SAR RAW DATA COMPRESSION WITH DCT-BAQ

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ABSTRACT

In this study Synthetic Aperture Radar (SAR) raw data compression techniques are introduced. Two encoding approaches are generally used. Direct encoding in spatial domain and transform encoding in transform domain. A well-known spatial domain compression technique is based on Block Adaptive Quantization (BAQ)[3,6]. BAQ encoding is implemented by dividing the SAR Raw data set into data blocks of small size and by estimating for each block, the standard deviation value. In transform domain we use discrete cosine transform (DCT). SAR Raw data transform coefficients have high dynamic range. This causes reduction for compression performans. We have applied new approach for reduction of dynamic range. We have coded DC component of the transform coefficients with 8 Bits for each data block and transmit standard deviation and DC component seperately from transform domain coefficients. Dynamic range reduction of transform domain coefficients improves compression performans results versus BAQ

I. INTRODUCTION

Synthetic Aperture Radar, (SAR) is a remote sensing system, which is used for earth observation. There are several applications of SAR data is used for observation systems. The developments of advanced SAR systems for earth observation from satellite, offers flexible microwave sensors, capable of multiple imaging modes and resolutions. These features together with the wide swath requirements, determines the production of a huge amount of data. The amount of produced data is constrained by storage and downlink bandwidth. Additional we need to use SAR raw data compression not only the down link requirements but also at the remote sensing ground stations for archiving and transmitting raw data to the end users. To manage this problem, many efforts have been taken place in order to develop suitable compression techniques for raw data coding.

The analog signal received by SAR sensor is generally treated as follows. First it is heterodyned to an intermediate frequency, then it is demodulated to baseband in-phase (I) and in-quadrature (Q) channels, sampled according to the Nyquist rate and finally it digitized. The digital signal may be stored onboard and eventually downlinked to the Earth station where processing is made. For continuous operations the downlink must be in real time.[4]

The data rate is proportional to the pulse repetition frequency, to the sampling rate for each received pulse, and to the number of quantization bits for each sample. The resulting rate is generally very high. For example 105 Mbit/s for ERS-1 mission.

Data compression is an essential requirement for spaceborn SAR sensors to reduce the data volume that must be temporarily stored onboard, transmitted from satellite to ground station, and then stored on the ground.

II. SAR RAW DATA STATISTICS

The SAR echo is downconverted to baseband and split into I and Q compenents. The statistics of the I and Q compenents can be assumed to be Gaussian, with zero mean and unknown varience. SAR echo is a superposition of responces of many small scatters.[6], The radar return S is written as

$$S = I + jQ = \sum_{i=1}^{N} S_i \exp(j\phi_i) = \sum_{i=1}^{N} I_i \cos\phi_i + j\sum_{i=1}^{N} Q_i \sin\phi_i \quad (1)$$

where S is represented sum of returns due to the independent scatterers, S_i is the amplitude and ϕ_i is the phase delay. Thus the amplitude S_i and phase ϕ_i are statistically independent of each other, the phases ϕ_i are uniformly distributed. From these assumptions, the real and imaginary part of the complex signal have zero means, and unknown variances, and uncorrelated. From the central limit theorem that as $N \to \infty$, real and imaginary parts are Gaussian with unknown variances.

III. BLOCK ADAPTIVE QUANTIZATION (BAQ) ALGORITHM

A well-known spatial domain compression technique is based on Block Adaptive Quantization (BAQ). The BAQ algorithm is based on the observation that SAR raw data can be modelated as a Gaussian distributed random variable with a slowly varying standard deviation value. BAQ encoding is implemented by dividing the SAR raw data set into data blocks of small size and by estimating, for each block, the standard deviation value. Following this step each sample within the block is normalized to the estimated standard deviation value. Finally, the normalized sample is compared to the optimum quantization levels of an n bit quantizer with unitary standard deviation. The quantized samples and the standard deviation of each block are transmitted to allow data decoding. The chosen number n bits depend on the system data rate constraints.[3]

