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UNLOCKING ONBOARD SAR PROCESSING: FOCUSING AND SHIP DETECTION ON SENTINEL-1 IW DATA

Abstract

Unlocking real-time space-based surveillance and monitoring intelligence is an emerging need in the Earth Observation (EO) domain. Ship detection holds a significant place in port management, as it relates to ship traffic, maritime rescue operations, illegal vessels identification, cargo transportation and national defense. Currently, the use of optical images for real-time monitoring is prevalent due to their ease of interpretation and processing.

Synthetic Aperture Radar (SAR) systems can provide high-quality images at a sub-meter resolution regardless of lighting and weather. However, SAR data acquired onboard the spacecraft consists of raw signals which are nearly uninterpretable to the human eye. To produce a recognizable image and to enable further data processing, the so-called focusing procedure must be performed. This is a demanding computational task currently performed on the ground in dedicated processing facilities, hindering real-time surveillance capabilities.

This work demonstrates the possibility of enabling onboard processing of SAR data in real-time through the adoption of an innovative focusing technology coupled with object detection, using limited computational resources. Our approach aims to provide a coarse focused product onboard to unlock real-time monitoring capabilities, complementing the ground-based detailed focusing algorithms.

The focusing algorithm transforms the Level-0 raw signal into Level-1 Single-Look-Complex (SLC) data. It consists of a two-layers hybrid architecture: a traditional Fast-Fourier Transform (FFT) algorithm for range processing and a Deep Neural Network (DNN), trained to solve the azimuth processing task, which provides scalability and modularity benefits. After focusing, an object detection network is trained to detect the presence of ships in the SLC data.

The architecture is trained and tested on Sentinel-1 Interferometric Wide (IW) data. Starting from raw products, a dataset consisting of matched range compressed and focused data is created to train and validate the focusing network, whose performance is evaluated using the Structural Similarity Index Measure (SSIM), the Peak SideLobe Ratio (PSLR) and the achieved spatial resolution. A set of SLC data, labeled with bounding boxes around ships, is used to train the object detection network, whose outputs are evaluated using the Intersection over Union (IoU) score and compared with the ones obtained on SLC data derived with a traditional focusing algorithm. Both the focusing as well as the ship detection networks are optimized and deployed on different embedded devices, including, up to now, Intel Myriad,

Jetson Nano, and Jetson Xavier, to demonstrate the feasibility of running the overall pipeline onboard the future generations of SAR missions.