CHARACTERISTIC ANALYSIS OF VEHICLE TARGET IN QUAD-POL RADARSAT-2 SAR IMAGES

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Abstract：Radarsat-2 satellite offers general users the Quad-Pol SAR image service with a resolution of 8 meters, which provides valuable data source for the research of traffic vehicles monitoring with Quad-Pol SAR images. According to the vehicle target in such new SAR images, this paper put forward a target characteristic analysis method, which is a combination of target RCS measurement and polarization decomposition. Moreover, it choose more larger trucks as an example, give out a conclusion of characteristic analysis of vehicle targets through the on-site synchronous experimental data obtained at different incident angle. Thus provides the research foundation for further exploration of realizing the traffic monitoring with spaceborn Quad-Pol SAR images.

Keywords: Radarsat-2 Quad-Pol SAR image，vehicle target，RCS Measurement， polarization decomposition

1 Introduction

The successful launch and stable data acquisition of Cosmo-Sky-Med, TerraSAR-X, Radarsat-2, has opened a new field for the application of spaceborne SAR image [1-7]. Movement of target in SAR imaging may bring target image position displacement or fuzzy[7]. For traffic monitoring applications, compared with smooth traffic situations, we are more concerned about disrupted traffic caused by factors like snow disaster. In this application, vehicles were eager to be slow or static. To achieve those targets detection, the research for discrimination between target vehicles with confused clutter, like independent construction clutter along roads, appears to be particularly important. However, all this research foundation is to seek the inherent characteristic or variant discipline of vehicle target under different imaging conditions in Quad-Pol SAR imge.

This paper operated the ground synchronous experiment at two incident angle and multi vehicle azimuth with Quad-Pol Radarsat-2 data. In section 2, it illustrates the adopted analysis method. In section 3, it introduced the analysis result for vehicle target characteristics on the basis of Rasarsat-2 experimental data. The conclusion is given in section 4.

2 Characteristic Analysis methods

2.1 Vehicle Target RCS Measurement

For complex vehicles, Radar Cross Section σ (RCS) is depended on radar parameter (wavelength λ and polarization p), car parameters(Target model s, material $m1$ and azimuth α) and background paremeters (road roughness g and material $m2$) [5-8]. Parameters given in metadata file lutSigma.xml, which can be used to validate Radasat-2 image to image σ_0 . Then, σ can be obtained by Formula（1）.

$$\sigma = \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} \sigma_0(x,y)dxdy \approx \Delta x \cdot \Delta y \cdot \sum_{c,t} \sigma_0(c,t) \quad (1)$$

$\Delta x \cdot \Delta y$ represents the area of one pixel in SAR image. $\sum_{c,t} \sigma_0(c,t)$ stands for the integral of surface targets at the position of (c,t).

2.2 Vehicle Target Azimuth Measurement

Target azimuth can be measured by geological compass. SAR flying direction can be calculated by coordination of the four corners points in SAR image. SAR flying direction was usually settled as the reference direction. While the target head towards the reference direction, it is equal to 0^0, and regard the direction of target rotation in clockwise direction as positive, scope of $[0^0, 360^0]$. Local incident angle can be calculated at reference ellipsoid with the orbit coordinate of sensor and target coordinates surveyed by GPS.

2.3 Vehicle Target Polarization Decomposition

Pauli decomposition analysis is used on the scattering matrix of vehicle targets. Pauli decomposition has the nature to keep the total power unchanged. Computing span of four channels image plays a multi-look even effect, which not only helps reduce the speckle noise effect in SAR image, but also is beneficial for hard target detection.

3 Experiment

3.1 Experimental Dataset

We carried on two on-site experiments at different incident angles with Radarsat-2 image simultaneously, using three vehicles of the same types during the experiment each time. Figure 1 and 2 is the target parking orientation diagram and optical photographs of target vehicles in Experiment 1 and 2. The parameter information of sensors, vehicle targets, and background is listed in Table 1.

