Comparison between Different Data Image Compression Techniques Applied on SAR Images

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Abstract
In this paper, image compression technique is presented based on the Zonal transform method. The DCT, Walsh, and Hadamard transform techniques are also implements. These different transforms are applied on SAR images using Different block size. The effects of implementing these different transforms are investigated. The main shortcoming associated with this radar imagery system is the presence of the speckle noise, which affected the compression results.

مقارنة بين تقنيات مختلفة لضغط بيانات الصور مطبقة على صور (SAR)

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الخلاصة:
في هذا البحث، تم استخدام تقنيات لضغط الصور وقد تم الاعتماد على طريقة التحويل الموضعي (Zonal Transform وتم تطبيق هذه التقنية على الصورالرادارية ذو الفتحة التركيبية (SAR). لقد استخدمت تقنيات تحويل الجيب تمام المجزأ، تحويل ويلش، وأيضا" تم استخدام طريقة تحويل هادمرد في عملية الضغط. استخدمت بلوكات ذات أحجام مختلفة. ولقد تم التحقق من تأثيرات تطبيق الأنواع المختلفة من التحويلات في عملية الضغط. أن المساوئ الرئيسية المتعلقة بنظام الصور الرادرية هو ظهور الضوضاء النقطية والتي تؤثر على نتائج الضغط.

Introduction

Modern radar systems are designed to perform a multitude of functions ranging from target location to mapping large areas of planetary surfaces [1]. The mapping function is performed by synthetic-aperture radar (SAR), which measure the radar reflectivity of a terrain by illuminating the scene with coherent electromagnetic radiation at a wavelength λ and measuring the power returned in the echo signal [2]. Imaging radars (specifically side - looking radars) transmit pluses of energy though antenna radiating in the direction orthogonal to the motion of the sensor plot form and record the reflected signal [2][3]. The extent to which terrain information can be extracted from a SAR image depends on the radiometric and spatial resolution of the system. Radiometric resolution determines the accuracy with which the radar reflectivity of a target can be measured from the SAR image, while the spatial resolution is a measure of the accuracy with which the physical dimensions of an object can be determined [4,5].

The Synthetic Aperture Radar (SAR) is considered as an effective scanning system for the earth surface. It is operated using coherent electromagnetic wave (EMW) that lies in the range microwave (MW). The main shortcoming associated with this imaging system is the speckle noise.

Since (SAR) images have been found as to be an important source of visual data, for various applications, therefore, recently, much attention has been deported to study and analyze these types of images [6].

Zonal Coding:

The coding can be accomplished by pointing the coefficients of high energy in each block, which is limited by constant engineering locations in each block of the image. The coordinates of these locations are dependent on the transform that used within the Zonal code. For example the locations of high energy in DCT are consternated in the upper left corner in the transform block. The energy of coefficients decreased as we go far a way from the upper-left-block corner. In this way the most coefficients that place far from the corner having low energy could be discarding. For example 75% of the transform coefficient may be discarded without observing deformation quality in the coded image. There are many adaptive methods in the Zonal transform coding. One of these methods accomplished by coding only the transform coefficients with high energy using one of the following equations [7,8].

$$Nb(u,v)= round\ [av+1/2\ \log_2(\sigma^2(u,v))-1/2N^2 \sum_{u=0}^{N-1}\sum_{v=0}^{N-1} \mathrm{Log}_2(\sigma^2(u,v))] \qquad (1)$$

$$Nb(u,v)= round\ [av+1/2\ \log_{10}(\sigma^2(u,v))-2/N^2 \sum_{u=1}^{N}\sum_{v=1}^{N} \mathrm{Log}_{10}(\sigma^2(u,v))] \qquad (2)$$

where:

$Nb(u,v)$:represent the bits required to represent the transform coefficient,

av: represents the bits required to represent each elements of the image, $(N\times N)$ represent the block size, $\sigma^2(u,v)$ represents the variance of the transform coefficients in all image blocks located in point (u,v). In this way it is possible to point which coefficients should be discarded, using:

$$F(u,v)= \begin{cases} 0 & Nb(u,v) \le 0 \quad \text{Discard coeficient} \\ F(u,v) & Nb(u,v) > 0 \quad \text{Coded coefficient} \end{cases} \qquad (3)$$

After that the pointed transform coefficients will be quantize according to the following equation:

$$L(u,v)=2^{Nb(u,v)} \qquad (4)$$

Normally, Non-uniform quantization method is performed to rounding off the transformed, retained coefficients. This type of quantization utilize the Probability density form (Pdf) of the transformed coefficients, see Lloyed-Max Quantizer [9-11].

