

Preface

GMTI and GMTIm are important functions, which endow the SAR system with the abilities of the indication, parameter estimation, relocation, and focusing of moving targets, as well as high-resolution imaging of stationary scenes. With these advantages, the moving target processing functions of SAR systems are widely used in both military and civilian applications, and are becoming hot research issues in recent years.

With the development of signal processing theory and electronic technique, the airborne SAR system has also exploited several new operating modes. Besides the classical stripmap SAR/GMTI mode, the WAS-GMTI mode and FMCW SAR system are two representative new operating modes, which are drawing increasingly more attention of researchers. Based on the deep analysis of the signal model of the moving target, this book focuses on the theories and applications of GMTI and GMTIm algorithms in SAR/GMTI mode, WAS-GMTI mode, and FMCW SAR system, and also studies the corresponding key techniques of these operating modes. In addition, the nonideal errors that deteriorate the performance of GMTIm algorithm in real SAR data processing are discussed, and the compensation methods are provided. The main work and innovations of this book are as follows:

- (a) The echo signal model of the ground moving target in stripmap SAR/GMTI mode is established. By deeply analyzing the relationship between the motions and Doppler phases of the targets with fast radial velocities, the effects of Doppler ambiguity and third-order phase error are studied, and a new classify scheme of the moving targets is presented by concerning the Doppler ambiguity. Through the Doppler centroid estimation algorithm based on curve fitting, the Doppler centroid error of the clutter can be estimated and corrected, which is the foundation of the following processing steps. With the two-step GMTI algorithm, fast-moving targets that submerged by the clutter can be indicated and extracted. Using the GMTIm algorithm based on Hough transform and third-order PFT, the Doppler ambiguity of the moving target

can be accurately estimated, and the moving target can be correctly focused and relocated. Besides the advantages of indicating and imaging fast-moving targets, the proposed algorithms are also effective in slow-moving target processing, which makes them highly suitable for real SAR data processing.

- (b) The principles of the WAS-GMTI mode and the DBS algorithm are researched and introduced, and a new system design scheme is presented by combining the mechanic scanning mode and the airborne SAR system, which keeps the sharpening ratio constant without increasing the complexity of either the system or the processing. To find a balance between the resolution of DBS imaging and processing efficiency, a real-time DBS algorithm based on CZT is proposed, which is able to correct the RCM and meanwhile circumvents the Doppler centroid estimation. And then, a moving target indication and parameter relocation method in mechanic scanning mode is proposed. This method indicates the targets in each DBS image, and uses the radial movements of the moving targets between the DBS images of different scans to estimate the motion parameter. The effectiveness of the proposed method is confirmed by real WAS-SAR data processing results.
- (c) The nonlinearity correction and GMTI of FMCW SAR system are researched and analyzed. The principle of FMCW SAR is first introduced, and the echo model differences between the FMCW SAR and pulse SAR systems are delicately analyzed. The nonlinearity of transmitted signal in FMCW SAR is an important issue since it affects both the stationary FMCW SAR imaging quality and the moving target processing performance. The shortcoming of the classical derivative algorithm is analyzed, and then a novel nonlinearity correction algorithm based on homomorphic deconvolution is proposed, which provides accurate corrections without the restraints of the length of the controllable delay line. Based on the modeling of the moving target in FMCW SAR, a new azimuth moving target indication algorithm is proposed using the additional RWM induced by FMCW SAR system. This algorithm makes use of the additional phase, which is viewed as phase error in traditional GMTI algorithms, and therefore broadens the GMTI ability of FMCW SAR systems.
- (d) Currently, the performances of most GMTI algorithms that are effective in simulations are not satisfying in real SAR data processing. The effects of nonideal errors during the real data acquisition are analyzed, and the estimation and compensation method is provided. First of all, the motion errors of high-resolution SAR imaging are introduced, and the PGA technique is induced to correct the high-order phase error caused by these motion errors. Then, by establishing a more common moving target signal model concerning the effect of nonideal errors, the conclusion that the along-track velocity error of the aircraft and the radial velocity error can make the Doppler centroid of the moving target disperse, and deteriorate the imaging resolution. The effects of these two nonideal errors are confirmed by mathematical analysis and simulation, and a nonideal error estimation and compensation method is

proposed. Together with the proposed GMTI and GMTIm algorithms in this book, a whole moving target processing scheme is presented, which is very robust and highly suitable for real SAR data processing.

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