EFFECT OF THE POLARIZATION ON SISAR IMAGING AND FEATURE RECOGNITION IN FORWARD SCATTERING RADAR

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1. INTRODUCTION

In recent years, a number of researches have been dedicated to the theory and practice of shadow inverse synthetic aperture radar (SISAR) in FSR [1-7]. This method of signal processing introduces a unique basis for imaging and feature recognition of moving targets. However, almost all of the researches are carried out with the free space model under single polarization condition. In this paper, the SISAR principles are discussed for the ground moving target firstly. Then the FS signals of ground moving target are simulated under different polarization by the CST simulation software and the multi-polarization imaging results based on SISAR theory are presented. Afterward, the effect of multipath on imaging is analyzed and the imaging result in the two-ray propagation model is presented. In addition, target FS RCS under different polarization conditions are obtained using the software of CST to research the effects of multi-polarization on moving target feature recognition in FSR. Finally, we draw the conclusion that the imaging precision and the recognition probability will be improved using multi-polarization information.

2. SISAR PRINCIPLES

The analytical equation for SISAR signal and its spectrum were derived in [1].

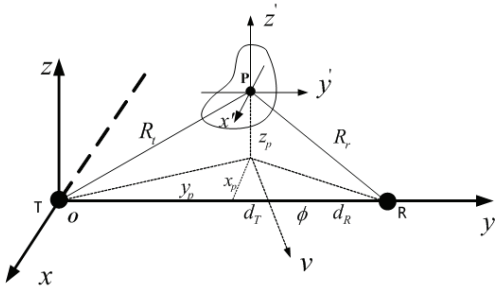

Fig. 1 SISAR geometry

The radio holographic signal (RHS) can be tied up with the complex profile function (CPF) by the relations [1]:

$$E(t)=\dot{Q}\int_{-\infty}^{\infty}\dot{H}\left(x'\right)\exp\left[j\frac{\gamma}{2}\left(\frac{x'}{v}+t\right)^2\right]dx' \tag{1}$$

CPF can be estimated by inverse transform with respect to equal (1) as following:

$$\dot{H}(x') = \frac{\gamma}{2\pi\dot{Q}} e^{-j\frac{\gamma x'^2}{2v^2}} \int_{-T_s/2}^{T_s/2} e^{-j\gamma t^2/2} \dot{E}(t) \exp[-j\gamma x' t/v] dt \tag{2}$$

3. EFFECT OF THE POLARIZATION ON IMAGING

In this section, the ground typical targets, vehicles, are modeled firstly. Then the FS fields under different polarization condition is simulated by CST Microwave studio EM simulation software by which the precise FS field of the target can be obtained. Afterward, the imaging results based on SISAR are presented.

The ground target, truck, is modeled as Fig. 2. And the imaging results based on SISAR are presented as Fig. 3.

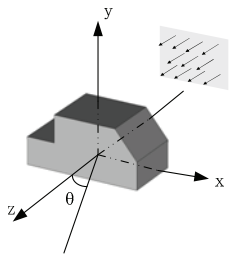

Fig. 2 the vehicle model

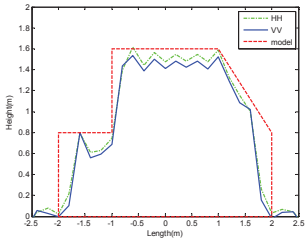

Fig.3 imaging results

For comparison, Fig.3 shows the imaging results under horizontal and vertical polarization condition and the model shadow contour. It can be seen that the imaging results are different for the same target under different polarization. Thus, the precision of imaging will be improved by the choice of optimal polarization.

4. EFFECT OF THE MULTIPATH ON SISAR IMAGING

In the conventional radar system, the signal propagation model is assumed to be free space model. For the ground FSR system, the ground reflection has to be considered. We should analyze the effect of multipath on SISAR imaging according to the practical case of ground based FSR (Fig. 4).

