Parallel Matlab Computation for STAP Clutter Scattering Function Estimation and Moving Target Estimation*

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Abstract

Conventional moving target estimation in STAP radar applications is based, in part, on adaptive clutter scattering function estimation techniques. These techniques classically rely on radar return data from adjacent range gates to estimate the clutter scattering function for the range gate of interest. Here, we are interested in using geographical information systems in conjunction with accurate platform positioning information as the basis for the clutter scattering function estimation. The goal is to improve the effectiveness of moving target estimation techniques by providing additional information to the decision-making process.

Our problem formulation is consistent with the model for space-time adaptive processing (STAP) presented in [1]. A pulse-Doppler radar platform with multiple transmit/receive elements emits several pulse train along an arbitrary flight path, such as a circle around the region of interest. Each pulse train is assumed to be perfectly coherent within one coherent processing interval (CPI), but different pulse trains are assumed noncoherent with respect to one another. The ground region is subdivided into pixels, or ground patches. The range and angle of each ground patch with respect to the platform for each transmitted pulse is assumed known, along with the illumination pattern. The received data for one pulse is modeled as the sum of the returns from all of the ground patches, each modulated by the transmit illumination. The data from all pulses or viewpoints is modeled in this way. Maximum-likelihood methodology is used to estimate the unknown scattering function [2] and a variant of the Adaptive Matched Filter [3] is used for moving target estimation.

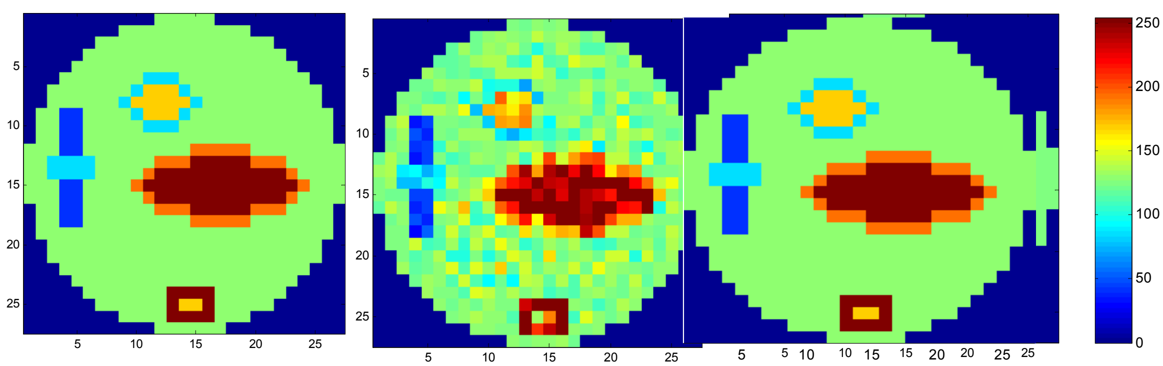

Figure 1: Artificial scattering function example. True scattering function, estimated scattering function, and estimated with land-use aggregation.

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Figure 1 illustrates the scattering function estimation. This is an artificially low-dimensional simulation in which there are 550 ground patches, each associated with one of 9 different land-use values. The land-use value determines the clutter scattering function in each ground patch.
In the data collection scenario the radar platform moves in a circular flight path around the region of interest, as illustrated in Figure 2. The left panel of Figure 1 shows the true scattering function, the middle panel shows the estimated scattering function when the land use is not assumed known, and the right panel shows the estimated scattering function when pixels with the same land-use are assumed to have the same scattering function value (we call this land-use aggregration).

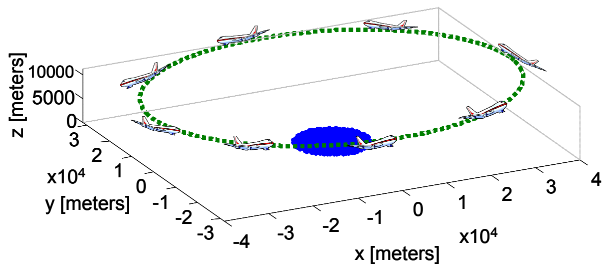

Figure 2: Simulated flight pattern for artificial scattering function example

An important question that arises is the assessment of the computational requirements associated with this application as the data set is scaled up to realistic sizes. To investigate this issue, a 15 km radius region centered on the Lake of the Ozarks in central Missouri is used as a full data set test case. With a pixel (ground patch) dimension of approximately 30 m, the region of interest comprises about 200,000 pixels. Figure 3 shows the illumination pattern on the ground for the full data set from a pair of looks. The digital terrain elevation map comes from a publicly-available website operated by the U.S. Geological Survey [4].

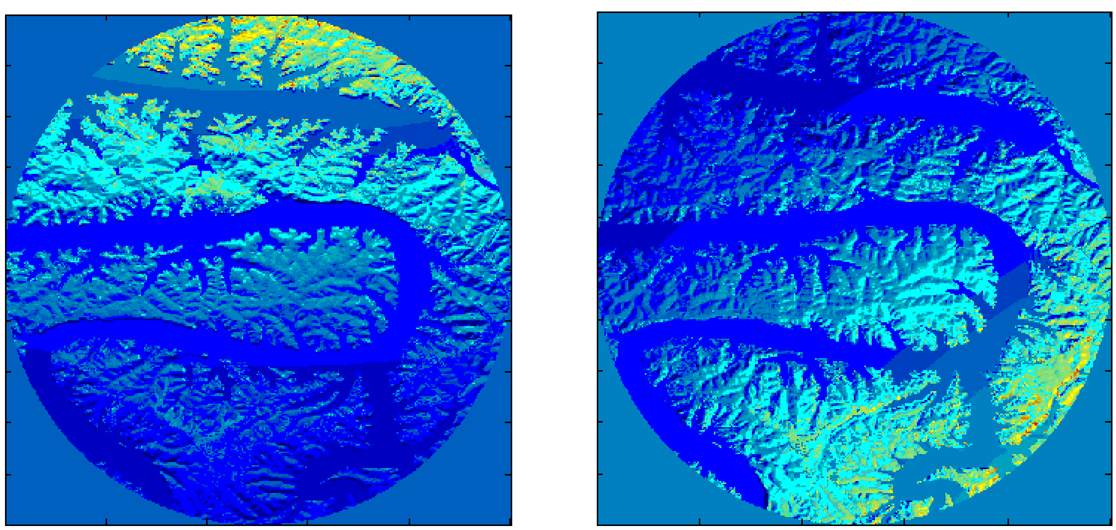

Figure 3: Illumination of full data set from different looks.

Our current activities include the execution of clutter scattering function estimation and moving target estimation on the full dataset illustrated above. The scattering function is based on 21 classes of land cover provided by the geographic information system. Given the large memory requirements for each look (greater than 250 MB/look); the computations are being executed in parallel (using MatlabMPI [5]) across 9 processors in a master-slave arrangement. The master processor is responsible for overall coordination of the computations, and the 8 slave processors are each responsible for an individual look. We will present quantitative performance measurements on these parallel computations, including parallel efficiency as well as quality of results on the clutter scattering function and moving target estimates.

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