Time-Domain Computer Simulation of Synthetic Aperture Radar (SAR) Image for Rough Surface

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In this paper, we present the image processing scheme of the synthetic aperture radar (SAR) based on the integration of backscattered coeffcient in time domain.

Over the last 5 decades, the synthetic aperture radar (SAR) has been developed as a unique imaging instrument with high resolution, day/night and all-weather operation capabilities. As a result, the SAR has been found a wide area of applications, including target detection, continuously observing dynamic phenomena such as seismic movement, ocean current, sea ice motion and classification of vegetation. In comparison with the spectral analysis (FFT) and frequency domain convolution, the time-domain (TD) analysis has been introduced and become the simplest and most accurate algorithm for SAR signal processing. As the time-modulated wave transmission and receiving by SAR, the TD algorithm directly process the signal echo by using the matched filters without approximation. However, the TD algorithm is also the most computational consuming, thus it can only be applied to size-limited SAR data. As the requirement of large-size and high-resolution SAR imagery, the investigation and development of a novel time-domain scheme is conducted with respect to the fast computational algorithm to implement the time-domain analysis. With the far field approximation and by considering the scatterers as non-dispersive media, the range and cross-range parameters are decoupled and the integral ends up with a closed form function. As a result, the SAR image simulation based on the analytical process largely increases the computational effciency and makes it possible to process large size of images.

In the simulation, geometrical optics and physical optics approximation are used to model rough surface scattering of the terrain specified by the digital elevation map (DEM). Scattering coeffcient calculated are assumed to be frequency independent. It is shown in this paper that the integral process of the SAR image in time domain can be derived into frequency domain to yield the integral of the scattered field over the bandwidth. Therefore dispersive scatterers can also be modeled by including an additional integration over the bandwidth.