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Innovative Multiple-Input Multiple-Output Synthetic Aperture Radar Concepts for Remote Sensing and Disaster Management

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1. Extended Abstract

Synthetic Aperture Radar (SAR) has become an important sensor for Earth observation. Manifold applications ranging from climate change research, over change detection and 4-D mapping up to security-related applications are now common. Apart from airborne SAR systems, there exists a large number of spaceborne SAR missions, like COSMO-SkyMed, TerraSAR-X/TanDEM-X, Radarsat-2 or Sentinel-1 [1], [2]. However, the steady demand for observations with higher resolutions, wider coverage, increased flexibility and shorter retake intervals, stretches the state-of-the-art SAR sensors to their maximum limits.

A consideration of various studies [3], [4] shows that SAR sensors with Digital Beam-Forming (DBF) capabilities have promising properties to overcome these limitations. The overall idea is to tailor the radiation characteristics of an antenna array within the digital part of the hardware and to apply thereby a spatial filtering. Since the filtering is done in the digital part, the raw data are still available and no information is lost. This allows for a great flexibility and various algorithms for signal processing and antenna beam-forming can be applied.

In addition, if multiple receivers along with multiple transmitters are used within the same radio channel, the Multiple-Input Multiple-Output (MIMO) technique offers a new field of operation in SAR. An example of such an advanced imaging mode are simultaneous fully polarimetric acquisitions [5]. For an improved suppression of cross-correlation interferences caused by multiple transmitted waveforms, it has been found that a couple of strict requirements for the waveform design itself and also for the digital antenna have to be fulfilled. Apart from the orthogonality, the transmitted waveforms need for a certain structure to provide a high resolution, a high peak to side-lobe ratio (PSLR) and integrated side-lobe ratio (ISLR). This can be achieved by making use of a so-called short-term shift orthogonality, which provides perfect orthogonality between the waveforms only for short shifts in time and frequency. The cross-correlation interferences (ambiguities) for greater shifts can be suppressed by an innovative DBF technique using frequency-dispersive and time-variant antenna beams.

2. References

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