SIMULATION OF DUAL-CHANNEL SAR-GMTI FOR VELOCITY ESTIMATION AND COMPENSATION

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1. INTRODUCTION

A SAR-GMTI (synthetic aperture radar - ground moving target indication) technique can be used for providing the position and velocity of ground moving targets in the high resolution SAR images. Recently, this technique has been known to have a possibility of the traffic monitoring of moving vehicle targets on the ground road by characterizing the dynamics of moving vehicles against a non-moving clutter background [1]. The velocity component of moving targets, however, can often make the targets to be displaced and defocused in the SAR image [2]. Therefore, a special compensation method for curing these problems is required for correcting the displaced position of the targets and mapping error in the final image products. In this paper, the displacement effect of the ground moving target position due to the variation of the velocity and acceleration is analyzed in range and azimuth directions, and its compensation algorithm is presented by estimating the velocity of the moving target. For this analysis of moving target displacement, the dual channel SAR-GMTI technique is introduced for detection of moving target, and the influences caused by the velocity and acceleration components of target in SAR images are then analyzed. The simulation is performed for algorithm evaluation, and the performance results are compared with respect to the estimated velocity and defocused quantity in both range and azimuth directions.

2. INFLUENCE OF MOVING TARGET IN DUAL CHANNEL SAR GMTI

This dual-channel SAR-GMTI model assumes that the aircraft moves with constant velocity V_p at the altitude of H, and the radar operates with side-looking configuration where the azimuth direction is ideally assumed to be parallel to the motion of the radar, and the range is assumed to be perpendicular to the motion of radar. A point target is assumed to move with the velocity V_a, and V_r , and acceleration A_a, and A_r in azimuth and range direction, respectively. The Doppler frequency in stationary target is changed by only platform moving velocity, but the Doppler component in moving target on the ground is affected by the additional Doppler frequency changing rate. This Doppler frequency changing rate causes the point target SAR image to be spread and displaced. Main reason of moving target position displacement in SAR image is the target movement with the velocity and acceleration. The target Doppler frequency rate is given by the range between radar and ground target. The constant Doppler shift results in range-walk phenomenon even after range compression. Range-walk is movement of compressed maximum magnitude in each azimuth time and thus the range-walk may cause a serious image defocusing problem in both range and azimuth directions. Furthermore, this range-walk causes the moving target to be shifted in azimuth direction, resulting in the change of the FM rate.

3. COMPENSATION SCHEME OF RANGE-VELOCITY ERROR

In order to compensate range-walk quantity, range velocity must be estimated. The SAR interferometric phase computed from two-channel SAR data can be used in determining the range velocity of moving target. The interferometric phase is related to the target motion components, and thus can be used to estimate the range velocity [4]. The range walk quantity is decided by azimuth time changes according to target position. Therefore, the range-walk quantity is estimated based on each target's Doppler centroid at each azimuth time. The compensation scheme for mapping error is similar to the range-walk procedure, but it is accomplished in range- time and azimuth-time domain. In addition, the moving target with azimuth velocity causes the difference of relative velocity between a platform and a target, and changes the FM rate of the received signal. This targets moving in azimuth direction make blurred SAR image of the target, but this can be corrected by focusing the moving target by choosing the correct azimuth FM rate using matched filer bank.

3. SIMULATION AND DISCUSSION

The simulation of dual-channel based SAR-GMTI is being performed for the evaluation of the proposed compensation method. The procedure of the simulation is composed of 5 steps as shown in Fig. 1. The simulation of dual-channel SAR-GMTI will show the results of each stage of processing: (1) moving targets without correction, which shows the defocusing phenomenon and position error of moving targets, (2) the range compressed results of the moving target, (3) the compressed energy in each azimuth time and the position of displacement, (4) the point target image after azimuth compression using estimated FM rate by matched filter bank, and (5) final mapping error compensation. The estimated velocity in range and azimuth direction is illustrated in Fig. 2. The solid line with circle is the estimated range velocity, and the dotted line with triangle is the estimated azimuth velocity. The predicted velocity in each direction is close to the target used in simulation.

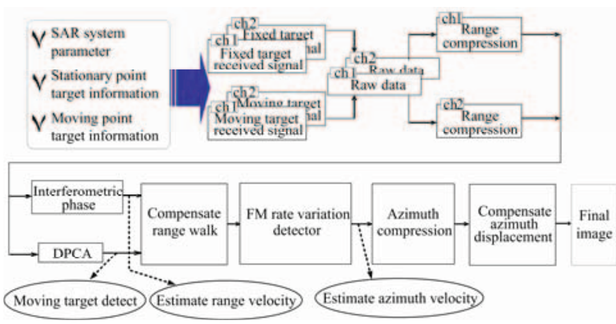

Fig. 1 Simulation of Dual-channel SAR-GMTI

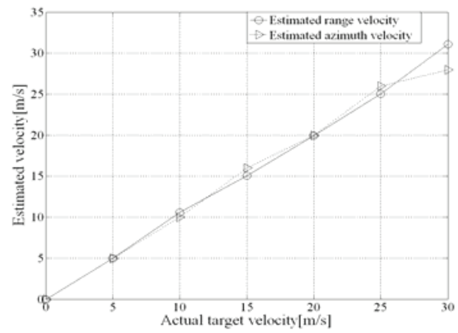

Fig. 2 Estimated Velocity Error

4. CONCLUSION

The velocity and acceleration of the ground moving target can cause the target position to be displaced and defocused in the SAR image. In this paper, The influence of the ground moving target due to the velocity and acceleration is analyzed in the dual-channel based SAR-GMTI system. In order to reduce the performance degradation, the velocity estimation of the moving target and its compensation scheme are presented in the dual-channel SAR system. The target velocity in range direction is estimated by the phase difference of dual-channel signals, and the azimuth velocity is computed from the correct FM rate by searching the matched filter bank with various FM rate. The range-walk quantity and the mapping error are compensated by location shift using the estimated range velocity, and the azimuth defocusing is resolved by modified FM rate. Finally, the performance of the proposed method is compared with respect to the estimated velocity and defocused quantity in both range and azimuth directions. The proposed scheme can be used for the improvement of the moving vehicle detection in the high resolution SAR image, which could be useful for the traffic monitoring on the road.

4. REFERENCES

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