SAR Image Compression using SPIHT Algorithm

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ABSTRACT
This paper discusses the design and implementation of SAR image compression based on the set partitioning using hierarchical trees (SPIHT) coding algorithm. SAR images are considered in our work due to large scope in its application area which requires reduction i.e. is compression. As per the survey SPIHT algorithm has achieved prominent success in image compression. Here we use a modified version of SPIHT for two dimensional signals which is lossless. Set partition coding is a procedure that recursively splits groups of integer data or transform elements guided by a sequence of adaptive threshold, and presented in octree form**.**

Keywords
SPIHT ,lossless, lossy compression , SAR image and Adaptive thresholding.

1. INTRODUCTION
Data compression is the technique to reduce the redundancies in data representation in order to decrease data storage requirements and hence communication costs [1]. Reducing the storage requirement is equivalent to increasing the capacity of the storage medium and hence communication bandwidth. Thus the development of efficient compression techniques will continue to be a design challenge for future communication systems and advanced multimedia applications [2][3].Data can be called as a combination of information and redundancy. Information is the portion of data that must be preserved permanently in its original form in order to correctly interpret the meaning or purpose of the data. Redundancy is that portion of data that can be removed when it is not needed or can be reinserted to interpret the data when needed. Most often, the redundancy is reinserted in order to generate the original data in its original form. A technique to reduce the redundancy of data is defined as Data compression[2][3].There is two type of data compression lossless and lossy algorithms, lossless algorithm which can reconstruct the original data exactly from the compressed data, and lossy algorithms, which can only reconstruct an approximation of the original message [3]. In our work we have selected SAR image because it has large scope for compression and this image has varied affliction like security system for defense, for natural clamatics etc.

1.1 Need for Compression
Image compression is a method to represent a digital image with reduced amount of data. In Literature a wide range of image compression methods such as Transformation of data, the projective representation on a smaller set of data, and Encoding of the data using encoders are studied and reviewed [4]. Digital image compression aims at reducing the coding, inter pixel and psychovisual redundant information. The probability of occurrence of events (such as gray level values) can be used for the coding redundancy. For reducing the inter pixel redundancy the 2D pixel array that is normally used for human viewing and interpretation must be transformed into a more efficient format. This transformation is called reversible if the original image elements can be reconstructed from the transformed image. The psychovisual redundancies can be reduced using the fact that the human eye does not respond with equal sensitivity to all visual information [4]. Therefore, without significantly impairing the quality of the image perception, certain information can be eliminated.

1.2 SAR images
Synthetic-aperture radar (SAR) its consists of photographs of region of Earth or other planets made by means of artificial satellites[5]. Satellite images have many applications in agriculture, geology, forestry, biodiversity conservation, regional planning, education, intelligence and warfare. There are also elevation maps, usually made by radar imaging. Interpretation and analysis of satellite imagery are required by many agencies for major decision like knowing weather forecast, defense. Image resolution of SAR in its range coordinate (expressed in image pixels per distance unit) is mainly proportional to the radio bandwidth of whatever type of pulse is used [5].There are four types of resolution when discussing satellite imagery in remote sensing: spatial, spectral, temporal, and radiometric. Radiometric resolution refers to the effective bit-depth of the sensor (number of grayscale levels) and is typically expressed as 8-bit (0-255), 11-bit (0-2047), 12-bit (0-4095) or 16-bit (0-65,535). Geometric resolution refers to the satellite sensor's ability to effectively image a portion of the Earth's surface in a single pixel and is typically expressed in terms of Ground Sample Distance [5].

2. STAGES

In our work the concentration is on each band of the SAR image just to get more information about each one therefore we followed many stages to know which band and it's importance in our work.

2.1 Adaptive Thresholding

It is the simplest method of image segmentation [6].During the thresholding process, individual pixels in an image are marked as "object" pixels if their value is greater than some threshold value (assuming an object to be brighter than the background) and as "background" pixels otherwise [6]. The key parameter in the thresholding process is the choice of the threshold value (or values, as mentioned earlier). Several different methods for choosing a threshold exist, thresholding algorithm can compute a value automatically, which is known as automatic thresholding [6].and the below algorithm show the steps of selective threshold value.

2.1.1Select Threshold value Algorithm

1- Select a general Threshold value for input image by take the maximum and minimum and take the average of it as initial threshold value.
2- Compute the average of the pixels at or below the initial threshold and pixels above of it.
3- Compute the average of below and above by this formula
Av= (above + below)/2 …….. (1)
And consider it as a threshold value.
4- Now all values or pixels at or below the threshold (which computed in step no 3) become 0 and pixels above become 1.

We sub banded the image into three layers Red and Green and Blue and for each band we apply the above algorithm just to a count the number of object in the image that we will consider for compression.

