# Segmentation Based Multilevel Wide Band Compression for SAR Images Using Coiflet Wavelet

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**Abstract**

Synthetic aperture radar (SAR) data represents a significant resource of information for a large variety of researchers. Thus, there is a strong interest in developing data encoding and decoding algorithms which can obtain higher compression ratios while keeping image quality to an acceptable level. In this work, results of different wavelet-based image compression and segmentation based wavelet image compression are assessed through controlled experiments on synthetic SAR images. The effects of dissimilar wavelet functions, number of decompositions are examined in order to find optimal family for SAR images. The choice of optimal wavelets in segmentation based wavelet image compression is coiflet for low frequency and high frequency component. The results presented here is a good reference for SAR application developers to choose the wavelet families and also it concludes that wavelets transform is rapid, robust and reliable tool for SAR image compression. Numerical results confirm the potency of this approach

**Keywords:** Image Processing, Compression, Segmentation, Wavelets, Quality Measures, SAR Images

## 1. INTRODUCTION

The necessity of efficient and consistent compression techniques for remote sensing imagery is increasing rapidly on the bases of network transmission [2]. In image processing domain the neglection of peculiar characteristics of the data accounts a lot in poor recognition system [9]. The usual approach to deal with this problem is to resort to edge-preserving filters. Segmentation, compression and filtering should be carried out jointly for extraction and better representation of most relevant features. Therefore a fundamental approach to image filtering and compression requires the prior segmentation of the image in homogeneous regions [5].This work includes the strong background of research result proposed by Zhaohui Zeng and Ian Cumming for SAR image compression using DWT [15]. Here wavelet-based despeckling is used implicitly to distinguish between noise components (high and low) and its state boundaries[4][2]. This work aims at studying and quantifying the potential advantages provided by wavelet towards segmentation based image compression. This work is investigated from few SAR image collections like ERS Synthetic Aperture Radar (SAR) imagery , ESA,JERS and radarsat . The paper follows as. Section 2 explains the compression schemes needed for SAR segmentation. Section 3 deals with wavelet analysis and its metrics which comprises the performance measures of wavelet families. Section 4 describes the compression coding schemes based on segmentation. Section 5 presents and discusses the results of a number of experiments, and Section 6 draws conclusions with possible scenario.

## 2. SAR IMAGE WAVELET COMPRESSION

In the scientific literature concerning SAR system, the term compression is often used to indicate the data processing which allows focusing the received echoes. SAR domain compression[3][14] is carried out off-line at the base station, which can leverage on more time and computation power. So image compression became an operating instrument, for scientific research[9]. In basic literature evaluation is done on quality metrics, neglecting the visual effects and the consequences on the image interpretability. In order to attain above conditions and limitations of SAR, new compression techniques on wavelet transform is characterized with good time-frequency localization, multiresolution representation low-complexity implementation through filter banks [5]. Since the wavelet transform is a bandpass filter with a known response function (the wavelet function), it is possible to *reconstruct* the original time series using either deconvolution or the inverse filter [15]. This is straightforward for the orthogonal wavelet transform (which has an orthogonal basis), but for the continuous wavelet transform it is complicated by the redundancy in time and scale. However, this redundancy also makes it possible to reconstruct the time series using a completely different wavelet function, the easiest of which is a delta (δ) function[1]. In this case, the reconstructed time series is just the sum of the real part of the wavelet transform over all scales which is stated in eqn(1)

$$x_n = \frac{\delta_j \delta_t^{1/2}}{C_\delta \psi_0(O)} \sum_{j=0}^{J} \frac{\Re\{W_n(s_j)\}}{s_j^{1/2}} \quad \text{----(1)}$$

The factor $\psi_n = (0)$ removes the energy scaling, while the $s_j^{1/2}$ converts the wavelet transform to an energy density. The factor $C_\delta$ comes from the reconstruction of a δ function from its wavelet transform using the function $\psi_n = (n)$. This $C_\delta$ is a constant for each wavelet function .Note that if the original time series was complex, then the sum of the complex $W_n(s)$ would be used instead [3][5]. To derive $C_\delta$ for a new wavelet function, first assume a time series with a δ function at time $n$ = 0, given by $x_n = \delta_n$. This time series has a Fourier transform $s\omega_k$ = $N$-1, constant for all $k$. Substituting $s\omega_k$ into (1), at time $n$ = 0 (the peak), the wavelet transform becomes

$$W_\delta(S) = \frac{1}{N}\sum_{k=0}^{N-1} \hat{\psi}^*(s\omega_k) \text{---------------------- (2)}$$

