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ONERA — THE FRENCH AEROSPACE LAB

PROPOSITION DE STAGE EN COURS D'ETUDES

Référence :**PHY-DEMR-2024-14**
(à rappeler dans toute correspondance)

Lieu : Palaiseau

Département/Dir./Serv. : DEMR/TSRE

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DESCRIPTION DU STAGE

Thématique(s) : Interferometric SAR, multi-temporal, phase linking, Earth deformation, signal processing , statistical learning, optimization.

Type de stage : ☒ Fin d'études bac+5 ☒ Master 2 ☒ Bac+2 à bac+4 ☐ Autres

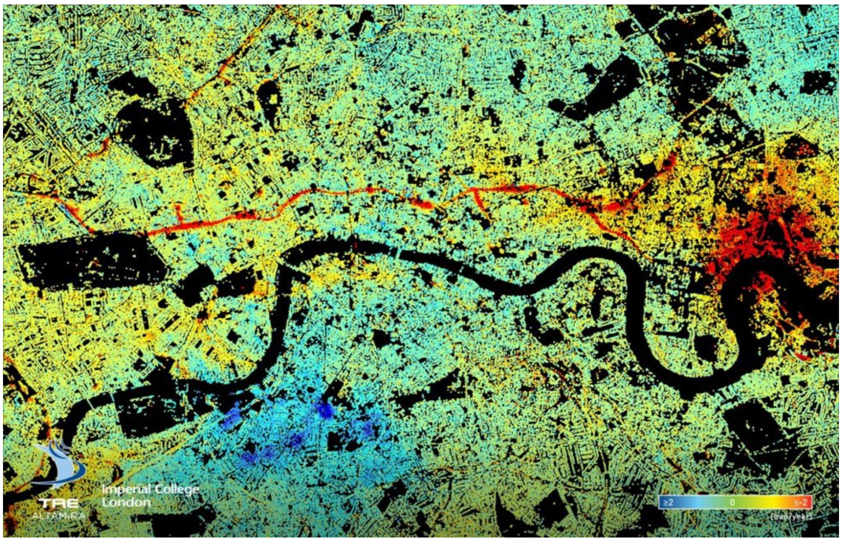
Intitulé : Robust and scalable interferometric phase linking for Earth deformation monitoring with SAR satellite image time-series

Sujet : Multi-Temporal Interferometric Synthetic Aperture Radar (MT-InSAR) techniques are becoming very popular, as the availability of SAR data is increasing. Leveraging the coherency allows for the measurement of Earth deformation up to millimeters accuracy (see example fig. 1). MT-InSAR techniques aim at exploiting all dimensions of the acquired SAR data, spatial and temporal, to optimally estimate the InSAR phases while retaining the spatial resolution. Phase linking (PL) driven by a maximum likelihood estimation (MLE) approach has been developed to jointly estimate InSAR coherence and phases (Minh et al. 2023). Most PL algorithms are built upon the sample covariance matrix, due to the assumption of an underlying Gaussian distribution. Recently, more general statistical models have then proposed and yielded new PL algorithms more robust to non-Gaussian data, yielding more accurate phase displacement estimates (Vu et al. 2023). One downside is that these robust methods involve a relatively high computational cost (compared to the standard PL), which can be limiting when processing large areas, or long baselines. This motivates the development and application of new methods that can achieve the best of both worlds.

In this internship, we propose to study PL approaches in the framework of covariance fitting methodology, which has the potential to achieve the aforementioned goal. The first part is dedicated to algorithm development (formulation), the second part is about the application on real data.

Part 1 - Developing covariance fitting based PL: Our team achieved promising preliminary results by formulating variants of PL as a covariance fitting problem (Vu et al. 2023). This framework provides more flexible solutions by allowing the choice of a variety of distances/divergences, plug-in covariance matrix estimators, and regularizations. As InSAR data exhibit a variety of statistical properties according to the resolution and the type of observed scene, covariance fitting approaches should be designed to achieve good performances in all cases. In this scope several developments need to be explored: formulation with new (robust) fitting objectives, and the automatic selection of the covariance regularization parameters. These problems will be addressed by leveraging and adapting the literature on robust estimation, and covariance matrix regularization (Ollila & Breloy 2022), that has not yet been explored in the scope of MT-InSAR.

Part 2 - Application to real-world data: With the development of new satellite constellations for high resolution SAR, there are more interests in urban areas monitoring. Ground deformation in cities is a significant problem to manage flood risk and effects of underground constructions (tunneling). The developed methods will be applied to real MT-InSAR data for earth deformation with a focus on high resolution data and urban area monitoring (Sentinel-1 and TerraSAR-X for example).



InSAR Ground Deformation Map of London city from TerraSAR-X data. The red line shows high displacements due to tunnel construction. (from TRE ALTAMIRA)

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References

Ansari, H., De Zan, F., & Bamler, R. (2018). Efficient phase estimation for interferogram stacks. IEEE Transactions on Geoscience and Remote Sensing, 56(7), 4109-4125.

Minh, D. H. T., & Tebaldini, S. (2023). Interferometric Phase Linking: Algorithm, application, and perspective. IEEE Geoscience and Remote Sensing Magazine, 11(3), 46-62.

Ollila, E., & Breloy, A. (2022). Regularized tapered sample covariance matrix. IEEE Transactions on Signal Processing, 70, 2306-2320.

Vu, P. V. H., Breloy, A., Brigui, F., Yan, Y., & Ginolhac, G. (2023). Robust Phase Linking in InSAR. IEEE Transactions on Geoscience and Remote Sensing.

Vu, P. V. H., Breloy, A., Brigui, F., Yan, Y., & Ginolhac, G. (2023, July). Covariance fitting based InSAR Phase Linking. In IGARSS 2023-2023 IEEE International Geoscience and Remote Sensing Symposium (pp. 8234-8237). IEEE.

Est-il possible d'envisager un travail en binôme ? **Non**

Méthodes à mettre en oeuvre :

☒ Recherche théorique	☐ Travail de synthèse
☒ Recherche appliquée	☐ Travail de documentation
☐ Recherche expérimentale	☐ Participation à une réalisation

Possibilité de prolongation en thèse : **Oui**

Durée du stage : Minimum : 4 mois Maximum : 6 mois

Période souhaitée : 2024

PROFIL DU STAGIAIRE

Connaissances et niveau requis :	Ecoles ou établissements souhaités :
The applicant will be doing a Master's (M2) and/or 3rd year engineering degree in signal and image processing, applied mathematics or data science. He/she will be proficient in statistical tools for signal processing and/or advanced numerical optimization. He/she will be able to use and develop Python code.	