Walsh Transform

In 1923, Joseph L. Walsh introduced a new-completed set of orthogonal function [12]. A set rectangular wave forms are formed from Walsh function which are taking only two amplitude value, i.e., 1 and -1 defined over a limited time interval, and hence multiplication by Walsh functions involves only algebraic sign a assignment [13,14]. The two -dimensional forward and inverse pairs of Walsh transform functions are given by:

$$W(u,v)=\frac{1}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\prod_{i=0}^{n-1}(-1)^{[bi(x)*b(u)_{n-1-i}+bi(y)_{n-1-i}*b(v)]} \quad (5)$$

and

$$f(x,y)=\frac{1}{N}\sum_{u}^{N-1}\sum_{y=0}^{N-1} f(x,y)\prod_{i=0}^{n-1}(-1)^{[bi(x)*b(u)_{n-1-I}+bi(y)_{n-1-i}*b(v)]} \quad (6)$$

Where bi(x) represents the i^th bit in binary form of the x value. The Walsh transform Kernels is separable and symmetric [15].

Hadamard Transform

Hadamard transform can be considered as a sub-optimal transform because of the simple performance. The two-dimensional Hadamard transform has been very successfully employed in reducing the amount of digital data needed to adequately represent two-dimensional image [16]. The main advantage of Hadamard transform is complex multiplication operations are replaced by sign changes [15,17]. The disadvantage of this transform is can not be performed by first algorithm as the FFT and FWT, but it can use a simple recursively method to generate the transform array with high orders from the transform array of low orders. The simple order with Hadamard array when N=2 is given as:

$$H2 = \begin{Bmatrix} 1 & 1 \\ 1 & -1 \end{Bmatrix} \quad (7)$$

By using the following recursive relation, the transform array can be created for any requested high order.

$$H2m = \begin{Bmatrix} Hm & Hm \\ Hm & -Hm \end{Bmatrix} \quad (8)$$

Where m represents any real number larger than one[18].The two dimensional forward Hadamard transform is given by:

$$H(u,v)=\frac{1}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)(-1)^{\sum_{i=0}^{n-1}[bi(x)bi(n)+bi(y)bi(v)]} \quad (9)$$

While the inverse Hadamard transform is given by:

$$f(x,y)=\frac{1}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} H(u,v)(-1)^{\sum_{i=0}^{n-1}bi(x)bi(u)+bi(y)bi(v)]} \quad (10)$$

Because the forward and inverse transform are identical a similar procedure can be used for computing both H(u,v) and f(x,y). Hadamard Kernels are separable and symmetric, therefore, rows and columns are orthogonal and the two-dimensional Hadamard transform pair can be obtained by successive applications of any one-dimensional Hadamard transform depending on the separable property [17]. The Kernel matrix of the transformation consists only +1, -1 value, only additions and multiplication are required [19].

DCT-Based Transform

The DCT is a fast transform with complexity of O (NlogN), it gives real values which correspond to the frequency content of the signal, it work extremely well with high correlated data [21]. One version of the DCT is the JPEG (Joint Photographic experts Group) compression-scheme, which is one of the most popular transforms for lossy compression of images, since it is being so famous in the field, DCT in the new literature is often referred to as, JPEG, or the JPEG- DCT [22,20].

