GRECO Based Fast Prediction of 3D Radar Images for Complex Targets

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Introduction

In a previous work, model based ATR from SAR images is implemented through matching between the 3D hot scattering point images (HSPI) and the 3D back projection scattering images (BPSI) , where HSPI is generated from 3D model, while BPSI is formed from SAR images projecting to a 3D target geometrical model.

A key issue is how to quickly generate the 3D HSPI and BPSI. Based on GRECO, a technique for fast prediction of 3D radar images used for matching is proposed.

Proposed Method

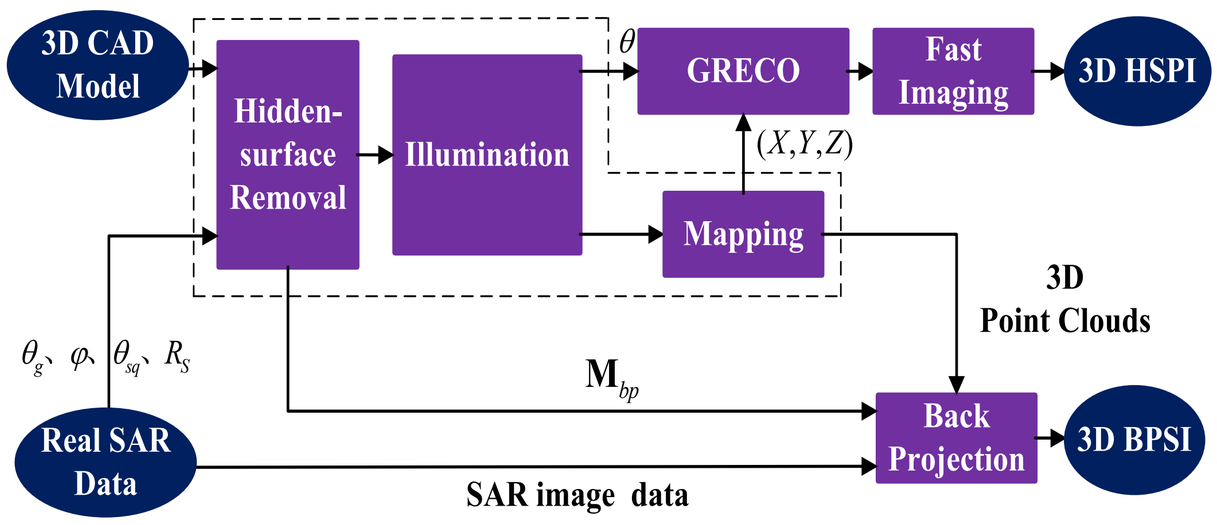


Fig. 1. Overview pipeline for our GRECO-based method.

The complex scattering function of the target based on GRECO is defined as

$$\sqrt{\boldsymbol{\sigma}_{\mathbf{i}}} = \lim_{r\to\infty} 2\sqrt{\pi} r \frac{\mathbf{E}_{\mathbf{S}}^{\mathbf{i}}}{\mathbf{E}_{\mathbf{0}}} e^{j2k_0 Z_i}$$

$$= j\frac{-k_0}{\sqrt{\pi}} \Delta S \cdot \cos\theta_i \cdot \mathrm{sinc}(k_0 l \tan\theta_i) e^{j2k_0 Z_i}$$

The HSPI of the model is expressed as

$$I_h(X_i, Y_i, Z_i) = \left| \sum_{t=1}^{N} \sqrt{\boldsymbol{\sigma}_{\mathbf{i}}} \cdot e^{j2k_0 \cdot (Z_i - Z_t)} \cdot [W(\pi \cdot (Z_i - Z_t)/\delta_{sr}) \cdot W(\pi \cdot (X_i - X_t)/\delta_{cr})] \right|^2$$

The BPSI of the SAR image is represented as

$$I_b(X_i, Y_i, Z_i) = I_S(r_i, h_i)$$

Therefore, three groups of parameters for each pixel are necessary to be obtained , which are listed in Table 1.

Table 1. Three groups of parameters for each pixel

Incidence angle	3D coordinates	Back projection matrix
θ	（X,Y, Z）	$\mathbf{M}_{bp}$

