Abstract

Synthetic Aperture Radar (SAR) systems have emerged during the last decade, as a useful tool to gather and to analyze information from the earth’s surface. Along with the success of SAR imaging systems and the large amount of data which they routinely produce, SAR data compression has begun to attract the attention of researchers seeking solution for different image transmission and storage.

This thesis is concerned with developing new SAR data compression schemes and address key characteristics of SAR images i.e. Speckle noise. The study involves spatial domain speckle filters for noise removal and extensive implementation of Block adaptive quantization, linear mapping technique and non-saturated scalar quantizer, with emphasis on quantization and bit allocation to compress SAR signal.

A SAR system is a sophisticated high resolution microwave remote sensing instrument capable of producing high resolution images from a moving platform either in space or in the atmosphere. As it is a self illuminating remote sensing technique, it offers the advantage over passive optical sensing of operating in either day or night and in all-weather. When such radar is placed on board a satellite, compression of the raw SAR signal is necessary to reduce the large amount of collected data; the downlink needs to transmit to a ground station within a restricted bandwidth. Due to noise like characteristics of the SAR images, there is a weakened inter-pixel correlation among the adjacent resolution cells in SAR images as compared to the optical images. The disadvantage of SAR is high noise to signal ratio- typically 1:1 as compared to 1:1000 for optical images. This speckle noise is an intrinsic part of any image formation process which uses coherent imaging. Hence, standard image data compression techniques like Joint Photographic Expert Group (JPEG), Embedded Zero tree Wavelet (EZW) and Efficient Pyramidal Image Coder (EPIC) used for optical images like Lena, bard etc., are not suitable for SAR images as they result blocking effects and do not preserve the edges.
After a general presentation of the SAR system and principles, the research investigates suitable spatial domain speckle filters for noise removal followed by implementation of various methods for coding of raw SAR data compression which are based upon suitable transforms of the complex raw data.

The traditional compression algorithm is the Block Adaptive Quantization (BAQ). The theoretical foundation of it is the Gaussian distribution of the raw SAR data. Standard BAQ technique and its different variants like Block Magnitude Phase Quantization (BMPQ), FFT-BAQ, Block Adaptive Histogram Equalization (BHEQ) and Block Adaptive Vector Quantization (BAVQ) are not very efficient in compacting energy specially when the input SAR data is heavily saturated or the standard deviation of the input signal is very high or there is some saturation with the receiver. In that case the SAR data is not Gaussian distributed and BAQ is not an optimum solution.

In the present thesis we have developed an algorithm for anti-saturation quantizer and done various iterations to optimize it. Design of Optimal Non-uniform Scalar Quantizer (ONSQ) has been done, which will be used while encoding and decoding the saturated SAR data. MATLAB based programming has been done for this purpose. We finish by developing an optimal algorithm which takes care of complete range of saturation degree (SD) of input SAR data. Experimental results show that the developed algorithm outperforms the standard BAQ and its variant algorithms at least by 2.5 dB as far as Signal to Noise Ratio (SNR) is concerned, even at 100% saturation of input data where it is nearly 0 dB by other algorithms.

The thesis also illustrates processing of the proposed algorithm for the point targets and has summarized the results in terms of Peak Side Lobe Ratio (PSLR), Integrated Side Lobe Ratio (ISLR) and Compression ratio (CR).

The programs, we have developed, in the thesis have several advantages as they are open source and easy to modify. The program is coded in MATLAB; therefore it
doesn’t need a vast programming knowledge to be able to customize it. We can run it on any platform that can run MATLAB 7+. For plotting purpose of various graphs and histograms, we have used ORIGIN 8.0 and Microsoft Excel as plotting tools.

At the end of the thesis, we suggest possible extensions for improving the coding performance as well as the reconstruction signal quality.