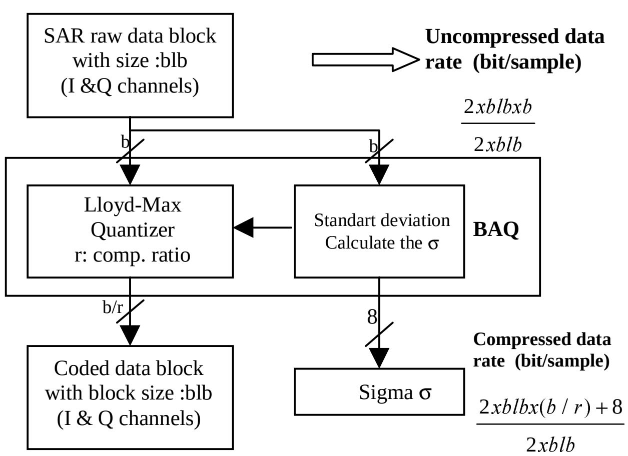


Figure 1. Block diagram of BAQ Algorithm

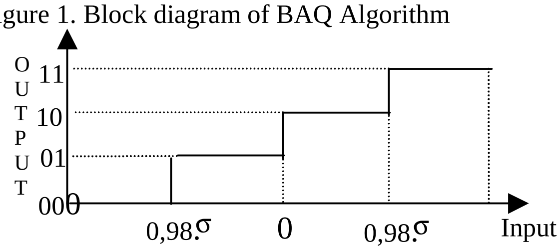


Figure 2. Coding caracteristic for a 2-b BAQ

IV. DCT-BAQ ALGORITHM

Using Transform domain for data compression is the decorrelation stage of the compression algorithm. For efficient data compression process the transform should be:

- Orthogonal series expansions as it provide series of coefficients, which are uncorrelated.
- Unitary as it preserves the signal energy and pack most of the information into a smallest number of them
- Linear as it offers a fast computer algorithm.

In this study we chose Discrete Cosine Transform (DCT) for SAR raw data compression. DCT is a fast transform, requires real operations, near optimal substitute for the Karhunen –Loeve (KL) transform for highly correlated images. Low complexity arithmetic and has very good energy compaction.[7]

In transform domain if the transform coefficients are Gaussian distributed, BAQ can be used for data quantization. Transform domain coefficients have high dynamic range, so performans of the compression is reduced. For reduction of dynamic range, we can code DC component of the transform coefficients with 8 Bits for each block and transmit standard deviation and DC component separately. We code DC component separately and rest of the transform coefficients are Gaussian distributed. BAQ is used for the rest of the transform coefficients.[12]

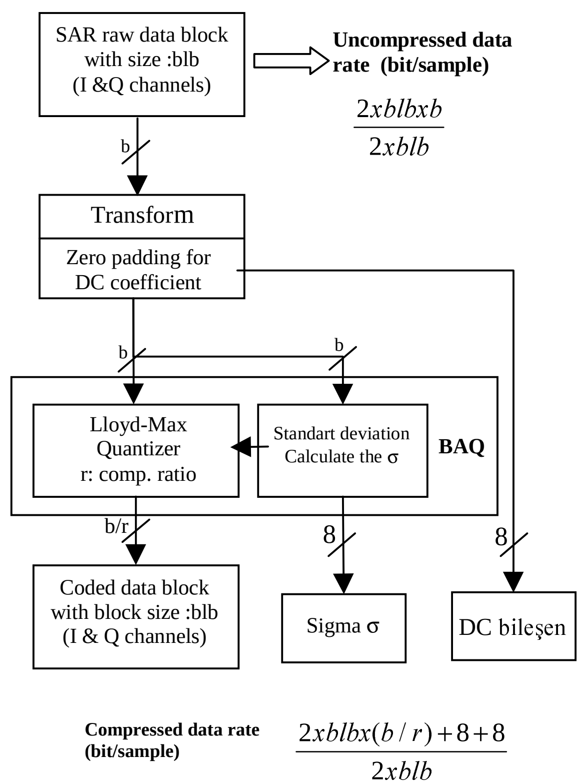
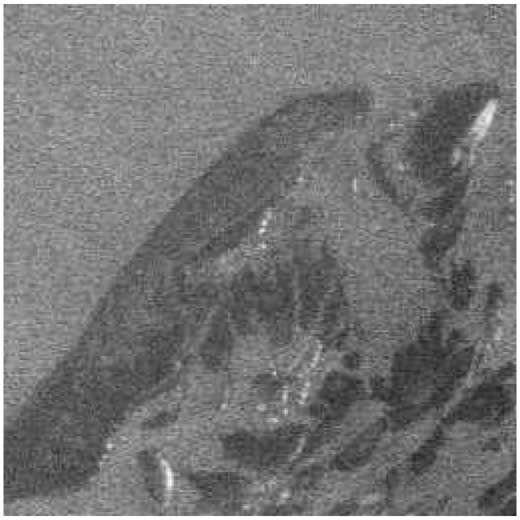