The reconstruction eqn (2) then gives eqn (1) .The $C_\delta$ in eqn (1) is scale independent and is a constant for each wavelet function.

$$\sigma^2 = \frac{\delta_j \delta_t}{C_\delta N} \sum_{x=0}^{N-1} \sum_{j=0}^{J} \frac{\left|W_n(s_j)\right|^2}{s_j} \text{-------(3)}$$

The total energy is conserved under the wavelet transform, and the equivalent of *Parseval's theorem* for wavelet analysis is given in eqn(3).Both eqn (1) and eqn (3) should be used to check wavelet routines for accuracy and to ensure that sufficiently small values of $s_j$ and $\delta_j$ *have* been chosen.

## 3. WAVELET ANALYSIS

This section describes the method of wavelet analysis, includes a discussion of different wavelet functions, and gives details for the analysis of the wavelet power spectrum. Results in this section are adapted to Segmentation based wavelet compression from the continuous formulas given in coiflets. The wavelet bases performed over SAR images are as follows. Haar wavelet is the simplest of the wavelet transforms[10]. This transform cross-multiplies a function against the Haar wavelet with various shifts and stretches, like the Fourier transform cross-multiplies a function against a sine wave with two phases and many stretches. Daubechies wavelets are a family of orthogonal wavelets defining a discrete wavelet transform and characterized by a maximal number of vanishing moments for some given support. Meyer's wavelet construction is

fundamentally a solvent method for solving the two-scale equation. Symlet wavelet is only nearly symmetric, and is not exactly symmetrical. Coiflets are discrete wavelets designed by Ingrid Daubechies, to have scaling functions with vanishing moments. Biorthogonal wavelet is a wavelet where the associated wavelet transform is invertible but not necessarily orthogonal. Reverse biorthogonal is a spline wavelet filters.
To verify the validity of the wavelet families the results are compared based on PSNR ratio and MSE. With the extension of the work, subjective evaluation is also done based on the decomposition level. Compression is been the main phenomena for the evaluation job [8][12]. The DWT was used with coiflets, least asymmetric compactly-supported wavelet with eight vanishing moments with four scales. The 120 x 120 pixel region SAR images are used for applying wavelet families. They were contaminated with speckle noise[2][3].

Some of the parameters taken for analysis of wavelet on SAR images are Mean Square Error, Peak Signal to Noise Ratio, Compression Score and Recovery Performance.

