Self-Supervised Learning for SAR Tomography
PhD Topic - 2024

Keywords: SAR imaging, tomography, statistical learning, plug-and-play ADMM.

1 Context

SAR Tomography (TomoSAR) aims to obtain an image with 3D resolution capabilities from multiple radar measurements. TomoSAR is capable of generating 3-D representations of various environments, such as forests, ice areas, and urban landscapes. This method is becoming popular for Earth monitoring, as the availability of SAR data is constantly increasing (TerraSAR-X, sentinel missions, UAVSAR, etc.). In particular, as spatial resolution and time-series capabilities improve, TomoSAR finds applications in urban analysis enabling the visualization of 3-D for large ground areas, benefiting town planning, city management, and crisis monitoring. Typically, the imaging problem is formulated as

$$\min_{x \in \mathcal{X}} \quad f(x) + h(\varphi(x))$$

where x is the reflectivity of the scene (lying in the constrained set $\mathcal{X}$), f is the data fitting term, and, h is a penalty that promotes a sparse structure in a basis of representation $\varphi(x)$ (e.g., the Fourier transform). The problem is usually not directly tractable, and practitioners can resort to variable splitting and ADMM algorithms to approach its solution. In this context, plug-and-play ADMM techniques aim at replacing the denoising step of the ADMM algorithm with a pre-trained neural network, thus addressing a problem with an implicit regularization function h. In the context of SAR data, the main challenge is to learn such implicit regularization directly from the data, as the ground truth is rarely available.

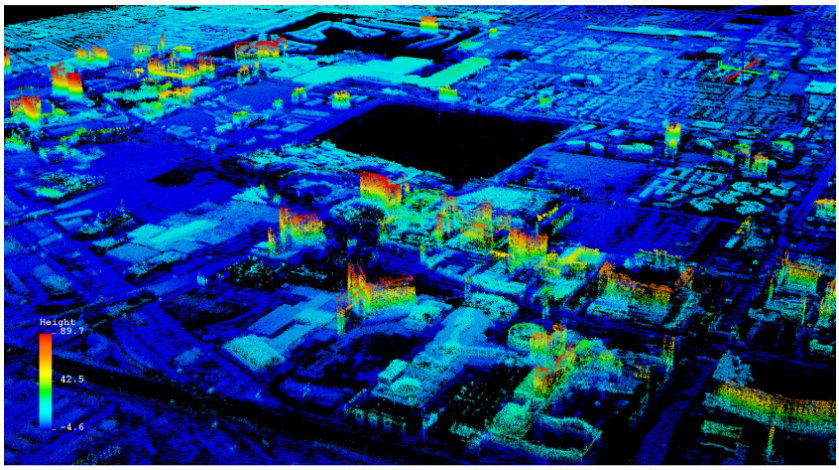

Figure 1: TomoSAR points cloud of downtown Las Vegas from [6]

2 Objectives

In this thesis, we aim to address the aforementioned issue and explore leads from self-supervised methodologies. The plan of work is the following : train an architecture to mimic the output of the denoising step of a TomoSAR algorithm [5, 4, 6], hence validating that state-of-the-art performance can be achieved with an implicit regularization. Then we will explore recent self-supervised methodologies [2, 1, 3] in order to learn meaningful implicit regularization functions directly from the data.

3 Profil

Candidates should be pursuing a Master in computer science or applied mathematics. The candidates should have a strong interest in scientific research and a theoretical grounding in optimization or machine learning. Notions in signal processing are a plus for this subject. Knowledge of Python programming is preferable, although it may be possible for a candidate with knowledge of another programming language to learn Python during the thesis. A first experience with a deep learning library such as TensorFlow or PyTorch is welcome.

4 Organization

This thesis is expected to start in 2024. The thesis will take place at the Center for Studies and Research in Computer Science and Communication (CEDRIC) of the *Conservatoire National des Arts et Métiers* (CNAM) in the center of Paris. The CEDRIC is a laboratory founded in 1988, bringing together over 80 teacher-researchers in 7 thematic teams. Its activities cover a wide range of research fields, from multimedia data mining and radio communications to statistical learning, interactive media, and optimization. The supervision team will consist of Clément Rambour and Arnaud Breloy from the Complex data, machine learning and representations team.

5 Application

Send a CV and M1/M2 grades at: `clement.rambour@cnam.fr` and `arnaud.breloy@cnam.fr`

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