Figure 3. Block diagram of DCT-BAQ Algorithm

V. RESULTS AND CONCLUTION

We tested accuracy of the DCT-BAQ algorithm on ERS SAR image shown in figure 4.

In Figure 5 we can see SNR performance of both BAQ and DCT-BAQ algorithm for I and Q components of SAR raw data versus block size. Dynamic range reduction of transform domain coefficients improves compression performans about 10 dB.[11,12]



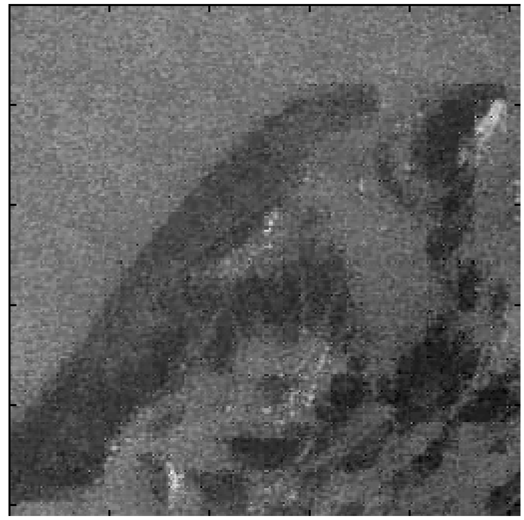


Figure 4. a) ERS SAR original image b) ERS SAR Decompressed image CR=3.55 DCT-BAQ SNR=23.1 dB

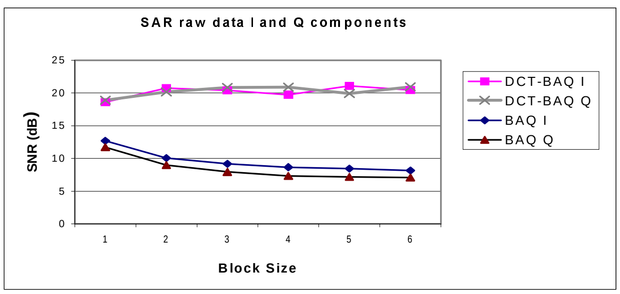


Figure 5. SNR performance of both BAQ and DCT-BAQ algorithm for I and Q components of SAR raw data versus block size

Compression ratio versus block size is shown for both BAQ and DCT-BAQ algorithms in Figure 6.For larger block size, performance of the compression ratio is 4.

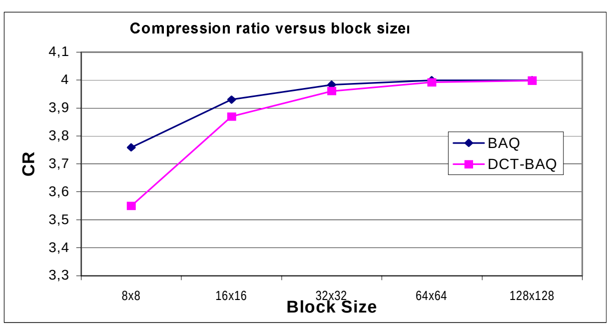


Figure 6 Compression ratio versus block size

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