SEMUS - An Open-Source RF-Level SAR Emulator for Interference Modelling in Spaceborne Applications

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Introduction

Spaceborne Synthetic Aperture Radar (SAR) has become a valuable technology for Earth monitoring. Due to the increasing ubiquity of wireless communications and the ever-increasing utilization of the radio spectrum, radio frequency interference (RFI) is expected to become a major issue impacting spaceborne SAR technologies in the near future. To analyze and solve the interference problem, a simulator/emulator is required at the RF level.

Aims

- Introduction of an ***integrated framework*** for developing a real spaceborne SAR emulator called **SEMUS** (**S**AR **EMU**lator for **S**paceborne applications).
- Development of an end-to-end ***open-source emulator*** code to emulate a spaceborne SAR satellite with all required functions to generate the SAR raw PHD (Level-0) up to generating the focused SAR image (Level-1). Develop a robust mitigation algorithm to reconstruct a clear SAR image.
- Validation of the ability to inject an ***arbitrary RF Interference waveform(s)*** into the RF level SAR raw PHD (Level-0) and focalization of the contaminated Level-1 image.

Methodology

SEMUS is developed to emulate a real spaceborne SAR scenario operating at any arbitrary frequency band and any geographic location.

The range-Doppler Algorithm (RDA) is utilized to process the Level-0 data and generate Level-1 image.

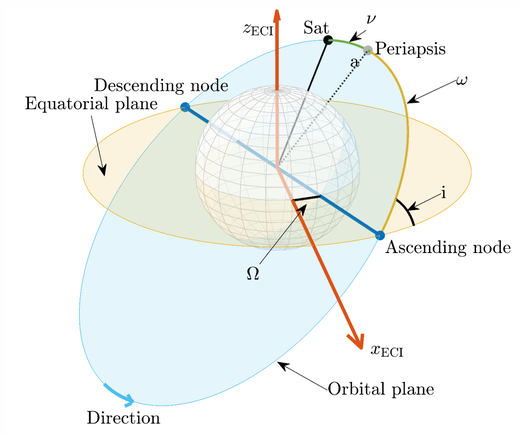

Figure 1: The satellite orbital parameters for the orbital propagator in the SAR Geometric model.

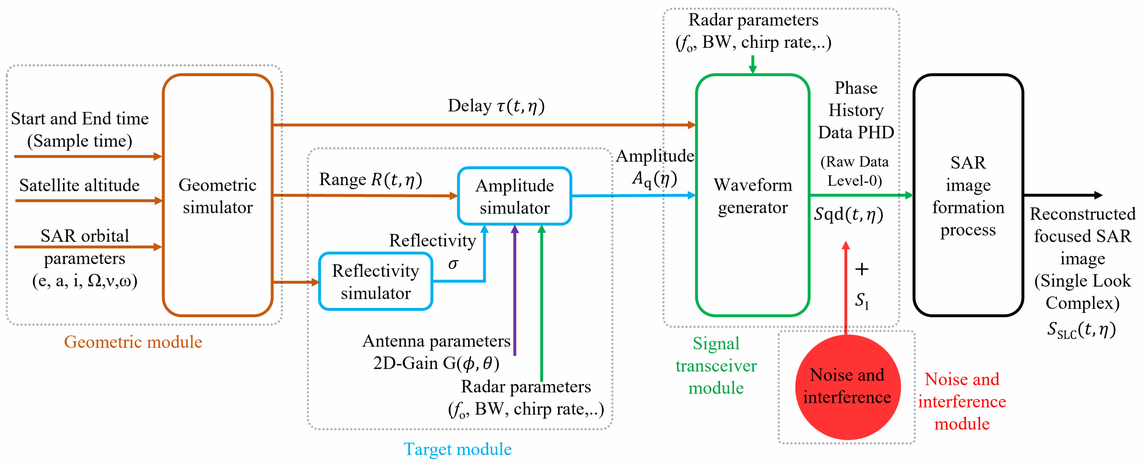

Figure 2: The detailed architecture of the proposed real spaceborne SAR emulator, SEMUS, based on (a) geometrical module, (b) target module, (c) noise and interference module, and finally (e) signal transceiver module.

