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TECHNOLOGY DEVELOPMENTS AND ACTIVITIES AT THE EUROPEAN SPACE AGENCY FOR COGNITIVE SYNTHETIC APERTURE RADAR PAYLOADS

Abstract

This paper offers an insight into the recent advancements in artificial intelligence applied to synthetic aperture radar (SAR) technology, with a focus on developments supported by the European Space Agency (ESA). The discussion encompasses the advancements made in the field of artificial intelligence applied to SAR data, specifically emphasizing on-board digital processing functions for next-generation SAR payloads.

Previous SAR missions, like Sentinel-1, incorporate sensing channels in their payload for calibration, characterization, and monitoring of the spacecraft payload. The availability of powerful on-board processing devices and increase on-board memory is enabling new possibility to develop cognitive microwave instruments and in particular radar and Synthetic Aperture Radar, which can trigger an autonomous action without a specific commanding from ground. Cognitive radar is defined as a system that incorporates adaptive and intelligent signal processing. In satellites examples are to adapt to operational mode or instrument configuration based on the scenario monitored, adjusting waveform parameters such as frequency, pulse width, pulse repetition interval, transmitted power, up to the transmit and receive antenna patterns or pointing of the satellite platform.

The paper highlights the latest technology breakthroughs and on-going developments related to cognitive radar applications for next-generation payloads with on-board processing capabilities, including advancements in adaptive compression techniques, object detection on raw radar data and other techniques enabled by machine learning. Furthermore, it delves into ongoing research and development activities in the realm of digital signal processing, digital beamforming, and signal processing techniques geared towards more flexible and adaptive SAR payloads. These elements are considered building blocks for a cognitive system and its adoption in future missions.

In addition to providing an overview of the current state of technology, the paper explores the potential future applications of artificial intelligence in SAR missions. The incorporation of artificial intelligence in synthetic aperture radar systems holds promise for enhancing SAR performance metrics and reducing latency to enable innovative downstream applications in the realm of Earth observation and remote sensing.