Figure 1: The distribution diagram of vehicles $0^0, 225^0, 270^0$ (from left to right) in Experiment 1

Figure 2: The distribution diagram of vehicles $180^0, 225^0, 270^0$ (from left to right) in Experiment 2

Table 1: Specific parameters of Radarsat-2 experimental image

Parameters of Radarsat-2 image	Experiment 1	Experiment 2
Imaging Mode	Fine Quad-Pol	Fine Quad-Pol
Sampling Interval (m) (Range * Azimuth)	4.93*4.73	4.74*4.73
Incident Angle（Degree）	22.16~24.09	38.37~ 39.85

Target Local Incident Angle（Degree）	23.207	39.667
Target Size(m)(Length Width Height)	8.7,2.3,3.4	11.9,2.5,3.8
Road Material	Mixed soil subgrade	Asphalt
Road Width（m）	13	24

3.2 Experimental Data Processing

Figure 3(a) and 3(b) is 9 * 9 pixels window which center point is the location of truck target in span image. The mean value of road background σ_0 equals to 0.1202, variance equals to 0.0146 in Experiment 1. The mean value of road background σ_0 equals to 0.2796, variance equals to 0.0496 in Experiment 2.

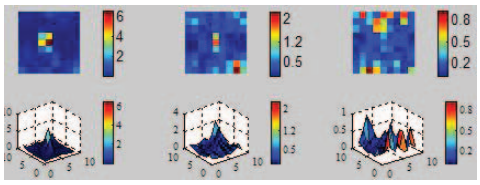

Figure 3(a): Experiment 1 σ_0 of $0^0, 225^0, 270^0$

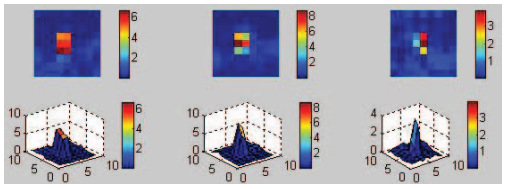

Figure 3(b): Experiment 2 σ_0 of $180^0, 225^0, 270^0$

Use the Pauli polarization decomposition algorithm to decompose the target chip at each azimuth. All polarization component (each line contains hh + vv, hh-vv, 2hv, in turn), and its component elements rate is shown in Figure 4.

4 Conclusion

In this paper, following conclusions is reached. Firstly, the impact placed by incident angle on the backscattering characteristics of vehicle target is the most significant. Secondly, azimuth attitude has a greater impact on the value σ_0 of vehicle targets. 0^0 and 180^0 is the optimal azimuth attitude for detection, 90^0 and 270^0 is the worst, while others are between the two. Lastly, Full-polarization data could make use of polarization decomposition technique to further verify the characteristics of vehicle target.

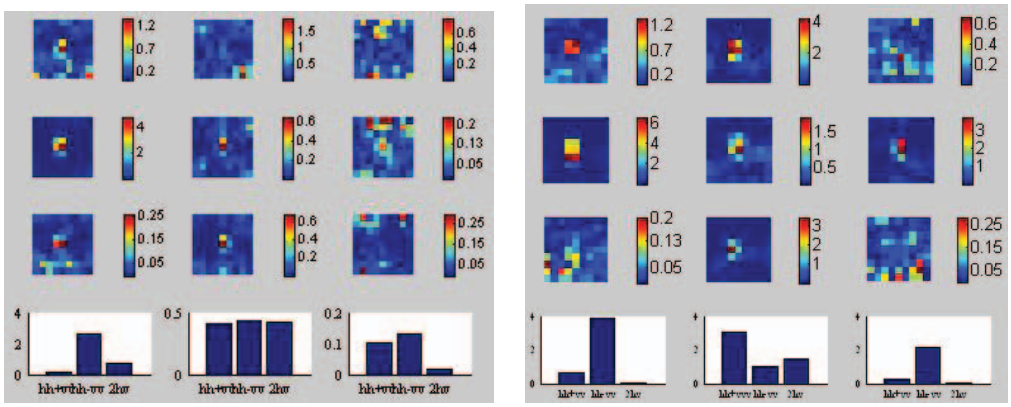

Figure 4：Target slice data of Pauli decomposition and its composition ratio Experiment 1（Left）、2（Right）

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