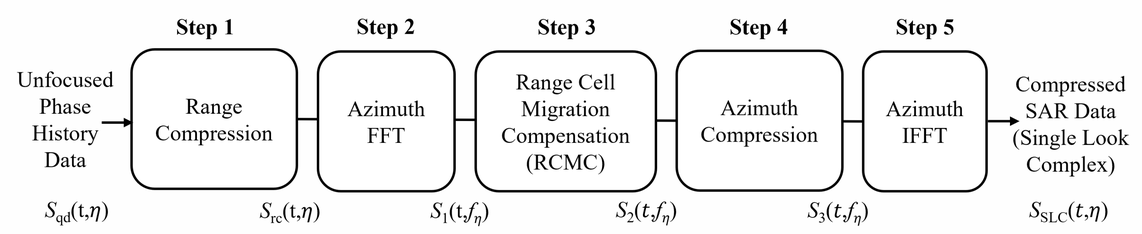

Figure 3: The range Doppler algorithm (RDA) block diagram.

Implementation and Results

- An example of a spaceborne SAR operating in **L-band** is created.

A **strip-map** collection mode is utilized to image one strip in a **low squint case** for simplicity to capture the illuminated swath for an acquisition period of 1s above **Melbourne**, Australia.

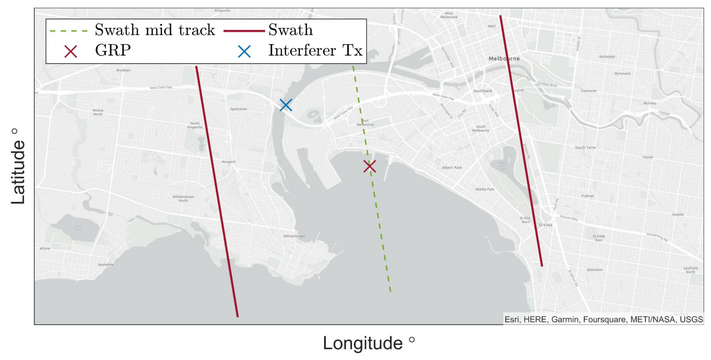

Figure 4: Swath, mid swath, and interferer's location.

- From visualizing the contaminated SAR image, the image has **reduced** quality with distortion at certain pulses due to the interference.

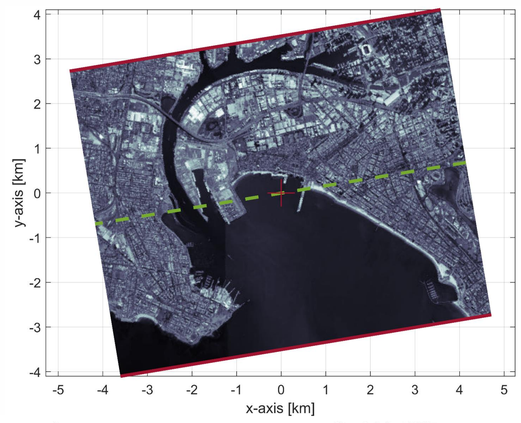

Figure 5: The satellite optical reflectivity map indicating the GRP, mid-swath line, and the swath edges..