The purpose of image coding is to represent the image with a fewer number of bits, while maintaining the visual quality of the image. Image transforms have been widely used to implement image coder. Image transforms are useful for coding, since images generally have a compact representation in the transform domain[21]. The two-dimensional forward discrete cosine transform is given by [23-25].

$$C(u,v)=\frac{1}{2N3}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\,[\cos(2x+1)\frac{4}{N}\pi][\,[\cos(2y+1)\frac{4}{N}\pi] \qquad (11)$$

The inverse cosine transform is given by:

$$f(x,y)=\frac{1}{2N3}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} C(u,v)\,[\cos(2x+1)\frac{4}{N}\pi][\,[\cos(2y+1)\frac{4}{N}\pi] \qquad (12)$$

The Experimental Work

From the results of the experimental work, Fig. (1) Showed three set of SAR images, image (a) is a SAR image using the Zonal compression with DCT. (b) Zonal compression with Walsh transform, (c) Zonal compression with Hadamard transform. In Fig. (1) we see that the PSNR of the image that use the DCT is better than the PSNR with the images (b) and (c) so the MSE of image (a) is less than the others. (a1) (b1) (c1) are the histogram of (a) (b) (c), these histograms of the three SAR images show the relationship between the data values and the frequency of these values. The value of block size is 4 the compression ratio is 2. Fig. (2) and Fig. 3 are the same Fig. 1 except the value of block size and the compression ratio are 8, 4, 16, 6 respectively.

Conclusions

1. The relationship between the compression ratio and the block size is proptional, so when the block size increase the compression ratio will be increase so the PSNR of the image will be decrease and the MSE will be increase, and verse versa.
2. When the zonal compression with DCT on the SAR image is applied, it can be seen that the PSNR of the image is better than the PSNR of the image that the Walsh and the Hadamard are applied on them.
3. From the comparison between the results of the PSNR and the MSE of the SAR image, it cleared that the Walsh transform is better than the Hadamard transform, i.e. the noise block of the images is very high with Walsh transform.
4. From the results of this type of images (SAR images), it can be seen that the noise block of the compression images is clear with Fig. (2) and Fig. (3), i.e. the optimal results appear with Fig. (1) With block size=4 and comp. ratio=2.