2.2 Statistical measures (Mean and Standard Deviation)

We have computed the mean and standard deviation for all our image for each band R,G and B just we want to know at which band we have the higher information for compression ,and neglect the band those don't have much information for compression, The mean is the arithmetic average of a set of values, or distribution [7], and it can be computed by using equation (2).

$$\mu = \frac{1}{N} * \frac{1}{M} \sum_{i=1}^{N} \sum_{j=1}^{M} x(i,j) \quad \text{.... (2)}$$

The standard deviation is kind of the "mean of the mean," and often can help you find the story behind the data ,that is complete detail [8].

$$\sigma = \sqrt{\frac{1}{N} * \frac{1}{M} \sum_{i=1}^{N} \sum_{j=1}^{M} (x(i,j) - \mu)^2} \quad \text{..... (3)}$$

Table (1) and (2) show the result of Mean and standard deviation of our SAR images.

Table (1) Mean values of our SAR image

Id	Name of image	color	Red	Green	Blue
1	Baghdad	89.7571	91.5813	97.5841	80.1061
2	Delhi	111.7216	118.1786	119.2261	97.7602
3	Cairo	110.8211	113.8071	116.8199	100.3396
4	Paris	99.9737	104.0691	103.9315	91.9205

Table (2) standard deviation values of our SAR image

Id	Name of image	color	Red	Green	Blue
1	Baghdad	36.7853	37.5878	35.6273	34.9226
2	Delhi	45.8225	44.5214	42.8557	46.7698
3	Cairo	37.4700	38.3698	34.6660	37.4316
4	Paris	48.1371	49.7630	47.0327	46.5383

2.3 Entropy

Entropy is a measure of how evenly energy is distributed in a image or data , entropy provides a measure of the amount of energy that cannot be used to do work[8].

$$e = -\sum_{i=1}^{L} P(z_i) \log P(z_i) \quad \text{.... (4)}$$

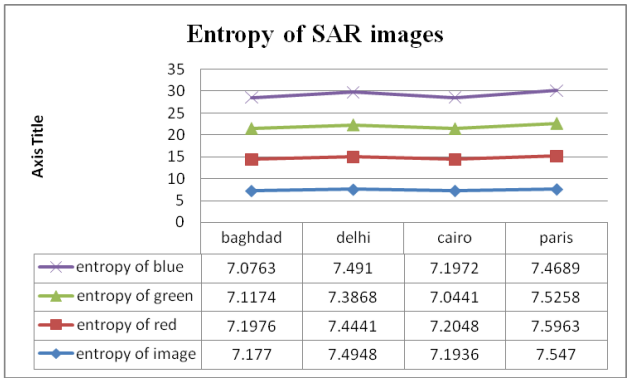

Figure (1) Entropy of our SAR image

2.4 Compare and reconstruction

Reconstruction is the construction of image in where trying to get the original quality image from the segment of the original image used for comparing the data (image).

2.4.1 Approach for reconstruction

We have used three different approaches in our work: first ignore the maximum entropy band from the SAR image, and second one ignore the minimum entropy band and for getting best quality take all combination of the image[1].

2.4.1.1 Ignore maximum entropy band

In this Approach first we have calculate the entropy value of each band by using entropy formula equation (4), and then check this values which one it has maximum value then we will ignore it by ignore his band, in our work we have used four SAR images for each one we checked the maximum entropy value and ignore that band, and calculate the MSE and PSNR of all images .and table (3) and table (4) show the result of MSE and PSNR.

2.4.1.2 Ignore minimum entropy bands

In this Approach we have ignore the minimum entropy band from our SAR image and check the MSE and PSNR of result image compare with the original, and table (3)and (4) show the result of ignoring the minimum band from all our SAR image.

2.4.1.3 All combination

In this Approach we work with: ignore Red band from all our SAR image and then ignore Green band and finally ignore Blue band and get the result and table (3) and (4) show the result.

2.4.2 MSE (Mean Square Error)

The mean squared error (MSE) of an estimator is one of many ways to quantify the difference between values implied by an estimator and the true values of the quantity being estimated. MSE measures the average of the squares of the "errors." The error is the amount by which the value implied by the estimator differs from the quantity to be estimated. The difference occurs because of randomness or because the estimator doesn't account for information that could produce a more accurate estimate.

$$MSE = \frac{1}{M * N}\sum_{i=1}^{M}\sum_{j=1}^{N}[x(i,j) - y(i,j)]^2 \quad \text{.... (5)}$$

Where
M, N: size of the image
X(i ,j):original image
Y(i,j):result image

2.4.3 PSNR (Peak Signal in Noise Ratio)

Peak signal-to-noise ratio is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale .The PSNR is most commonly used as a measure of quality of reconstruction of lossy compression code (e.g., for image compression). The signal in this case is the original data, and the noise is the error introduced by compression. When comparing compression codecs it is used as an *approximation* to human perception of reconstruction quality, therefore in some cases one reconstruction may appear to be closer to the original than another, even though it has a lower PSNR (a higher PSNR would normally indicate that the reconstruction is of higher quality). One has to be extremely careful with the range of validity of this metric; it is only exclusively valid when it is used to compare results from the same codec (or codec type) and same content.

