



Offre n°2023-06880

Reconstruction of the Cosmic Web skeleton

Niveau de diplôme exigé : Master's or equivalent

Fonction : Internship Research

A propos du centre ou de la direction fonctionnelle

The Inria centre at Université Côte d'Azur includes 37 research teams and 8 support services. The centre'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

Context. The large-scale structure of the universe, also called cosmic web, is represented and analyzed through the distribution of galaxies and dark matter. The cosmic web is a dynamic structure that evolves under the effect of gravity and the expansion of the universe. This structure is not random but organized as a network of filaments connecting dense regions of galaxies. Identifying these features and reconstructing the cosmic web with vectorized representations is a key scientific challenge to better understand the structure of the universe. Numerous algorithms have been proposed in the literature for performing these tasks, as underlined in the survey of Libeskind et al [1]. Popular approaches rely upon mathematical tools such as graph theory [2], stochastic geometry [3], or Morse theory [4] to cite just a few of them. Only a few methods have addressed this problem from computational geometry tools that construct space-partitioning data structures to decompose the 3D space into volumes, surfaces and lines. Yet such data structures seem particularly well suited for reconstructing the underlying structure of the universe.

Objectives. The goal of this internship is to investigate new methods for reconstructing the skeleton of the cosmic web that exploit efficient space-partitioning data structures from computational geometry field. This topic is particularly timely. The candidate will study the potential of Delaunay triangulation, Voronoi diagrams and power diagrams for capturing and connecting filaments of galaxies and clusters of galaxies. His/her algorithms will be tested on simulated data with Ground Truth, typically the simulations Gaea, that provide the dark matter distribution, positioning of the galaxies and the halos. Considering as input data, a set of 3D points representing the galaxies, a first objective will be to construct a space-partitioning data structure where edges align with chains of points. One possible solution could be to first group points into either large cluster (ie halos connecting the extremities of filaments) or secondary clusters (contained in the filaments), before connecting them using a Delaunay triangulation. If time remains, one could also imagine adapting a Delaunay triangulation dynamically to the distribution of dark matter with a Delaunay point process [5].

This is a fast-growing topic with the imminent start of major new generation galaxy surveys performed with the recently launched ESA Euclid mission and the Large Synoptic Survey Telescope at Rubin Observatory. which will enable unequaled tri-dimensional mapping of the galaxy and dark matter distribution.

Keywords: Geometry processing, computer vision, cosmology, massive point clouds, point set processing, geometric data structures

Candidate profile: The ideal candidate should be student in M2 or M1 in Computer Science or Mathematics, have good knowledge in 3D geometry and applied mathematics, be able to program in C/C++, be fluent in English, and be creative and rigorous.

Application deadline: December 18, 2023

Contacts: Florent Lafarge (Inria , florent.lafarge@inria.fr), Sophie Maurogordato (OCA, sophie.maurogordato@oca.eu) and Christophe Benoist (OCA, christophe.benoist@oca.eu)

Location: Inria Sophia Antipolis with visits at the Observatoire de la Côte d'Azur

References

- [1] Libeskind et al. Tracing the Cosmic web. Monthly Notices of the Royal Astronomical Society, Volume 473, 2018
- [2] Bonnaire et al. T-ReX: a graph-based filament detection method. Astronomy and Astrophysics, volume 637, 2020
- [3] Tempel et al. Bisous model - Detecting filamentary patterns in point processes. Astron.Comput. volume 16, 2016
- [4] Sousbie. DisPerSE: robust structure identification in 2D and 3D. ArXiv 1302.6221, 2013
- [5] Favreau et al. Extracting Geometric Structures in Images with Delaunay Point Processes, IEEE Trans. on Pattern Analysis and Machine Intelligence (PAMI), Vol. 42(4), 2020

Mission confiée

-

Principales activités

-

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.)
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Informations générales

- **Thème/Domaine** : Interaction and visualization
Biologie et santé, Sciences de la vie et de la terre (BAP A)
- **Ville** : Sophia Antipolis
- **Centre Inria** : [Centre Inria d'Université Côte d'Azur](#)
- **Date de prise de fonction souhaitée** : 2024-04-01
- **Durée de contrat** : 6 months
- **Date limite pour postuler** : 2024-04-30

Contacts

- **Équipe Inria** : [TITANE](#)
- **Recruteur** :
Lafarge Florent / Florent.Lafarge@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.

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

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.