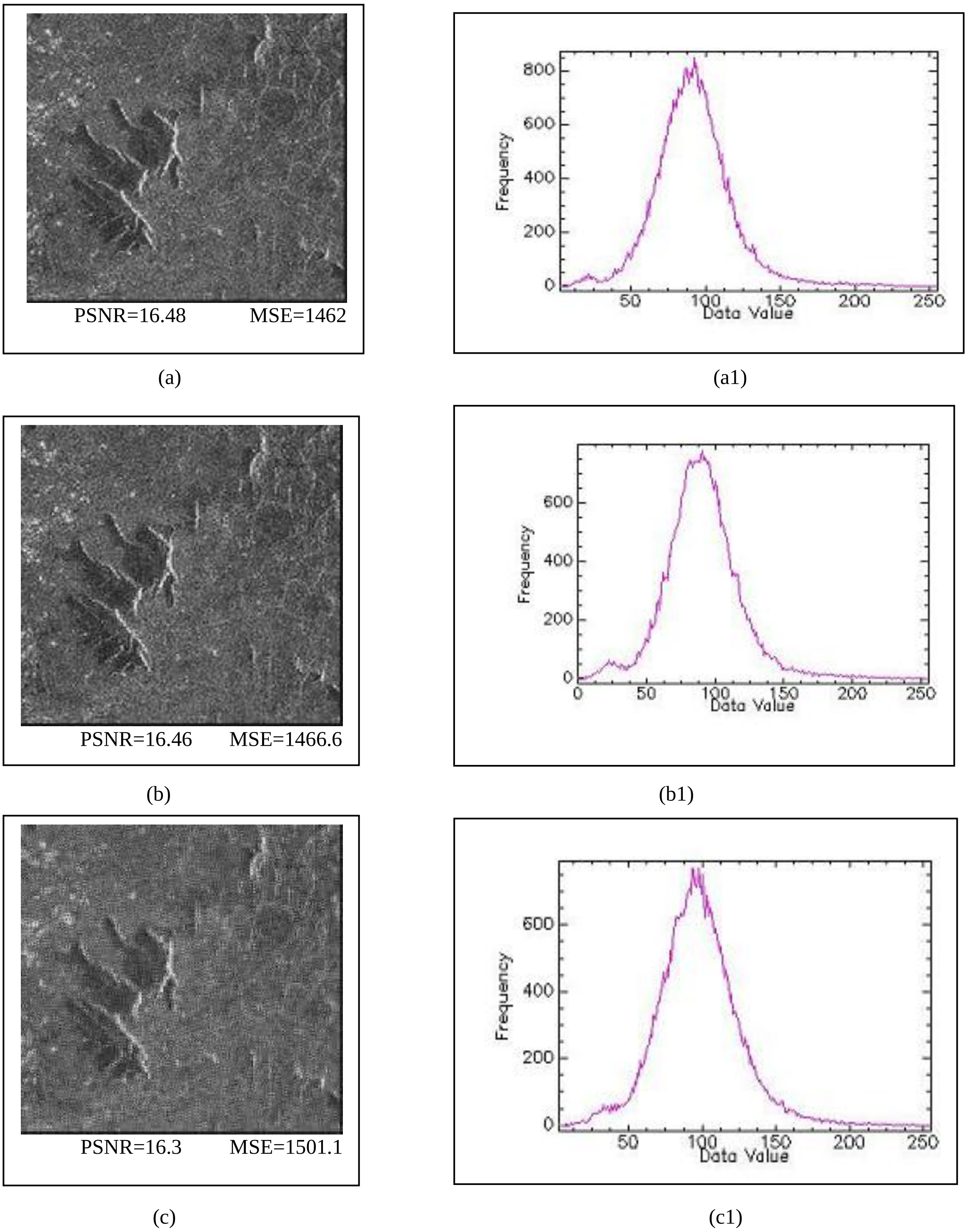
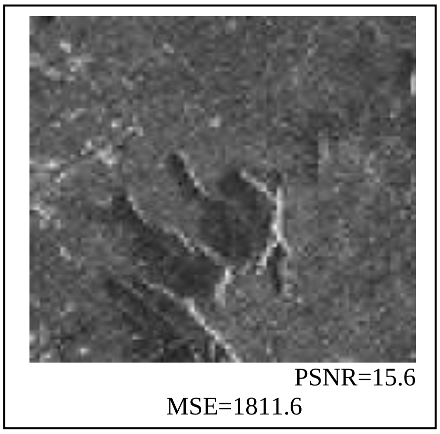
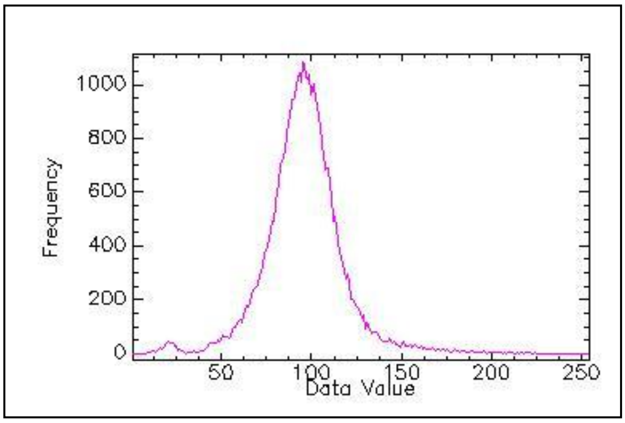


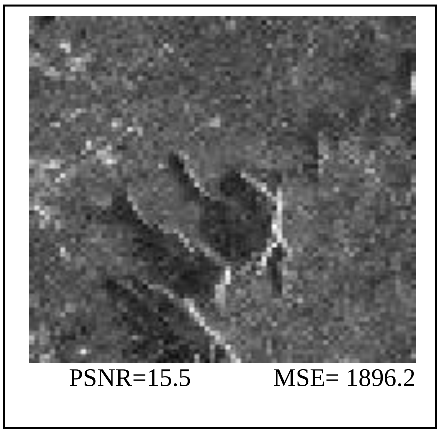
Fig. (1): Refer to the SAR images after the compression using (a) DCT (b) Walsh transform (c) Hadamard transform with block size=4 and comp. ratio=2. (a1) (b1) (c1) are the histograms of SAR images.



