A Parallelized Approach for SAR Polarimetric Computations of Entropy/Alpha Angles

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Polarimetry has become a widespread and assessed technique in the framework of Synthetic Aperture Radar (SAR) due to the interest in many applications, as, for example, agriculture monitoring, sea ice classification and characterization, sea oil slick observation and target detection beneath foliage [1].

In SAR polarimetry, the stochastic scattering characteristics of the natural scenes are described by second order statistics, more specifically, the covariance matrix obtained by the outer product of the scattering vector. Techniques using the covariance matrix for the interpretation of polarimetric signatures have been subject of considerable research. In 1996, Cloude and Pottier [2] proposed to describe the polarimetric characteristics of stochastic objects in terms of a set of parameters obtained by the spectral decomposition of the covariance matrix. Remarkably, the two parameters, namely, entropy and alpha angle account for the purity and type of the scattering mechanisms, respectively. Such an approach has asserted itself as a major standard for many polarimetric SAR applications.

From the computational point of view, the evaluation of the covariance matrix amounts at a moving average filter while the Cloude and Pottier decomposition essentially consists of a pixelwise calculation of eigenvalues and eigenvectors of 3x3 matrices. Although the calculation scheme appears to be simple and set up using library (e.g., Python, IDL) routines, the computation can be heavy for large SAR images, especially for those released by the recently operating sensors.

In this work, we introduce a computational approach based on parallel computing on Graphics Processing Units (GPUs) using the CUDA language [3] for the evaluation of the Cloude and Pottier decomposition. The calculation of the covariance matrix is performed by an optimized approach massively using shared memory for the implementation of the moving average. To avoid the use of libraries within CUDA kernels, the computation of eigenvalues and eigenvectors of the covariance matrix exploits a direct analytical approach using the hermitian property of the covariance matrix itself, as in [4].

Numerical results show the benefits of the parallel implementation. In particular, speedups of more than 40 have been observed, for a fixed accuracy, when comparing the parallel implementation to a fully sequential, Python version.

References

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