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GPU-Based Back-Projection of Synthetic Aperture Radar (SAR) Data onto 3D Reference Voxels

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Abstract : Processing SAR data usually requires constraints in extent in the Fourier domain as well as approximations and interpolations onto a planar surface to form an exploitable image. This results in a potential loss of data requires several interpolative techniques, and restricts visualization to two-dimensional plane imagery. The data can be interpolated into a ground plane projection, with or without terrain as a component, all to better view SAR data in an image domain comparable to what a human would view, to ease interpretation. An alternate but computationally heavy method to make use of more of the data is the basis of this research. Pre-processing of the SAR data is completed first (matched-filtering, motion compensation, etc.), the data is then range compressed, and lastly, the contribution from each pulse is determined for each specific point in space by searching the time history data for the reflectivity values for each pulse summed over the entire collection. This results in a per-3D-point reflectivity using the entire collection domain. New advances in GPU processing have finally allowed this rapid projection of acquired SAR data onto any desired reference surface (called backprojection). Mathematically, the computations are fast and easy to implement, despite limitations in SAR phase history data size and 3D-point cloud size. Backprojection processing algorithms are embarrassingly parallel since each 3D point in the scene has the same reflectivity calculation applied for all pulses, independent of all other 3D points and pulse data under consideration. Therefore, given the simplicity of the single backprojection calculation, the work can be spread across thousands of GPU threads allowing for accurate reflectivity representation of a scene. Furthermore, because reflectivity values are associated with individual three-dimensional points, a plane is no longer the sole permissible mapping base; a digital elevation model or even a cloud of points (collected from any sensor capable of measuring ground topography) can be used as a basis for the backprojection technique. This technique minimizes any interpolations and modifications of the raw data, maintaining maximum data integrity. This innovative processing will allow for SAR data to be rapidly brought into a common reference frame for immediate exploitation and data fusion with other three-dimensional data and representations.

Keywords : backprojection, data fusion, exploitation, three-dimensional, visualization
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