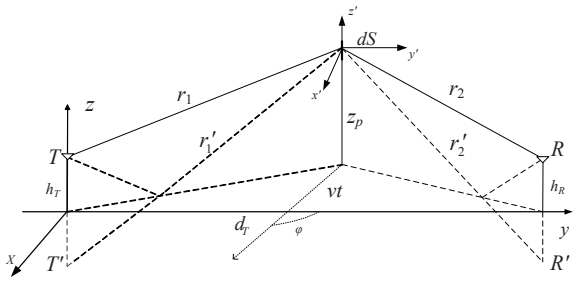

Fig. 4 Two-ray propagation model

The target imaging results based on SISAR are presented respectively in free space model and in two-ray propagation model in Fig 5.

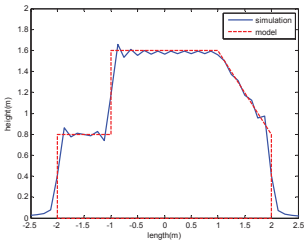

Fig. 5 (a) In the free space model

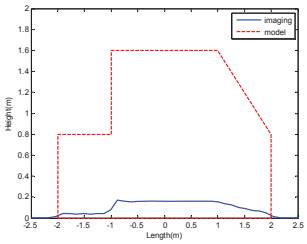

Fig. 5 (b) In two-ray propagation model

Fig. 5 (a) is the imaging result in free space model, and Fig. 5(b) is the imaging result in two-ray propagation model. From Fig 5(b) it can be seen that the profile of the image and the target shadow contour look similar, but the height of the image is much smaller than real height of the target.

5. EFFECT OF THE POLARIZATION ON FEATURE RECOGNITION

The normalized spectrum densities (SD) of RHS depend on the shape of the shadow profile of the target, which can be used in feature recognition in FSR [1, 2, 7]. Taking into account (1) the spectrum densities (SD) of RHS can be expressed as:

$$\left|\dot{G}_E(\omega)\right|^2 = \frac{2\pi}{\gamma}\left|\dot{Q}\right|^2\left|\dot{G}_H\left(-\frac{\omega}{v}\right)\right|^2 \approx \lambda^2\left|\dot{Q}\right|^2\sigma\left(\alpha_v,\frac{\omega}{kv}\right)\Big/(2\gamma) = \lambda^2\left|\dot{Q}\right|^2\left|S_{ij}\left(\alpha_v,\frac{\omega}{kv}\right)\right|^2\Big/(2\gamma) \tag{3}$$

From above equation the following important result can be obtained that the calculation of the SD, using the SISAR method, can take calculation of FS RCS. Therefore, the method of classification and recognition using the SD of RHS can be equivalent to using the differences in FS RCS information in forward scattering field. As we know that the target RCS is affected by the polarization forms of the incident field and receiving antenna, so the difference of FS RCS under different polarization can be used in target recognition to improve the probability of classification and recognition. A human model is shown in Fig.6. The multi-polarization FSRCS of the model is simulated using CST software as Fig. 7:

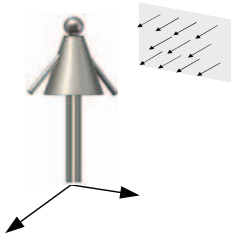

Fig. 6 the human model

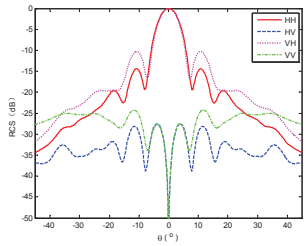

Fig. 7 RCS under different polarization conditions

From Figure 7, it can be seen that the cross-polarization FSRCS is much smaller than co-polarization FSRCS. Thus, only co-polarization FS RCS is usually used in classification and recognition of the target. It is obvious that the side-lobe of FS RCS is different under HH polar from VV polar, which is sensitive to the shape of the target.

We believe that the side-lobe differences of FS RCS under different polarization conditions can be used for recognition to enhance the probability of the target recognition.

5 CONCLUSION

In this paper, multi-polarization is firstly introduced to FSR target imaging and feature recognition, and the target FS field and FS RCS under multi-polarization conditions are obtained using the CST simulation software. And the effect of the polarization on SISAR imaging and feature recognition is analyzed. The simulation results show that the precision of imaging and recognition can be improved by using multi-polarization information in FSR. In addition, the effect of multipath on SISAR imaging is also analyzed in FSR.

6 REFERENCES

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