# ISAR Imaging of Space Objects via Compressed Sensing

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High resolution SAR (Synthetic Aperture Radar) and ISAR (Inverse Synthetic Aperture Radar) play important roles in military applications such as target identification, recognition, and classification. Especially ISAR has been proven to be a powerful signal processing tool for imaging moving targets usually on the 2D (two dimensional) down-range cross-range plane[1]. Higher bandwidth and angular width can offer better resolution in range direction and cross-range direction respectively. In real-world practices, the bandwidth and view angular width are limited. For ISAR imagery, the scattering field of the target is usually composed of only a limited number of strong scattering centers, representing strong spatial sparsity. CS[2-5] (compressed sensing) techniques offer a framework for the detection and allocation of sparse signals with a reduced number of samples[6]. In order to improve the quality of ISAR imaging results, CS is adopted. The results show that CS can work well in ISAR imaging of space objects with under-sampling radar signal.

ISAR imaging and 2D/3D reconstruction are the key techniques in space objects tracking and recognition. The BART (Bidirectional Analytic Ray Tracing) method[7] is applied to calculation of polarized scattering from volumetric target. Ray tracing is carried out both along the incident (forward) and anti-scattering (backward) directions recording different orders of ray's illumination on each facet or edge of the target and surface. Analytic tracing of polygon ray tubes is developed to precisely calculate the illumination and shadowing of facets, which exempt large patches of the target from any finer meshing. It significantly reduces the complexity relevant to the target electric-size.

The ISAR imagery demonstrates the distribution of strong scattering centers of space objects' scattering field in the RD (Range-Doppler) plane. The dominant scattering centers take only a fraction of the whole bins in the plane. In this sense, ISAR image represents strong spatial sparsity in the RD domain. Exploiting such sparsity is meaningful to achieve improved performance, such as super-resolution, feature enhancement and simplicity of data acquirement. More importantly, recent developing theory of the CS tells us that an unknown sparse signal is able to be exactly recovered from a very limited number of measurements with high probability by exploiting the sparsity of signal. This paper introduced CS into the ISAR imaging of space objects. KH-12 (Key Hole-12) satellite is taken as the example model. Results are shown in Fig.1 and Fig. 2.

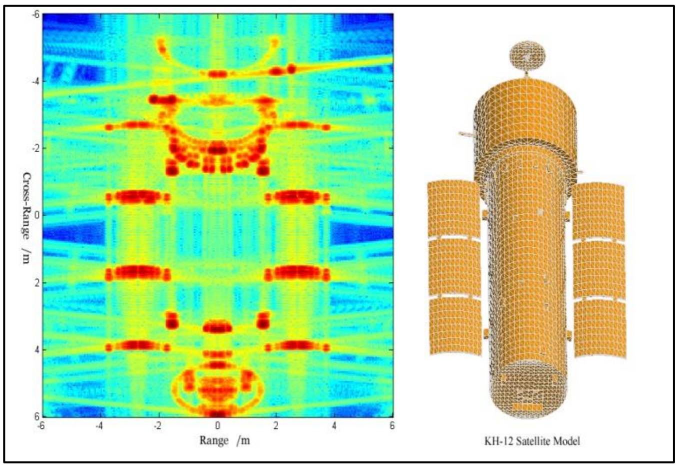


Figure 1. ISAR imaging simulation result of KH-12 satellite

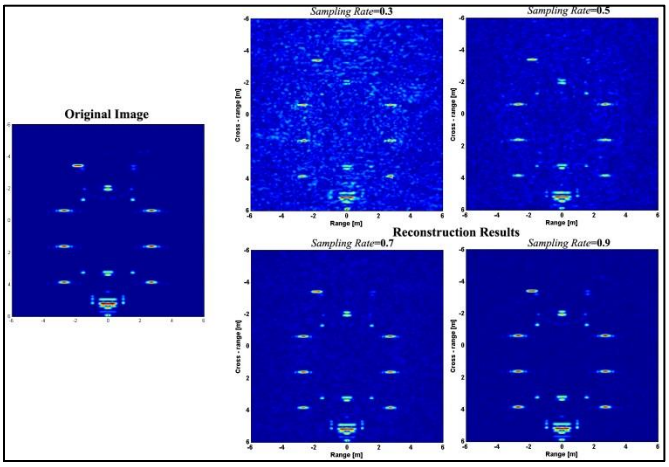


Figure 2. Reconstruction results via CS

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