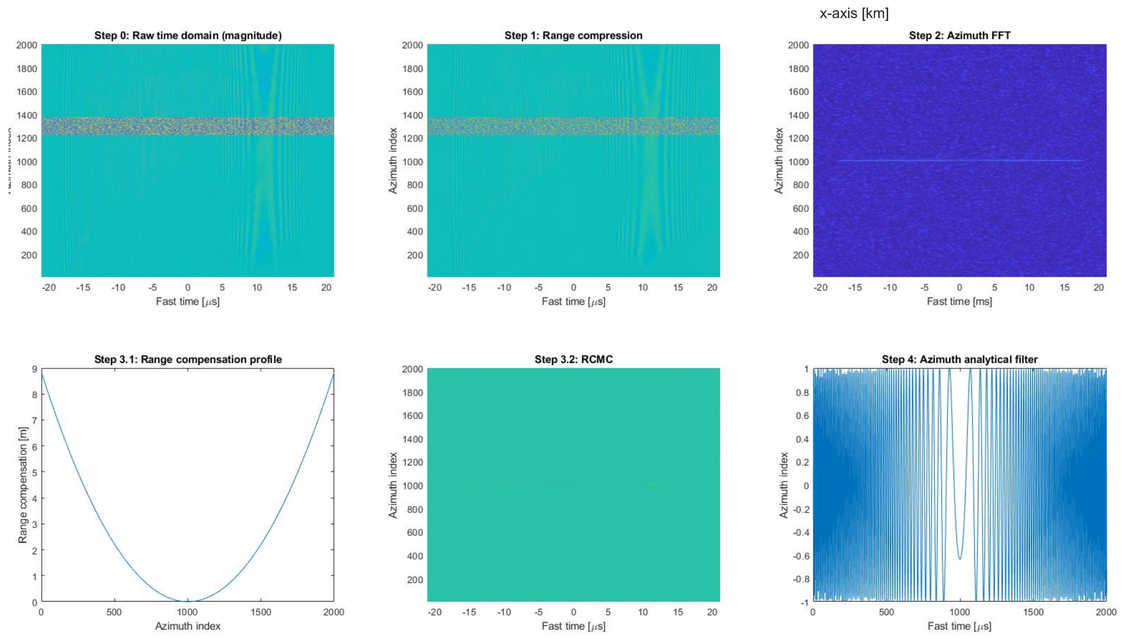

Figure 6: The signal processing of Level-0 SAR data contaminated with interference.

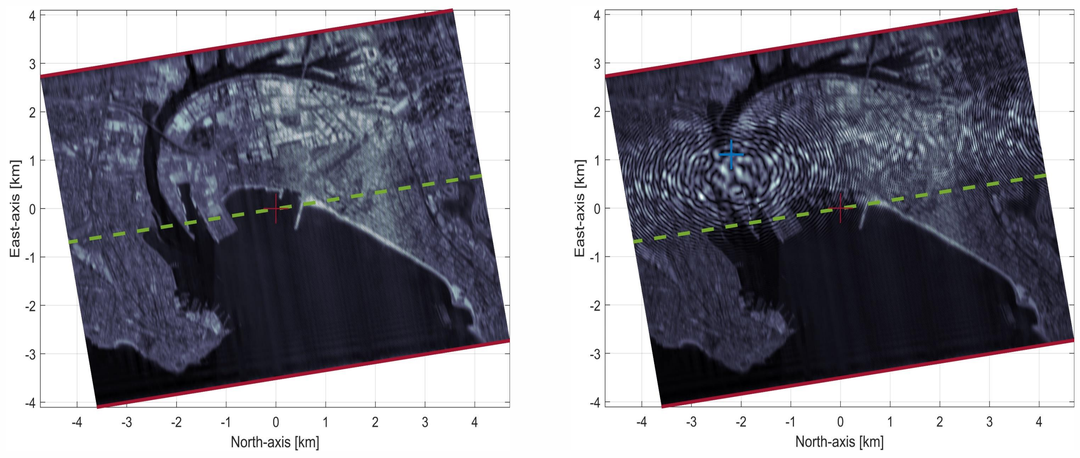

Figure 7: On the left the focused Level-1 SAR image, free of interference. On the right the focused Level-1 SAR image contaminated with interference.

References

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[2] I. G. Cumming and F. H. Wong, "Digital processing of synthetic aperture radar data," Artech house, vol. 1, no. 3, pp. 108–110, 2005.

[3] E. D. Jansing, Introduction to Synthetic Aperture Radar: Concepts and Practice. McGraw-Hill Education, 2021.

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