KNOWLEDGE-AIDED IMAGING OF MOVING TARGETS WITH SYNTHETIC APERTURE RADAR

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1. INTRODUCTION

We present a novel method of focusing moving targets in synthetic aperture radar (SAR) images through the estimation of various motion parameters. We examine the effects of target motion on SAR imaging and provide an approach for correcting these effects as part of the image formation process. It is shown that knowledge of the target cross-range position aids in focusing. Consequently, we concurrently estimate the target velocity and position. The performance of our new approach is compared both subjectively and with a variety of image metrics to the MITRE keystone remapping technique.

2. BACKGROUND

SAR is an imaging technique that forms coherent images of objects based on their radio reflectivity. SAR technology offers advantages over optical imaging because of its ability to image through inclement weather and to penetrate foliage and the ground depending on its operating frequency. SAR systems have many diverse applications, including radar imaging, topographical mapping of the earth surface, navigation and guidance, and environmental monitoring. Fine resolution is achieved in range through large signal bandwidth from a chirped pulse and in cross-range through a synthesized aperture much larger than the physical antenna of the imaging device. Proper focusing requires knowledge of the relative motion between the sensor and the imaged object. Consequently, conventional SAR imaging techniques perform poorly in the presence of moving targets [1, 2]. An area of active interest is the development of algorithms that can detect moving targets, extract target motion information, and focus and locate a target in a high resolution image without a priori knowledge of target motion. This is typically referred to as inverse SAR or SAR-Ground Moving Target Indication (GMTI).

3. FOCUSING AND LOCATING MOVING TARGETS

This presentation begins with a discussion of the SAR governing equations. We examine the effects of range velocity, cross-range velocity and range acceleration. Cross-range velocity and range acceleration are shown to be coupled terms.

We then present a new method for estimating the target velocity vector. First, the actual target cross-range position is determined either through the use of multiple phase centers for a monopulse or InSAR system or through some knowledge of the scene (e.g., the position of major roadways) for single channel systems. Next, the target cross-range shift is measured across a series of overlapping subapertures and used to estimate range velocity and acceleration. Cross-range velocity then is estimated through a search to optimize image quality metrics such as entropy and contrast. A final focused image is generated based on the estimated target position and velocity vector.

Our approach is unique in that it treats target focusing and localization as a coupled problem. Other recent work uses multiple phase centers to localize targets but only after focusing has been accomplished [3]. In addition, our technique does not rely on specific target features (e.g., prominent points) that may not exist on realistic targets [4, 5].

We compare our new algorithm to the existing standard. The MITRE keystone remapping technique removes the effects of linear range migration through a scaling of cross-range (slow) time [6]. It is innovative in that it does not require the estimation of target motion parameters or the tracking of individual targets during a collection. The technique applies a correction to the image that is based entirely on known parameters of the radar collection. However, it introduces a skewing of the target data. The effects of this skewing are not well discussed in the literature but can be significant enough to interfere with target identification and the application of conventional autofocus techniques. The effects of additional components of motion beyond range velocity are not addressed with the MITRE keystone remapping. Consequently, further processing is required to detect, fully focus, and localize moving targets in an image. We highlight these limitations and discuss possible methods to mitigate them.

4. REFERENCES

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