Offer #2024-07513

PhD Position F/M 3D Computer Vision and geometry processing

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

About the research centre or Inria department

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 regiona 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.

Assignment

Efficient data structures and algorithms for processing massive point clouds

Context
Analyzing 3D point clouds captured from real-world environments is a core component of Geometry. Processing and 3D Computer Vision. Processing tasks include, for instance, the estimation of local geometric properties, semantic segmentation, extraction of geometric primitives or reconstruction into surface meshes. Algorithms that perform these tasks are typically designed to handle up to a few million points efficiently [1,2]. With the technological advances on sensors and storage capacity, new acquisition protocols generate more and more massive point clouds that contain billions of points. The naive solution then consists in decomposing the space into blocks of reasonable number of points before performing parallel computing. This solution is however prone to border effect errors and does not allow the analyze of point clouds at global scales. Moreover, it requires high computing resources and storage capacity.
Scaling point cloud processing algorithms to billion points without naïve block decomposition is a challenging scientific problem. Among existing works, streaming methods that process data on the fly have been designed towards this goal. They however are tailored made for specific applications [3,4] and cannot be generalized easily to a generic toolbox. Other methods, e.g. [5], operate block decomposition by focusing on border effect reduction. Besides these strategies, the nature of the data structure that encodes input points is also a central question. For visualization applications for instance, octrees constitute a popular choice as levels of details for rendering points can be easily defined by this hierarchical structure [6,7].

Objectives
The goal of this PhD is to (i) investigate new data structures to read, compress and store the information contained in massive point clouds efficiently, and (ii) to rethink popular processing tasks so that they can operate at multiple scales directly from such data structures.
The candidate will study the potential of different space partitioning data structures that can be built efficiently in a hierarchical way and from which information can be stored and requested easily. He/she will also propose compression operations to convert clusters of input points into lightweight geometric objects, and clusters of these geometric objects into single one. The choice of geometric objects will have to account for representation genericity, compactness and efficiency to connect and aggregate them. Prior work shows, for example, that planar components (which are frequent in urban environments) can be turned into a hierarchy of floating polygons with a limited loss of information. Similarly, the notion of “superpoints” introduced in [9] could also be a solution for compressing non-planar components.
The candidate will also revisit some traditional point cloud processing tasks such as estimation of local geometric properties, surface reconstruction or primitive detection under the idea that the atomic geometric element is not a 3D point anymore, but geometric object living at a given scale of the data structure. Continuing on the previous example with polygons and superpoints, planar shape detection could be simply addressed by selecting polygons in the hierarchy of the data structure, and surface reconstruction, by assembling the geometric objects with a space partition.
The candidate will also investigate the potential of the proposed data structures in recent 3D deep learning architectures which still largely suffer from scalability issues. In particular, the proposed data structures could be an effective alternative to the very coarse simplification of input point clouds [10].

Keywords
Geometry processing, 3D computer vision, massive point clouds, point set processing, geometric data structures

References
[1] The CGAL Project. CGAL User and Reference Manual. CGAL Editorial Board, 5.5.1 edition, 2022.
[2] CloudCompare, version 2.10.3, 2022.
[3] Pajarola. Stream-Processing Points. IEEE Visualization 2005
[4] Zhou and Neumann. A streaming framework for seamless building reconstruction from large-scale aerial lidar data. CVPR 2009
[5] Mostegel, Prettenthaler, Fraundorfer and Bischof. Scalable Surface Reconstruction from Point Clouds with Extreme Scale and Density Diversity. CVPR 2017
[6] Schütz, Ohrhallinger, Wimmer. Fast Out-of-Core Octree Generation for Massive Point Clouds. Computer Graphics
Forum, vol 39(7), 2020
[7] Elseberg, borrmann and Nuchter. One billion points in the cloud – an octree for efficient processing of 3D laser scans. ISPRS Journal of Photogrammetry and Remote Sensing, vol 76, 2013
[8] Fang, Lafarge, and Desbrun. Shape detection at structural scales. CVPR 2018
[9] Landrieu and Simonovsky. Large-scale Point Cloud Semantic Segmentation with Superpoint Graphs. CVPR 2018
[10] Potamias, Bouritsas and Zafeiriou. Revisiting Point Cloud Simplification : A Learnable Feature Preserving Approach. ECCV 2022

More information can be found at https://team.inria.fr/titane/files/2024/03/sujet_Massive_PCP.pdf

Skills

The ideal candidate should have good knowledge in 3D geometry and computer vision, be able to program in C/C++ and Python, be fluent in English, and be creative and rigorous.

Benefits package

- 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
- Social security coverage

Remuneration

Duration: 36 months
Location: Sophia Antipolis, France
Gross Salary per month: 2100€ brut per month (year 1 & 2) and 2190€ brut per month (year 3)

General Information

- **Theme/Domain :** Interaction and visualization
  Scientific computing (BAP E)
- **Town/city :** Sophia Antipolis
- **Inria Center :** Centre Inria d'Université Côte d'Azur
- **Starting date :** 2024-10-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2024-05-19

Contacts

- **Inria Team :** TITANE
- **PhD Supervisor :**
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About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different

professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

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.

Instruction to apply

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 technical 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.