Workflow

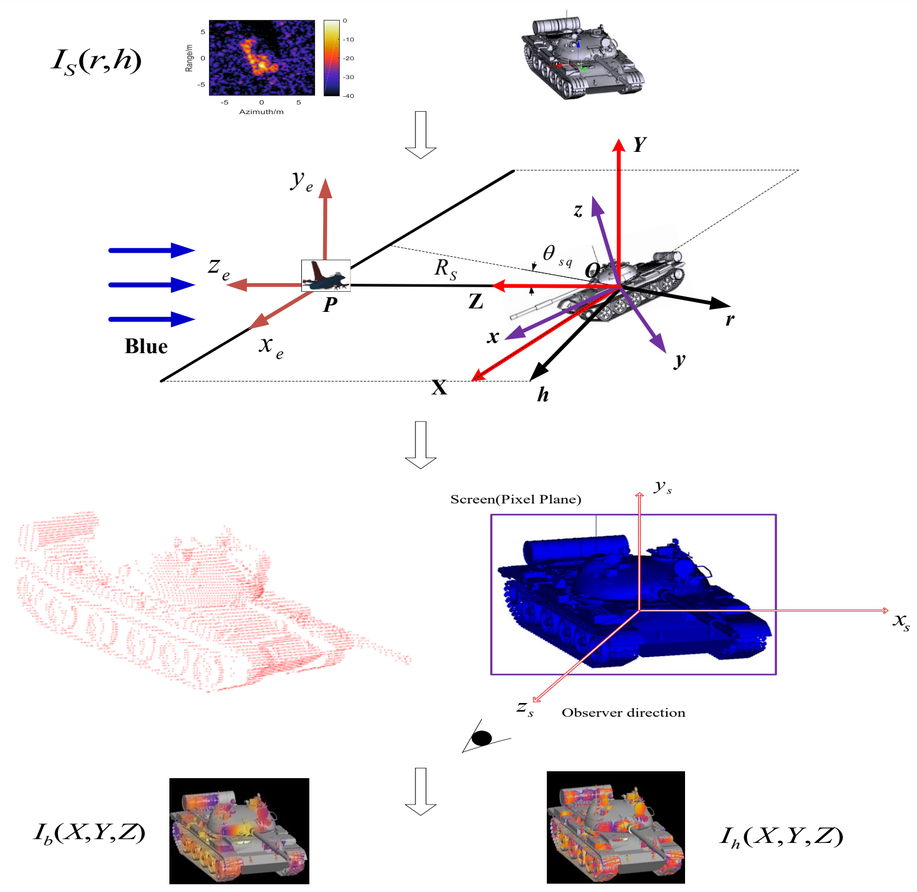


Fig. 2. Key steps of the procedure

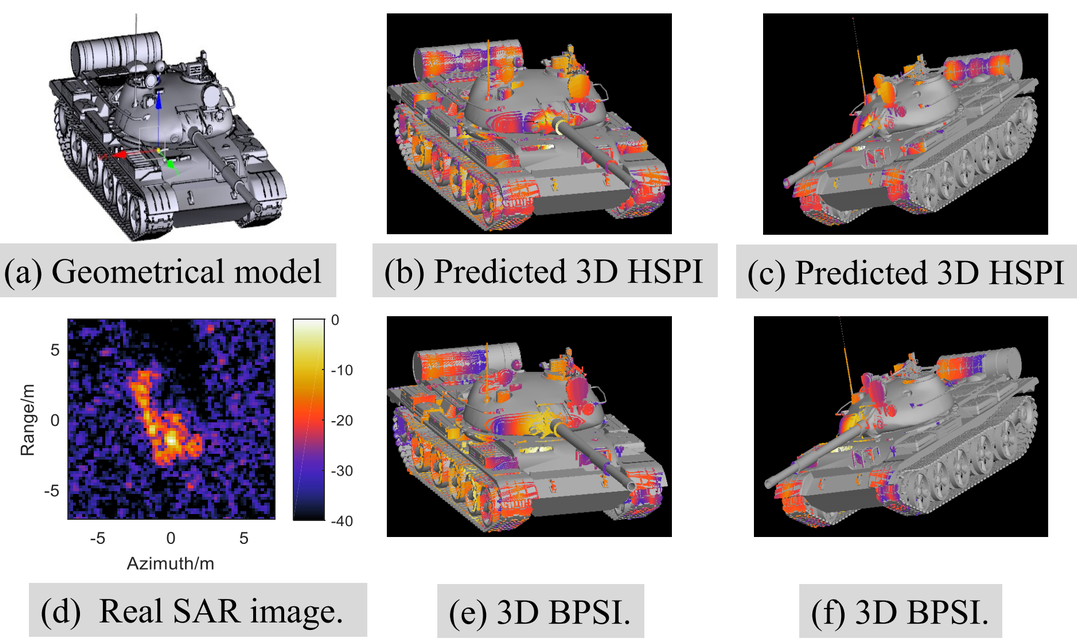
- **Step1:** Geometry used in simulation is built by OpenGL to identify the visible surfaces of complex targets.
- **Step2:** Determinate the incidence angle and 3D coordinates to surface.
- **Step3:** EM calculation and fast 3D image generation.

Experiment

The 3D radar image prediction is carried out using a T62 tank model and the MSTAR public data, shown in Fig.3. Imaging parameters and numerical results are listed in Table 2.

Table 2. Parameters of MSTAR SAR Images and Numerical results

	Squint angle	Elevation angle	Azimuth angle	Observing distance	Center frequency	Range resolution	Azimuth resolution	Match score	Runtime
T62	0	15°	198.5°	4959m	9.6Ghz	0.3047m	0.3047m	0.9012	5s



(a) Geometrical model (b) Predicted 3D HSPI (c) Predicted 3D HSPI

(d) Real SAR image. (e) 3D BPSI. (f) 3D BPSI.

Fig 3. MSTAR SAR image and T62 model

Summary

- A technique for fast prediction of 3D radar images for complex targets is proposed.
- Experimental results illustrate the quick and useful of the proposed technique.
- GPU based parallel computing may be applied to further accelerate imaging process.