveau requis :

Langues :

Compétences relationnelles :

Compétences additionnelles appréciées :

Benefits package

- Restauration subventionnée

- Transports publics remboursés partiellement
- Congés: 7 semaines de congés annuels + 10 jours de RTT (base temps plein) + possibilité d'autorisations d'absence exceptionnelle (ex : enfants malades, déménagement)
- Possibilité de télétravail et aménagement du temps de travail
- Équipements professionnels à disposition (visioconférence, prêts de matériels informatiques, etc.)
- Prestations sociales, culturelles et sportives (Association de gestion des œuvres sociales d'Inria)
- Accès à la formation professionnelle
- Sécurité sociale

General Information

- **Theme/Domain :** Computational Neuroscience and Medicine Statistics (Big data) (BAP E)
- **Town/city :** Paris
- **Inria Center :** Centre Inria de Paris
- **Starting date :** 2025-11-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2025-08-16

Contacts

- **Inria Team :** HEKA
- **PhD Supervisor :**
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Instruction to apply

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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.

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