JOINT COMPRESSION AND SPECKLE REDUCTION OF SAR IMAGES USING EMBEDDED ZEROTREE MODELS

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ABSTRACT

We propose a new method for speckle reduction in synthetic aperture radar (SAR) imagery based on the embedded zerotree image compression algorithm. This new approach to denoising is inspired by the realization that the wavelet transform domain and the zero-tree image model are natural for both compression and denoising. We illustrate the proposed scheme using fully polarimetric SAR images and a variety of compression ratios.

1. INTRODUCTION

Real-time transmission of sensor data such as synthetic aperture radar (SAR) images is of great importance both for time-critical military search and destroy missions and for scientific survey applications. Image compression is the enabling technology for real-time transmission of SAR images; for example, real-time transmission of SAR imagery over a T1 carrier line (1.544Mb/s) requires compression ratios in excess of 73:1. Since post-processing of the collected sensor data involves search, classification, and tracking of targets (typically military vehicles, trees in a rain forest, oil spills, etc.), sensor data compression algorithms differ from the algorithms developed for still images destined for human viewing.

One of the major challenges with compressing SAR images is speckle noise. Speckle noise is found in all coherent imaging systems and can (in the log-magnitude domain) be modeled as additive white Gaussian noise [1]. Since it adds a random texture to SAR images, speckle interferes with compression by reducing the spatial correlations that compression algorithms rely on. Thus, some kind of despeckling preprocessing is required before adequate compression ratios can be attained.

2. JOINT COMPRESSION AND SPECKLE REDUCTION

Recently, considerable success has been obtained using wavelet thresholding for speckle reduction [2, 3, 4]. Wavelet denoising works because it separates signal and noise in the magnitude of the wavelet coefficients (large coefficients are signal and small coefficients are noise) and hence simple thresholding removes the noise. Since the wavelet transform packs the key elements in a SAR image into a small number of wavelet coefficients, wavelet thresholding easily suppresses the evenly distributed speckle noise.

As an example, Figure 1 (top) shows a fully polarimetric SAR image of the Lincoln North building in Lincoln, MA. Figure 1 (bottom) shows the result of redundant wavelet denoising. Note that the details are preserved while the speckle noise is greatly attenuated. In addition to improved visual appearance, wavelet despeckling also appears to improve detection performance [2].

The same conventional wisdom that applies to wavelet-based noise reduction also applies to wavelet-based compression [5]: since the wavelet transform packs the key elements in a SAR image into a small number of wavelet coefficients, a highly compressed version of the image that remains faithful to these elements can be obtained by coding only the large coefficients.

Shapiro’s embedded zerotree compression algorithm models the self-similarity inherent in most images and uses it to predict the locations of the small wavelet coefficients [6] which are deemed to be insignificant information and are encoded as zeros. This is indeed very similar to wavelet thresholding in the sense that it attempts to faithfully preserve the large coefficients while discarding small coefficients.

3. RESULTS AND CONCLUSIONS

Figure 2 contains a sequence of images obtained by compressing the original SAR image of Figure 1 (top) using the embedded zerotree algorithm. Closer inspection of the compressed images shows that as the compression ratio increases, so does the degree of despeckling. In fact, the 76:1 compressed image bears a close resemblance to the wavelet despeckled image of Figure 1 (bottom).

Compression and speckle reduction are two of the critical challenges for real time SAR image transmission and processing. Since compression and denoising are so intimately related, maximum system performance will be obtained only after combining the two procedures. We are currently investigating jointly optimal systems.

4. REFERENCES


Figure 1: (top) Original SAR image (bottom) Despeckled SAR image using redundant wavelet processing.

Figure 2: Joint compression and speckle reduction of the Lincoln North building from Figure 1. Compression ratios: (top) 13:1, (middle) 76:1, (bottom) 346:1.