M2 internship: Anomaly detection schemes in SAR imaging

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M2 internship in the SONDRA laboratory at Centralesupelec and at ONERA
Starting date: between January and April 2021
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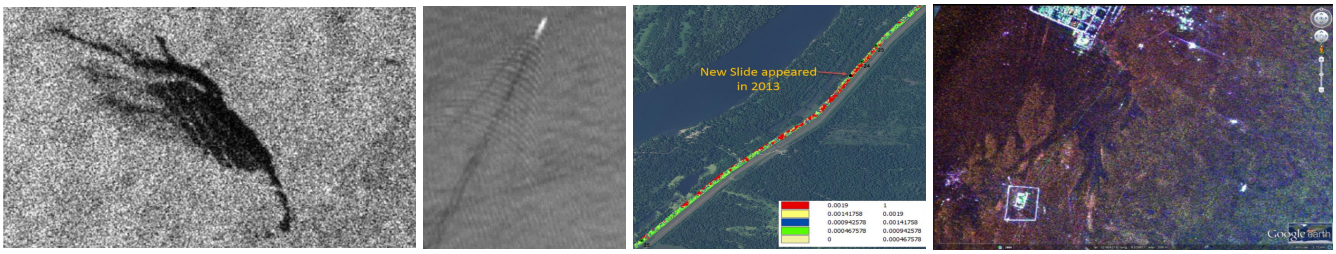
A doctoral thesis can be continued after this internship.

Topic

Keywords: Anomaly Detection, Robust detection, Synthetic Aperture Radar (SAR)

Anomaly detection aims to discover abnormal patterns hidden in multidimensional radar signals and images. This research field is essential in data mining for quickly isolating irregular or suspicious segments in large amounts of the database. Some examples are given below: a) Oil Slick, b) Turbulent ship wake, c) Levee anomaly, d) Archeology. A plethora of anomaly detection schemes has been proposed in the literature [1, 2, 3]. Among them, the unsupervised methods are the most interesting since they are widely applicable and do not require to label the data.



(a) (b) (c) (d)

In this framework, we are focused on statistical detection, distance-based and density-based methods that constitute the main families of anomaly detection methods. The latter already has remarkable success for detecting anomalies in biological data [3, 4], hyperspectral data [5, 6, 7, 8, 9], etc. However, none of them is well adapted for SAR imaging applications since (i) the diversity of SAR images (i.e. the number of channels, frequency bands, etc.) is reduced compared to hyperspectral images rendering the extraction process of features limited. (ii) The noise distribution is generally heavy-tailed, notably for high-resolution SAR images. (iii) The signal to noise ratio is weaker compared to optical images. Therefore, the discrimination between a real anomaly and the noise is more challenging than for RGB images. Note that there is some marginal tentative in the literature [10, 11].

In this thesis project, we propose to design new schemes tackling these issues and limitations. More specifically, the goal of this thesis is to develop efficient and robust methods to extract abnormal ROIs in SAR images. We firstly propose to handle heavy-tailed noise with the family of elliptical distributions [12, 13], which better fit the noise distribution. Secondly, statistical and pixel-wise distances will be improved by using a natural Riemannian metric rather than the standard Euclidean metric for better detecting abnormal ROIs. Under the availability of labeled data, metric learning approaches [14] are also under the scope. Additionally, whitening and denoising preprocessing steps are going under investigation to mitigate noise power. Finally, the developed methods will

be applied for detecting anomalies in SAR images obtained from SETHI, Sentinel-1, UAVSAR and TerraSAR-X missions. Notably, these proposed methods could be used for monitoring intrusion in vegetation zones.

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