

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

Type de contrat : CDD  
Niveau de diplôme exigé : Bac + 5 ou équivalent  
Fonction : Doctorant

### Contexte et atouts du poste

This thesis is part of the "Road-All" 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.

### Mission confiée

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 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?

### Principales activités

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).

### Compétences

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

Languages: English

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

### 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

### Informations générales

- **Thème/Domaine** : Optimisation, apprentissage et méthodes statistiques  
Calcul Scientifique (BAP E)
- **Ville** : Montbonnot
- **Centre Inria** : CRI Grenoble - Rhône-Alpes
- **Date de prise de fonction souhaitée** : 2021-11-01
- **Durée de contrat** : 3 ans
- **Date limite pour postuler** : 2022-06-30

### Contacts

- **Equipe Inria** : STATIFY
- **Directeur de thèse** :  
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### A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 200 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3500 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 180 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

#### 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, Herve Delingette, 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 Zakaria, Colin Gilmore and Joe LoVetri, Inverse Problems, 2010, 26 (11), pp. 21.

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

### Consignes pour postuler

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

**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.

**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.