**Position:** PhD Thesis (CIFRE)
**Institution:** Mines ParisTech
**Dates:** Open until filled

**TITLE:**

Deep Learning on Radar High-Resolution Range Profile: GANs and XAI

**CONTEXT**

High-resolution range profiles (HRRPs) provide one-dimensional echo information of a target. This information reflects the energy distribution of the target in each range cell along the radar line of sight. The range cells of the target provide characteristic geometrical information of the target structure. This information is mainly used for recognition.

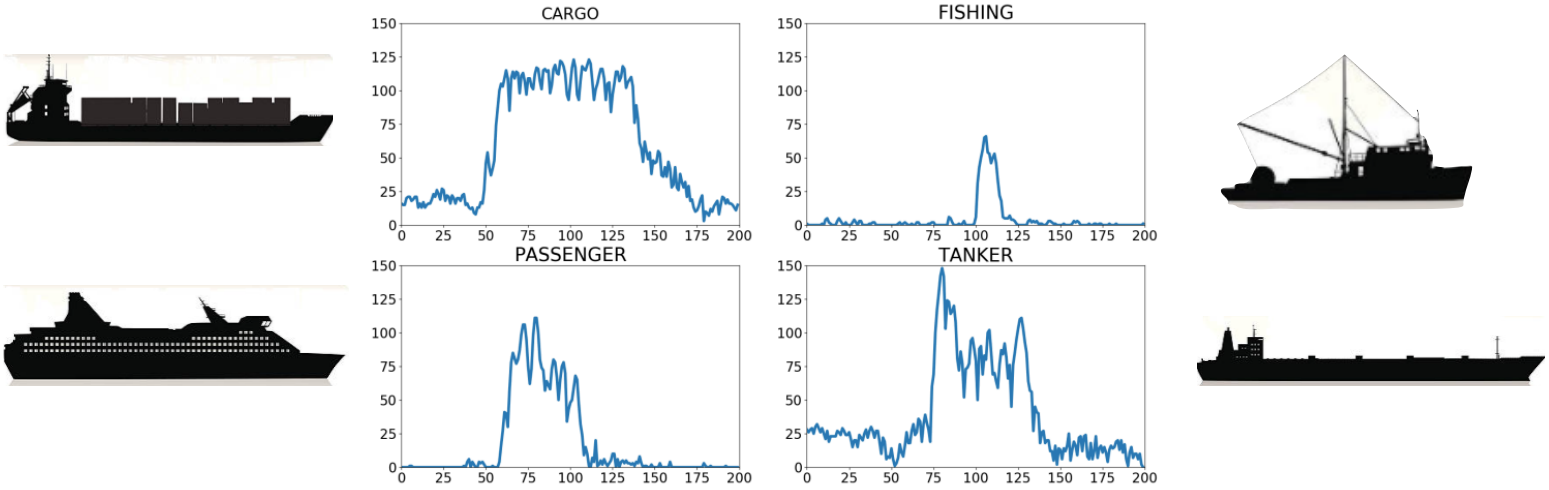


Fig 1. Examples of the high-resolution range profile (HRRP) and their corresponding 2D shape.

In this thesis we would study the use of (Generative Adversarial Networks) GANs [3-6] to generate transformation between the different data representations, HRRP, 2D shapes, colour images or even 3D descriptors. Additionally, in the context of Explainable Artificial Intelligence (XAI), the interpretation of the models will motivate the development of new architectures, mainly using attention mechanisms[1], morphological methods [2] and others.

## SCIENTIFIC COLLABORATION

This thesis is part of scientific collaboration between Thales and Mines-ParisTech / PSL Research University. The industrial part is the Business Unit Advanced Radar Concept based on Limours (France), whose mission is to define and evaluate innovative radar solutions that will be incorporated into the Thales product catalog in future years. Limours site brings together more than 900 employees working from the design of solutions to acceptance with customers, including the production of surface radars. This site has undergone major changes in recent years and continues to adapt to customer needs in terms of sky surveillance and sensitive areas.

## WHO ARE YOU ?

Graduate from an Engineering school or university (Bac + 5) with a master in artificial intelligence or/and data science or/and computer science or/and mathematics.
You benefit from a pronounced taste for applied research which allows you to easily understand upstream and innovative subjects.
Knowledge of signal and data processing are major assets for this position as well as an aptitude to work simulation and practical scenarios.
Autonomy, curiosity and proactivity will be valuable assets.
The following will be considered as a plus:
- Knowledge of Python and previous relevant internship/work experience.
- Languages: Fluent French and English.

## THESIS DESCRIPTION

In this context, your main missions as part of this CIFRE thesis will be:

1) Study the state-of-the-art on generative adversarial networks (GANs) [3-6]
2) Study the models GANs for generating high resolution distance profiles of targets [7]
3) Generate the hybrid data starting from the databases of actual radar measurements available [8].
4) Define, apply and validate 3D reconstruction techniques from a series of measurements on simulated and real data.
5) Design of new architectures for GANs based on Attention Mechanisms [1] and Morphological filters[2].
6) Write scientific papers to illustrate the goodness of thesis propositions. The drafting of patents can also be considered during the development of the thesis.

7) Participe in Machine Learning/Deep Learning/ Signal Processing/ Radar International Conference to share thesis findings with the international scientific community.

Most of this thesis will be carried out in Ile de France between Limours and Paris.

**SUPERVISION**

The PhD student will be under the supervision of Santiago VELASCO-FORERO (https://scholar.google.com/citations?user=l3-z3GMAAAAJ). He/she will be fully integrated in the CMM (https://www.cmm.minesparis.psl.eu/) team of the Mines ParisTech as well as in the Business Unit Advanced Radar Concept of Thales.

**TO APPLY**

**Please send your full CV, motivation letter, and contact information to**
santiago.velasco@mines-paristech.fr

**BIBLIOGRAPHY**

[1] Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A. N., ... & Polosukhin, I. (2017). Attention is all you need. In *Advances in neural information processing systems* (pp. 5998-6008).

[2] S. Velasco-Forero, R. Pagès and J. Angulo, Learnable Empirical Mode Decomposition based on Mathematical Morphology, SIAM Journal on Imaging Sciences, 2022, 15(1), 23–44.

[3] Wan, J., Chen, B., Xu, B., Liu, H., & Jin, L. (2019). Convolutional neural networks for radar HRRP target recognition and rejection. EURASIP Journal on Advances in Signal Processing, 2019 (1), 1-17.

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[6] E. Schonfeld and B. Schiele, A U-Net Based Discriminator for Generative Adversarial Networks, (2020), CVPR

[7] Bauw, M., Velasco-Forero, S., Angulo, J., Adnet, C., & Airiau, O. (2020, September). From unsupervised to semi-supervised anomaly detection methods for HRRP targets. In 2020 IEEE Radar Conference (RadarConf20) (pp. 1-6). IEEE.

[8] Chih-Lung Lin et. al., Radar High-Resolution Range Profile Ship Recognition Using Two-Channel Convolutional Neural Networks Concatenated with Bidirectional Long Short-Term Memory, 2021, Remote Sensing.

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