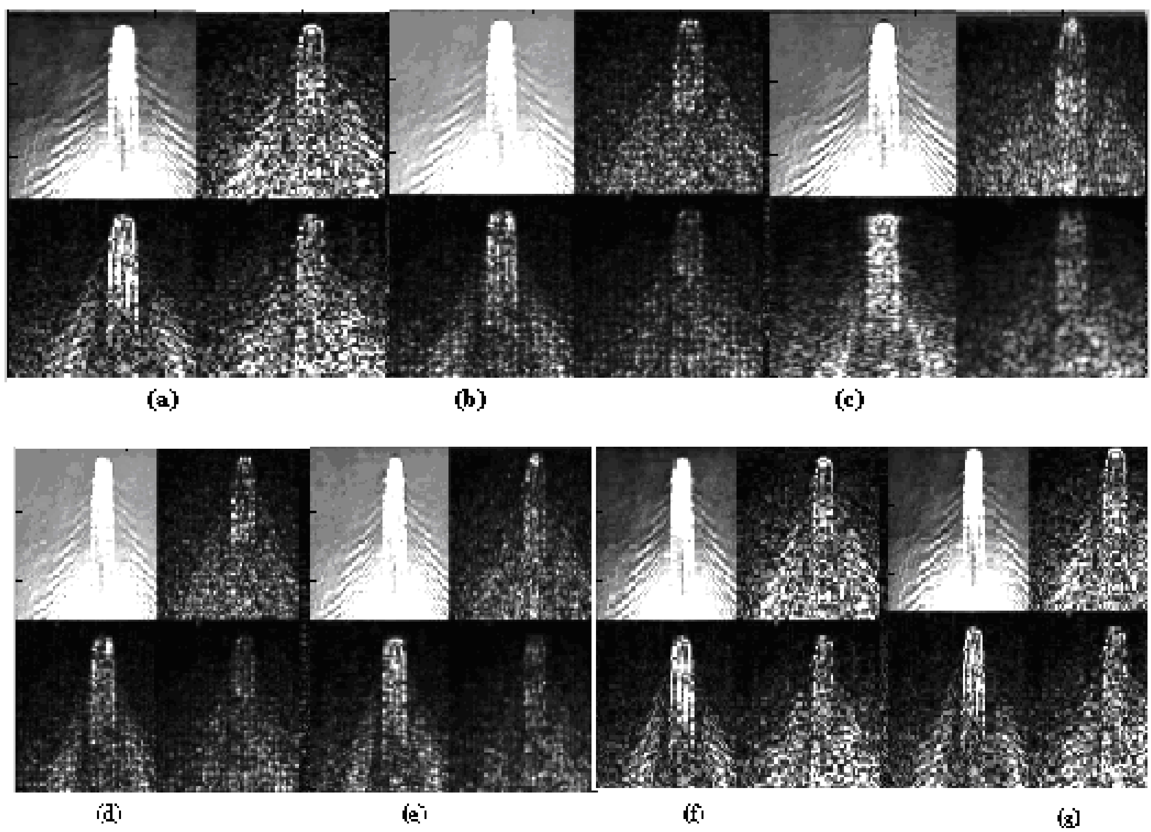


**FIGURE 1:** (a)Haar wavelet (b) Daubechies wavelet (c) Meyer Wavelet (d) Symlet wavelet (e) Coiflets wavelet (f) Bi orthogonal wavelet (g) Reverse Bi orthogonal

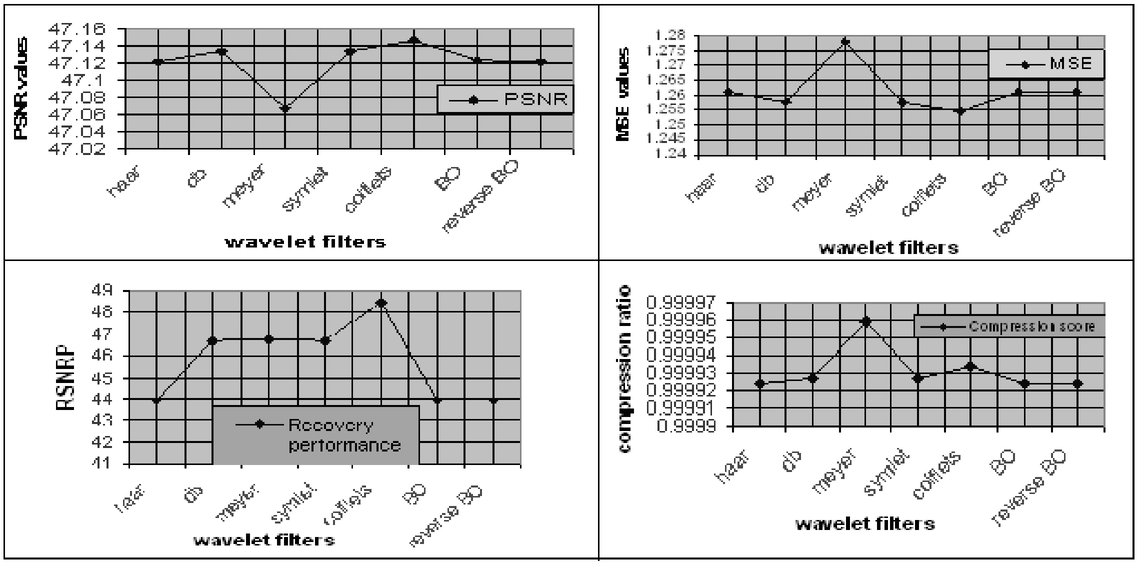


**FIGURE 2:** (a) Peak Signal to Noise Ratio (b) Mean Square Error Rate (c) Recovery Performance (d) Compression Score

A sample of one SAR image is subjectively explained by the results in the above figure (1) and objectively in figure (2). From the above got results the coiflets of wavelet families out performs the rest of the wavelet families.

