Offer #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 isuue 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/optimise 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 optimisation 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 :** Centre Inria de l'Université Grenoble 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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The keys to success

References

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

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Instruction to apply

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