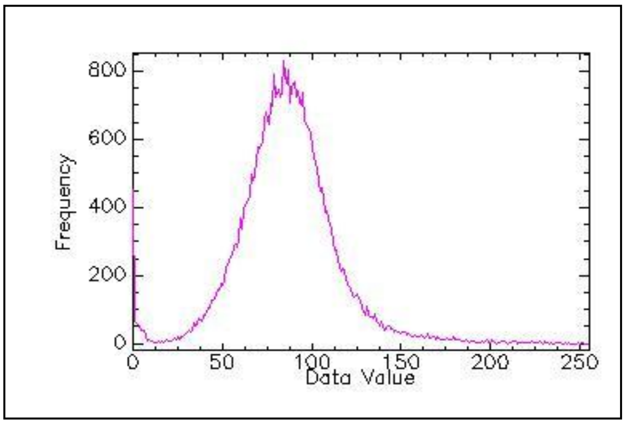
(a)



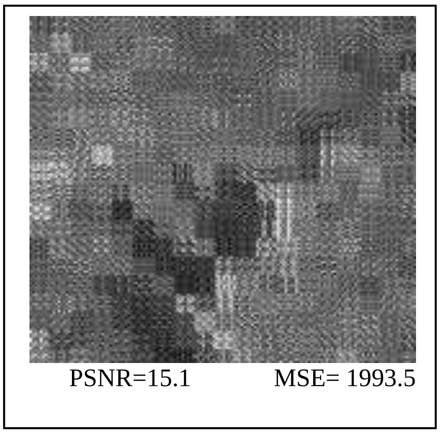
(a1)



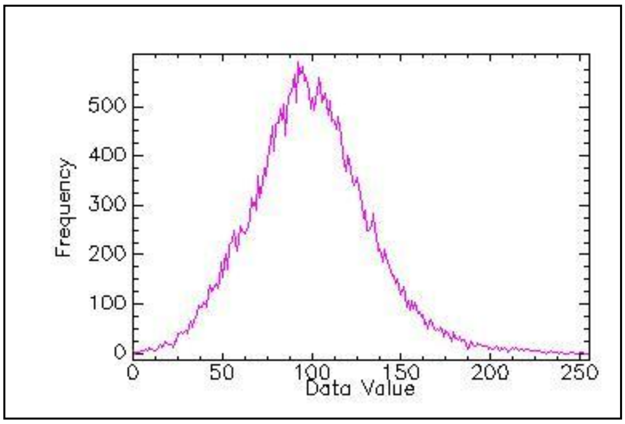
(b)



(b1)

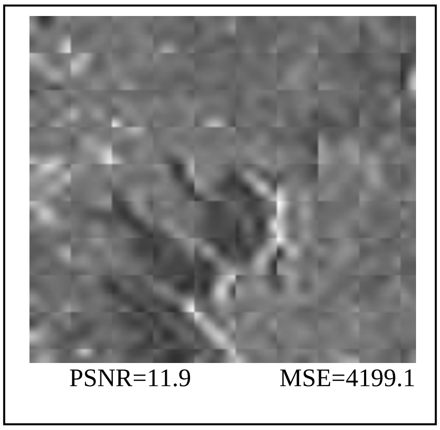


(c)

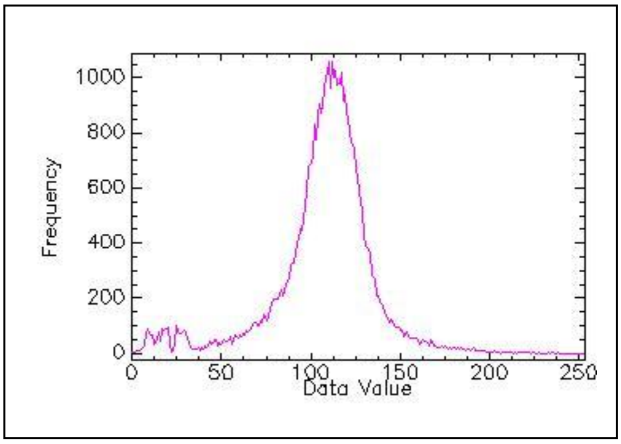


(c1)

