



2021-04119 - PhD Position F/M Fusion of 3D point clouds and radar tomography for volume modelling of engineering structures

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

Context

This thesis is part of the "Road-AI" challenge between Inria and Cerema (which stands for Centre for Studies and Expertise on Risks, the Environment, Mobility and Urban Planning).

Sensitive elements on engineering structures (such as bridge piers or decks, for example) are monitored by visual surface inspections. For structures that are difficult to access, a drone flight can be used to acquire a cloud of points by photogrammetry (photo registration).

The subsurface state of the elements is also very important to confirm or invalidate a diagnosis made on the visible part, or to detect an anomaly or disorder not visible on the surface. One possible technique for this is to use a GPR (Ground Penetrating Radar), sensitive to the change of dielectric permittivity within the structure, which by inversion allows to proceed to a tomographic (volumetric) analysis of the object, and this is in 3D by repeating the measurements around the surfaces.

Supervisors : Pierre Alliez (TITANE Inria team), Florence Forbes (STATIFY Inria team), Christophe Heinkelé (ENDSUM Cerema team).

The project is part of a new collaboration between three teams, respectively in Nice, Grenoble and Strasbourg. Regular meetings and longer visits to the three locations are expected during the three years.

Assignment

Several questions emerge from this issue:

1) How to reconstruct simultaneously the surface and the representative volumes of the structures in the presence of noisy and sparse data?

2) The propagation of the radar signal (electromagnetic waves) requires the resolution of a direct problem which implies the issue of also meshing the internal part of the object. This calculation must be as efficient as possible, so there will be question of discretization of the 3D domain and the internal surfaces, and thus the optimization of the volume meshes according to the wavelengths used. The knowledge of the surface should make it possible to add constraints or a priori to the volume reconstruction problem.

3) How to obtain an active learning method, able to position/optimize the UAV measurements in order to obtain accurate tomographic sections of the object?

Main activities

The PhD student will be in charge of training in research (bibliography, exploration of new solutions, development, testing and experimentation, step-by-step presentation of his/her work, writing) and will start on the following questions:

1) The reconstruction of the surfaces of structures from 3D point clouds obtained by dense photogrammetry, the photos being taken by drones.

2) Techniques that allow the problem to be reversed, i.e. to identify parameters that are not visible on the surface, taking into account, for example, redundancies in the 3D radar measurements. One possibility would be to move towards supervised learning techniques such as deep learning.

3) The optimization of meshes and, in particular, should the elements be ordered?

4) Determining the most optimal positions of the radar measurements to proceed with the reconstruction, and deducing an optimal trajectory for the drones for each type of structure.

5) Handling of the CGAL library (<https://www.cgal.org/>) for the discretization aspects (surface and internal).

Skills

Technical Skills: Applied mathematics, numerical analysis, statistics, machine learning

Languages: English

Software: Matlab, LaTeX, C++ Language (Cgal), Python

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

General Information

- **Theme/Domain :** Optimization, machine learning and statistical methods
Scientific computing (BAP E)
- **Town/city :** Montbonnot
- **Inria Center :** CRI Grenoble - Rhône-Alpes
- **Starting date :** 2021-11-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2022-06-30

Contacts

- **Inria Team :** STATIFY
- **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.

The keys to success

References

A Survey of Surface Reconstruction from Point Clouds. Matthew Berger, Andrea Tagliasacchi, Lee Seversky, Pierre Alliez, Gael Guennebaud, Joshua Levine, Andrei Sharf, ClaudioSilva. Computer Graphics Forum, Wiley, 2016, pp.27.

Curved Optimal Delaunay Triangulation. Leman Feng, Pierre Alliez, Laurent Buse, HerveDelingette, Mathieu Desbrun. ACM Transactions on Graphics, Association for Computing Machinery, 2018, Proceedings of SIGGRAPH 2018, 37 (4), pp.16.

CGALmesh: a Generic Framework for Delaunay Mesh Generation. Clement Jamin, PierreAlliez, Mariette Yvinec, Jean-Daniel Boissonnat. ACM Transactions on MathematicalSoftware, Association for Computing Machinery, 2015, 41 (4), pp.24.

Finite-element contrast source inversion method for microwave imaging. Amer ZakariaColin Gilmore and Joe LoVetri, Inverse Problems, 2010, 26 (11), pp. 21.

Fast Bayesian Inversion for high dimensional inverse problems, Benoit Kugler and FlorenceForbes, Sylvain Doute. To appear in Statistics and Computing, 2021

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.

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.