$$PSNR = 10 * \log_{10}\left(\frac{255^2}{MSE}\right) \text{.... (6)}$$

3. RESULTS

Table (3) MSE of image and select min and max bands

id	Image name	Ignore red	Ignore green	Ignore blue
1	Baghdad	3.2667e+003	3.597e+003	2.5455e+003
2	Delhi	5.2840e+003	5.3139e+003	3.8785e+003
3	Cairo	4.8081e+003	4.9495e+003	3.8231e+003
4	Paris	4.3636e+003	4.2730e+003	3.4804e+003

Table (4) PSNR of image and select min and max bands

Id	Image name	Ignore red	Ignore green	Ignore blue
1	Baghdad	12.9898	12.5710	14.0730
2	Delhi	10.9012	10.8767	12.2441
3	Cairo	11.3111	11.1852	12.3067
4	Paris	11.7324	11.8234	12.7145

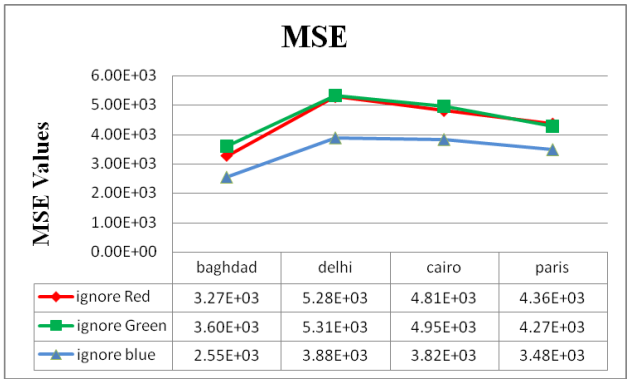

Figure (2) MSE of our SAR image

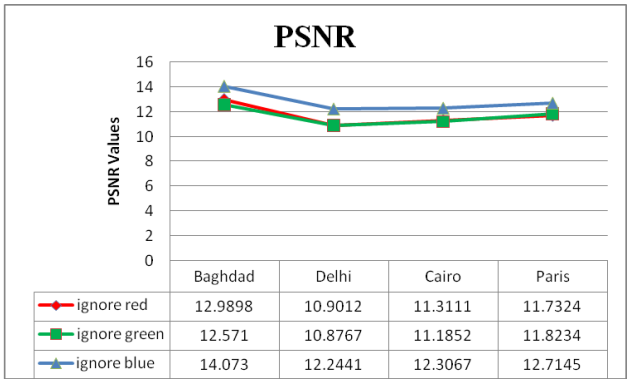

Figure (3) PSNR of our SAR image

in our work we have take the maximum and minimum entropy bands and ignore the reminder , and in reconstruction part we generate this band by take the average value of minimum and maximum band for each pixel and the figure (4) show the original SAR image and the image after reconstruction, and table(5) show the result.

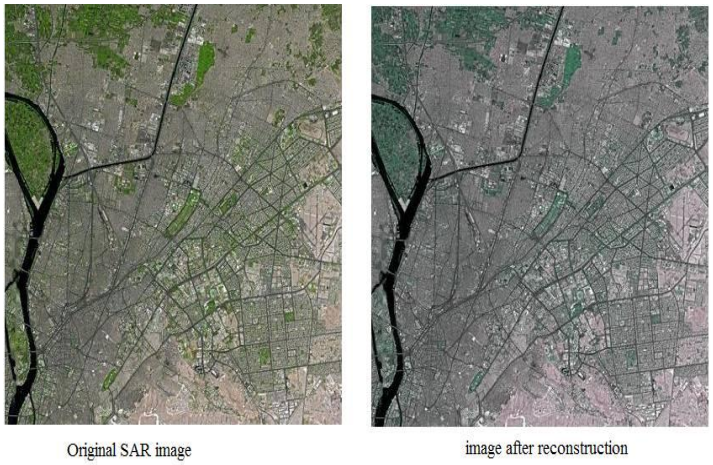

Figure (4) image and image after decompression

Table (5) MSE and PSNR of original image and image after decompression

Id	Name of image	Minimum	Maxim _um	ignore	MSE	PSNR
1	Baghdad	Blue	Red	Green	53.0197	30.8864
2	Delhi	Green	Blue	Red	18.0778	35.5593
3	Cairo	Green	Red	Blue	104.7109	27.9309
4	Paris	Blue	Red	Red	17.4352	35.7165

4. CONCLUSION

Compression is of great interest to many researchers, commercial people or educationist due to the cost and efficiency required for designing and deploying an application. Image compression is one of such area of importance because many image that transmits information through internet requires it's compression ,and because daily we are using the MMS and GPRS that's why size of image its important ,while sending image with big size throw GPRS its costly and for MMS there are limitation to size of image we can send it, and about our algorithm Set Partitioning in Hierarchical Trees (SPIHT) is a simple and efficient algorithm with many unique and desirable properties , Idem potency lossless re-compression at same bit rate ,our algorithm gives the base or initial threshold which can be considered as adaptive for further processing**.**

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6. REFERENCES

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