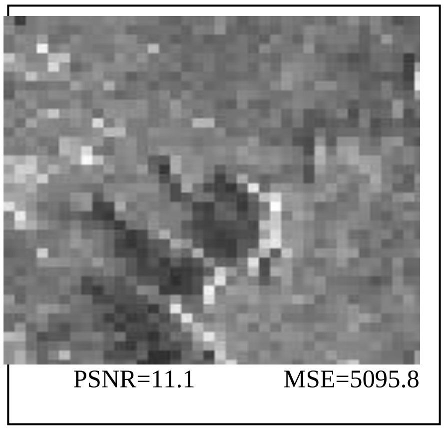
Fig.(2): Refer to the SAR images after the compression using (a) DCT (b) Walsh transform (c) Hadamard transform with block size=8 and comp. ratio=4. (a1) (b1) (c1) are the histograms of SAR images.



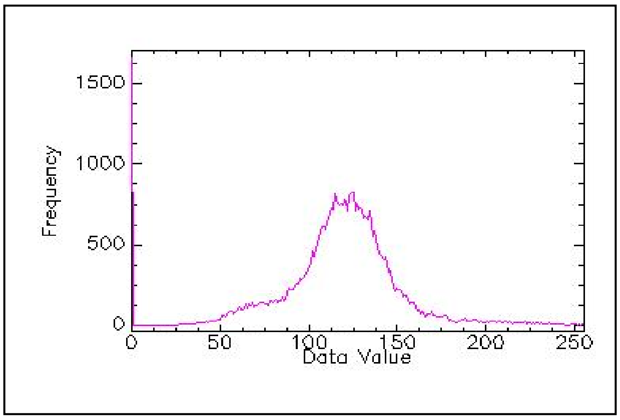
(a)



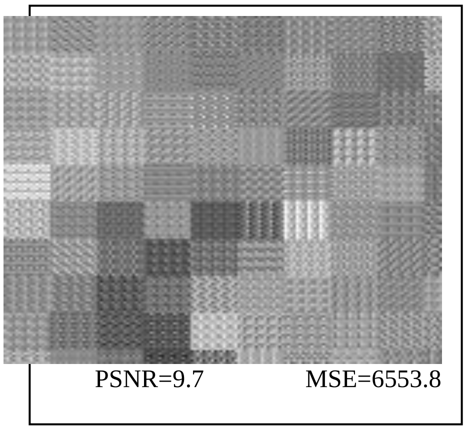
(a1)



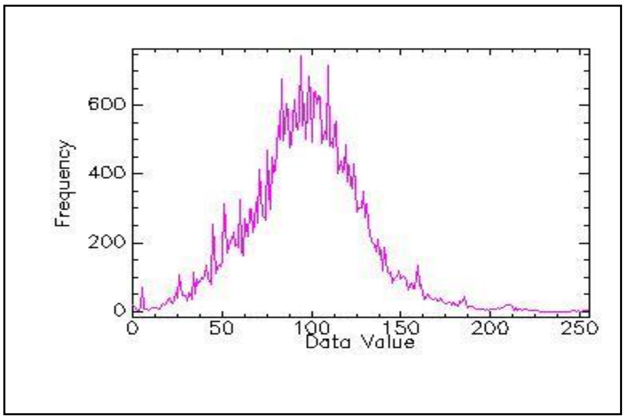
(b)



(b1)



(c)



(c1)

Fig.(3): Refer to the SAR images after the compression using (a) DCT (b) Walsh transform (c) Hadamard transform with block size=16and comp. ratio=16. (a1) (b1) (c1) are the histograms of SAR images.

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