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THE FRENCH AEROSPACE LAB

PROPOSITION DE STAGE EN COURS D'ETUDES

Référence : **PHY-DEMR-2024-24**
(à rappeler dans toute correspondance)

Lieu : Palaiseau

Département/Dir./Serv. : DEMR/TERA

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DESCRIPTION DU STAGE

Thématique(s) : Imagerie SAR, deep learning, reconstruction d'images

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

Intitulé : Deep learning for corrupted spectrum SAR image inpainting

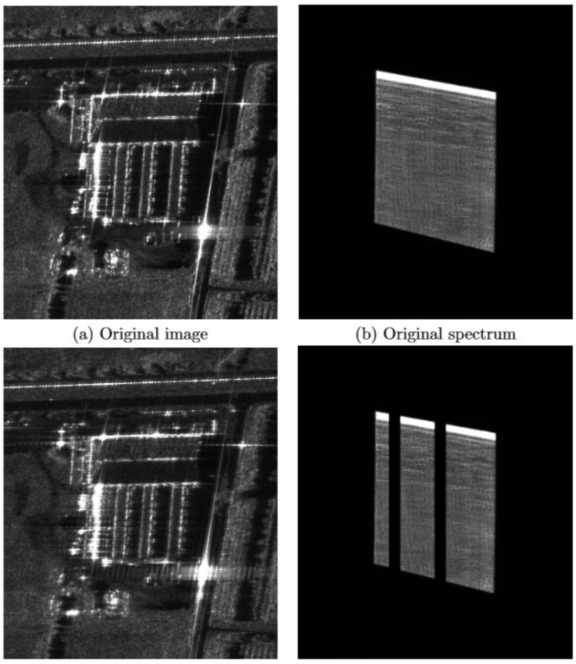
Sujet : In Synthetic Aperture Radar (SAR) systems, electromagnetic pulses are transmitted towards the scene of interest, and their backscattered echoes are processed to form an image. In this context, the impulse response, and hence the resolution, of the SAR image is determined by its spatial frequency support, which is proportional to the transmitted pulse. A contiguous frequency band is often not available to form a SAR image: for instance, due to the presence of other sources emitting within the same frequency range as the SAR. Alternatively, energy transmission may be restricted in certain frequency bands, requiring frequency notches for the transmitted pulses. As a consequence, the spectrum of the resulting SAR image has gaps that produce ringing artifacts which blur and degrade the SAR image.

The blurring due to the notching in the transmitted or received signals can be modeled as a spatial frequency mask with zero gain in the frequency range corresponding to the notches and unity everywhere else. Thus, a naive strategy for image restoration would be to deconvolve this notching mask in the spectral frequency domain. However, this would amplify the noise in the image because of the frequency response nulls in the filter. Some assumptions about the underlying scene are need it to solve this ill-posed problem.

In classical SAR image restoration, sparsity constraints had enabled increased resolvability of point scatters yielding significant sidelobe reduction. Sparse regularizers properly describe point scatterers but they do not generally account well for all the geometrical structures potentially found in the background of a SAR image. Choosing a suitable prior to constrain the underlying reflectivity field needs for expert's knowledge of the scene.

The objective of this internship is to investigate learning-based techniques that leverage data-driven regularizers for SAR image restoration. The proposed framework will be designed to overcome the imperfections in the emitted signal spectrum. We will consider the case of notched spectra. This transformation on the original scene spectrum yield a degradation of the SAR image. The purpose of the proposed methods is to inverse this transformation and recover the original spectrum, yielding enhanced SAR image reconstruction.

This work will be conducted using real airborne data, already available, acquired by ONERA's platform SETHI.



(a) Original image (b) Original spectrum

(c) Frequency notched image (d) Frequency notched spectrum

Figure 1: Example of a frequency spectrum and the resulting ringing artifacts.

[1] Kragh, T. J., & Kharbouch, A. A. (2006). Monotonic iterative algorithms for SAR image restoration. In 2006 International Conference on Image Processing (ICIP) pp. 645-648. IEEE.
[2] Nguyen, L. H., Tran, T., & Do, T. (2014). Sparse models and sparse recovery for ultra-wideband SAR applications. IEEE Transactions on Aerospace and Electronic Systems, 50(2), 940-958.
[3] Nguyen, L. H., & Tran, T. D. (2019, November). Deep CNN for extraction of sidelobes from SAR imagery in spectrally restricted environment. In 2019 53rd Asilomar Conference on Signals, Systems, and Computers (pp. 2044-2047). IEEE.
[2] Gregor, K., & LeCun, Y. (2010, June). Learning fast approximations of sparse coding. In Proceedings of the 27th international conference on international conference on machine learning (pp. 399-406).
[3] Mardani, M., Sun, Q., Papyan, V., Vasanawala, S., Pauly, J., & Donoho, D. (2019). Degrees of freedom analysis of unrolled neural networks. arXiv preprint arXiv:1906.03742.
[4] Li, Y., Tofighi, M., Monga, V., & Eldar, Y. C. (2019, May). An algorithm unrolling approach to deep image deblurring. In ICASSP 2019-2019 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 7675-7679). IEEE.
[5] Venkatakrishnan, S. V., Bouman, C. A., & Wohlberg, B. (2013, December). Plug-and-play priors for model based reconstruction. In 2013 IEEE Global Conference on Signal and Information Processing (pp. 945-948). IEEE.

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

Méthodes à mettre en oeuvre :

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

Possibilité de prolongation en thèse : **Non**

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

Période souhaitée : À partir de février 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	