# Inria

# Offre n°2024-08438

# Post-Doctoral Research Visit F/M Topological Methods for Spatial Transcriptomics Data

*Le descriptif de l'offre ci-dessous est en Anglais*

**Type de contrat :** CDD

**Niveau de diplôme exigé :** Thèse ou équivalent

**Fonction :** Post-Doctorant

## A propos du centre ou de la direction fonctionnelle

The Inria center at Université Côte d'Azur includes 42 research teams and 9 support services. The center's staff (about 500 people) is made up of scientists of different nationalities, engineers, technicians and administrative staff. The teams are mainly located on the university campuses of Sophia Antipolis and Nice as well as Montpellier, in close collaboration with research and higher education laboratories and establishments (Université Côte d'Azur, CNRS, INRAE, INSERM ...), but also with the regional economic players.

With a presence in the fields of computational neuroscience and biology, data science and modeling, software engineering and certification, as well as collaborative robotics, the Inria Centre at Université Côte d'Azur  is a major player in terms of scientific excellence through its results and collaborations at both European and international levels.

## Contexte et atouts du poste

With the launch of the AI4scMed project (multiscale AI for single-cell based precision medicine) of the PEPR Santé Numérique, we seek to hire an excellent candidate for a post-doctoral research position of 2 years specialized in data science and single-cell data. The successful candidate will be primarily based at Centre Inria d'Université Côte d'Azur in Biot, France, with collaborations at ENS Lyon, EC Nantes and INSERM Marseille.

## Mission confiée

The goal of this postdoctoral research position is to develop the theoretical and practical applications of Topological Data Analysis (TDA) to spatial transcriptomics data, with a particular focus on multi-parameter persistence methods. TDA is a field of data science that gained a lot of attention during the last few years due to its ability to generate new descriptors and features for data sets (such as persistence diagrams and Mapper complexes), which encode topological information—for instance, the number and sizes of topological structures in the data, including, e.g., connected components, loops and cavities—that is usually complementary to traditional features, and can thus greatly improve performances of standard methods in Machine Learning. Moreover, as TDA is firmly rooted in algebraic topology, its descriptors enjoy many properties, such as being invariant to any continuous deformations, as well as being robust to potentially non-linear noise, as proved by the celebrated stability theorem. These properties have made TDA a useful tool in the analysis of spatial transcriptomics data, which jointly measures the RNA expression of all genes and the spatial coordinates,
of single cells in a piece of tissue. As the geometric arrangements of single cells is known to correlate to more complex biological phenomenon, such as the immune response in the presence of tumors, descriptors have recently as powerful summaries, that can be seen as generalizations of other state-of-the-art descriptors based on spatial statistics, such as Ripley's K-function. However, an inherent limitation of current approaches based on topology is their inability to study, capture and encode the patterns formed by the joint interactions of spatial coordinates and several marker genes: as of today, all topological approaches can only characterize
the topological arrangements of single cells for a given single gene or cell type. This is problematic as restricting to single genes or cell types is highly restrictive in terms of information content, and can lead to unreliable results, as it is prone to errors as long as the cell type inference method (with, e.g., transfer learning) is not perfect.

## Principales activités

Hence, the successful candidate will work on multi-parameter TDA, a powerful field that emerged recently in the TDA community, for designing new analysis tools for spatial transcriptomics data. This includes the statistical analysis and design of confidence models for
multi-parameter Mapper complexes, which are visualization tools based on the topology of data. This will allow for efficient and robust biological inference based on the topological structures exhibited in

Mapper complexes that are associated to interesting subpopulations of cells, following the preliminary work. Another line of work will be based on the use of multi-parameter persistence descriptors, which are useful descriptors of the multiparameter topological patterns that are present in (batches of) cells, and which take the form of images encoding the presence and sizes of these patterns. Again, the design of generative and predictive models fueled by these descriptors is expected for biological inference. Then, the candidate will apply its methods and models on real spatial transcriptomics datasets obtained within the PEPR consortium.

The application will focus on the study of long-range spatial interactions of receptor-ligand pairs in the tissue. The research will be jointly supervised by Bertrand Michel (LMJL, EC Nantes), Franck Picard (LBMC, ENS-Lyon), Paul Villoutreix (Marseille Medical Genetics, INSERM, Marseille), and Mathieu Carrière (DataShape, Centre Inria d'Université Côte d'Azur)

## Compétences

Any candidate should have a PhD degree in applied mathematics and/or computer science, excellent programming skills with an extensive knowledge of the principal data science libraries for (deep) machine learning and optimization (such as Scikit-Learn,
TensorFlow, PyTorch) and a lot of research experience on topics including topological data analysis and statistical machine learning. Some experience in single cell biology and spatial transcriptomics is a plus. Teamworking, communication and collaboration skills are also essential.

## Avantages

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (after 6 months of employment) and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Contribution to mutual insurance (subject to conditions)

## Rémunération

Gross Salary : 2788 € per month.

## Informations générales

- **Thème/Domaine** : Algorithmique, calcul formel et cryptologie
  Statistiques (Big data) (BAP E)
- **Ville** : Sophia Antipolis
- **Centre Inria** : Centre Inria d'Université Côte d'Azur
- **Date de prise de fonction souhaitée** : 2025-03-01
- **Durée de contrat** : 2 ans
- **Date limite pour postuler** : 2025-02-28

## Contacts

- **Équipe Inria** : DATASHAPE
- **Recruteur** :
  Carrière Mathieu / mathieu.carriere@inria.fr

## A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L'institut s'efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

## L'essentiel pour réussir

There you can provide a "broad outline" of the collaborator you are looking for what you consider to be necessary and sufficient, and which may combine :

- tastes and appetencies,
- area of excellence,
- personality or character traits,
- cross-disciplinary knowledge and expertise...

This section enables the more formal list of skills to be completed and 'lightened' (reduced) :

- "Essential qualities in order to fulfil this assignment are feeling at ease in an environment of scientific dynamics and wanting to learn and listen."
- " Passionate about innovation, with expertise in Ruby on Rails development and strong influencing skills. A thesis in the field of **** is a real asset."

**Attention**: Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

## Consignes pour postuler

Applications must be submitted online on the Inria website. Collecting applications by other channels is not guaranteed.

**Sécurité défense** :
Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

**Politique de recrutement** :
Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.