GENERATION OF RAPID CIVIL ALERTS BY SATELLITE ON-BOARD SAR PROCESSING

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ABSTRACT

Synthetic Aperture Radar (SAR) satellites provide valuable information about the maritime situation since several decades. With a growing number of Earth Observation satellites the amount of acquisitions available in a certain area per time drastically increases. However, users need fast access to the retrieved information to fully benefit from this development. For maritime applications, this is especially important as acquisitions over the oceans may not only have a longer than average delay until transfer to a ground station, but also the retrieved information – ship positions, wind speeds and wave height – is very time sensitive and becomes outdated within minutes.

Bringing the image generation, processing and delivery onto a satellite can save the time between acquisition and raw data downlink to the ground station and allow direct product delivery to users equipped with appropriate receivers. A delivery delay of just 3-4 minutes after the acquisition will enable these products to become a de-facto-standard for maritime operations, enhancing ship safety and security.

SAR processing is one component of a larger prototype system being developed in the H2020 EO-ALERT project, also comprising an optical data chain, data compression/encryption, and delivery (Tonetti et al., 2019). The system employs multiple boards with Zynq Ultrascale+ Multi-processor-System-on-Chip (MPSoC) combining FPGAs and ARM CPUs, which allows performing on-board processing despite the power and space constraints on a satellite. A tailored workflow and adapted processing algorithms from raw data via geo-referenced scene (L1) to derived products (L2) ensure that the requirements for SAR latency and product quality are met.

For L1 processing , the quad-core ARM Cortex-A53 processing system is in charge of computing the necessary focusing, calibration, and annotation parameters based on attitude, orbit, and instrument settings on input, while the programmable logic performs all SAR signal processing such as raw data correction, pulse compression, FFTs, pixel-wise complex filter multiplications, detection, and multi-looking. SAR focusing follows the monochromatic omega-k algorithm (Bamler 1992). This way, a matrix of 8192 pulses containing up to 32768 raw data samples is focused in less than 5 seconds.

The L2 products generated within the EO-ALERT project either provide ship detection or extreme weather detection information. For ship detection, the initial Constant False Alarm Rate (CFAR) algorithm (Tings et al., 2015) was ported to the programmable logic, while further processing steps like land masking and filtering are executed in the ARM processor. In case of the extreme weather algorithm (Pleskachevsky et al., 2016) the computational effort is just low enough to perform all processing steps in the ARM within the latency constraints.

While certain compromises had to be made w.r.t image quality compared to processing in a ground based facility, these result only in minimal effects on the final application products, which are still of high quality and provide valuable low-latency information to the end user.

Keywords— Synthetic Aperture Radar, FPGA, onboard processing, ship detection, sea state detection

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