SAR Image Compression Using Bounded Variation Component Analysis

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Abstract

*This paper proposes a scheme to compress SAR (Synthetic Aperture Radar) images aiming for preserving fine details such as bright targets. This scheme consists in decomposing a SAR image into bounded variation (BV) and oscillating components. The adaptive compression scheme is a modified version of the well known SPIHT method named in this paper as MSPIHT. The experiments using real SAR images were compared with JPEG*2000 *and the conventional SPIHT. The assessment results indicated a superior performance of method in preserving fine details.*

1 Introduction

Synthetic aperture radar (SAR) images are useful sources of information for several applications in remote sensing of environment. In the last years, the amount of SAR data has increased, and motivated researchers to develop algorithms for SAR image compression. Traditional algorithms fail to compress SAR images, particularly due to speckle phenomena. The algorithm introduced in [1] requires pre-processing steps including speckle filtering, which degrades fine details and edges.

Using the discrete wavelet transform (DWT) efficient compression procedures can be developed in a multiresolution space. Several methods based on wavelets [5] are available in the SAR image compression literature. This approach can be accomplished by decomposing SAR images in subbands and searching for the significant information for lossless compression. Regarding texture, wavelets coefficients present a subband frequency representation, where the significant texture information can be discriminated in middle frequency channels [5].

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In this paper we adopted the scheme presented in [4] to decompose the SAR image. Let $f : \Omega \rightarrow \Re$ be the image decomposed into $u \in BV$ component (BV - bounded variation space) and $v \in L^2$ component (L^2 - oscillating space), such that $f := u + v$. The u component which is a cartoon representation of f is a simplified piecewise smooth approximation. Our proposed framework tracks regions with targets in the u component and employs a lossless compression method to these regions, in order to preserve them.

This paper describes the proposed method in Section 2. We present experimental results and some concluding remarks in Section 3.

2 Method

The BV and L^2 decomposition spaces present distinct features. Thus, u (low frequency information) and v (high frequency information) components provide image analysis using distinct bands in the same resolution. Similar to [4], the proposed scheme employs the *Total Variation Minimization (TV)* method to obtain the u component. The oscillating component v is computed as a TV residual information.

To perform target detection, the u component is subdivided into blocks using the quadtree decomposition presented in [5] according to a defined criterion. If a block meets the proposed criterion, it is not subdivided, otherwise it is decomposed into four blocks. The criterion is defined as $\sigma_L < \sqrt{L}(\sigma_{L-1})$, where L is the quadtree decomposition level and σ_L is the standard deviation of the inspected block.

The proposed scheme is shown in Fig.1. Our aim is to allocate to fine details scales more bits in the compression process. Thus, in the highest decomposition scale (16x16 blocks) is used the arithmetic coder to provide a lossless data compression. We compress the other scales (32x32, 64x64,128x128) using the SPIHT algorithm [2] with decreasing bit rates.

The displayed result in Fig. 2(a) is a scene of the coastal zone in RN-Brazil. The image size is 256×256 pixels with

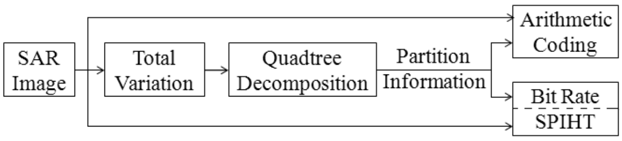

Figure 1. Proposed method

12.5 m resolution. It was acquired in amplitude detection from the RADARSAT system. The decomposition (BV) result can be observed in Fig. 2(b). One can observe preserved targets (bright points in top center and an oil slick down center) in the u component. The quadtree decomposition provides a partition (grid) displayed in Fig. 2(c). Bright targets can be observed in fine scales 16x16 and 32x32, and the oil slick area is divided in 64x64 blocks, as shown in Fig. 2(d).

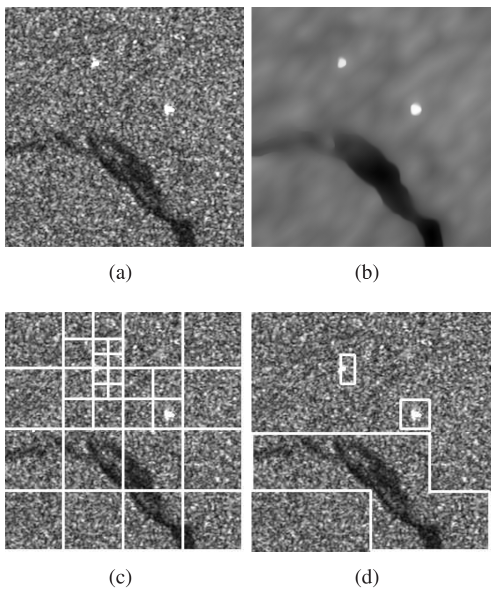

Figure 2. (a) The original SAR image, (b) the u component, (c) the quadtree decomposition (grid) superimposed in the original image and (d) the detected targets.

3 Results and Conclusions

The quantitative measures used to assess the experimental results were **PSNR** (Peak Signal to Noise Ratio) and standard deviation to mean ratio σ_m, as used in [5]. In addition, the **MIE** (Max Intensity Error) [3] was locally computed as a measure of fine details preservation. The modified SPIHT (MSPIHT) outperformed the standard JPEG2000 compression method according to all assessment measures. Furthermore, it was superior to the conventional SPIHT method related to MIE and σ_m.

The results are displayed in Table 1 using two different bit rates, 0.2 bpp and 1.0 bpp. One can observe that the proposed method presented similar PSNR values as SPIHT with a reduction about 0.5 dB.

Table 1. Assessment measures

Bit Rate		0.2 bpp	1.0 bpp
Proposed Method	PSNR(dB)	31.47	37.47
	MIE(dB)	12.30	7.780
	σ_m	0.194	0.277
SPIHT	PSNR(dB)	31.50	38.02
	MIE(dB)	13.80	10.41
	σ_m	0.166	0.231
JPEG2000	PSNR(dB)	31.13	37.34
	MIE(dB)	17.50	10.00
	σ_m	0.154	0.274
Original Image	$\sigma_m = 0.278$		

The results showed that the SPIHT performance related to fine detail preservation can be improved without changing the bit rate significantly.

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