Internship: *A Contrario* Framework for Reliable Small-Vessel Detection under Sea Clutter in SAR Data

Laboratory: SONDRA, CentraleSupélec ONERA NUS DSO Research Alliance, France & AMIAD.

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Duration: 4 to 6 months, starting from March-April 2026

Location: SONDRA (CentraleSupelec) & AMIAD (Ecole Polytechnique)

Detecting objects or anomalies through satellite imagery is crucial for various defense and security applications, including military intelligence and surveillance. Synthetic Aperture Radar (SAR) stands out as an advanced remote sensing technology essential for earth observation, particularly in maritime surveillance. However, detecting small vessels amidst sea clutter remains a significant challenge due to the unique characteristics of SAR imaging, including speckle noise and bright spots caused by signal coherence, heterogeneities in sea clutter resulting from varying weather conditions, and distorted appearances of ships imaged from different angles.

While numerous studies have focused on ship detection in SAR images, CFAR (Constant False Alarm Rate) detectors remain the most prevalent despite their struggles with complex scenes, particularly under non-Gaussian clutter or varying sea states [1]. Deep learning techniques offer a promising alternative, having significantly advanced object detection by extracting non-linear features from large annotated datasets. However, the scarcity of annotated data for SAR imagery limits supervised learning methods' effectiveness. To address this, unsupervised or weakly supervised learning methods are essential. Note however that strong speckle noise in SAR images poses a significant challenge, as methods effective for optical images require adaptation to work with SAR data.

This internship aims to develop a robust small-object detection method in SAR imagery. The project will involve a comprehensive literature review of SAR image detection [2, 3, 4, 5], unsupervised, and weakly supervised learning, and *a contrario*

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detection. Inspired by previous works based on the *a contrario* framework [6, 7, 1, 8], a weakly supervised pipeline will be proposed where vessels are treated as anomalies with respect to the background. The proposed method will be evaluated and benchmarked against existing techniques to demonstrate its effectiveness. The ultimate goal is to develop an adaptive, data-driven detection system that minimizes false alarms without requiring manually tuned thresholds or hand-crafted features, thereby enhancing the reliability and effectiveness of small-vessel detection in SAR imagery and contributing significantly to maritime surveillance capabilities.

References

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