## 4. SEGMENTATION BASED WAVELET COMPRESSION

The idea behind wavelet image compression, like that of other transform compression techniques is, it removes some of the coefficient data from the transformed image [8]. Encoding may be applied to the remaining coefficients. The compressed image is reconstructed by decoding the coefficients, if necessary, and applying the inverse transform to the result[17]. No much image information is lost in the process of removing transform coefficient data.

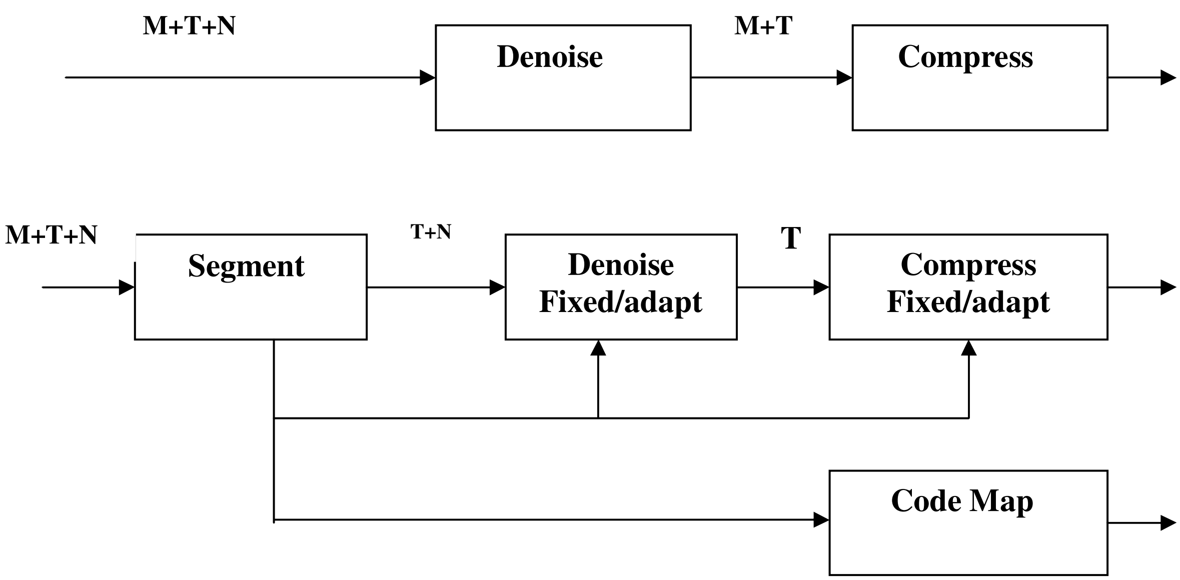


**FIGURE 3:** Segmentation based encoding schemes

This process of image compression through transformation and information removal provides a useful framework for understanding wavelet analysis[8]. Mathematical references develop multiresolution analysis through the definition of continuous scaling and wavelet functions[18]. In order to compare the performance of wavelet and contourlet transform in our proposed compression scheme, we compute the compression ratios (CR) for various quantization levels. CR is defined as the ratio between the uncompressed size and the compressed size of an image [13]. To compute the CR in a fairly way, the original image is encoded using the resulting number of bits it saved. This compression eliminates almost half the coefficients, yet no detectable deterioration of the image appears. The compression procedure contains three steps: (i) Decomposition. (ii) Detail coefficient thresholding[16] ,for each level from 1 to N, a threshold is selected and hard thresholding is applied to the detail coefficients, and(iii) Reconstruction.

## 5. PERFORMANCE EVALUATION

Fig 4 and 5 shows PSNR and compression ratio curves for various SAR images[3] through compression techniques. Fig 6 and 7 shows the Normalized cross correlation and Normal Absolute error rate for the sample SAR images between two methods wavelet based compression (WBC) and segmentation based wavelet compression (SBWC). The image size held is 256x256. These curves plot compression ratio versus image quality, as represented by PSNR. The most desirable state on this graph is the upper right quadrant, where high compression ratios and good image quality live.

From the Figure 6 and 7 the Cross-correlations help identify variables which are leading indicators of other variables or how much one variable is predicted to change in relation the other variable. The identified method is justified in all the above taken parameters which objectively states the phenomena in prominent manner

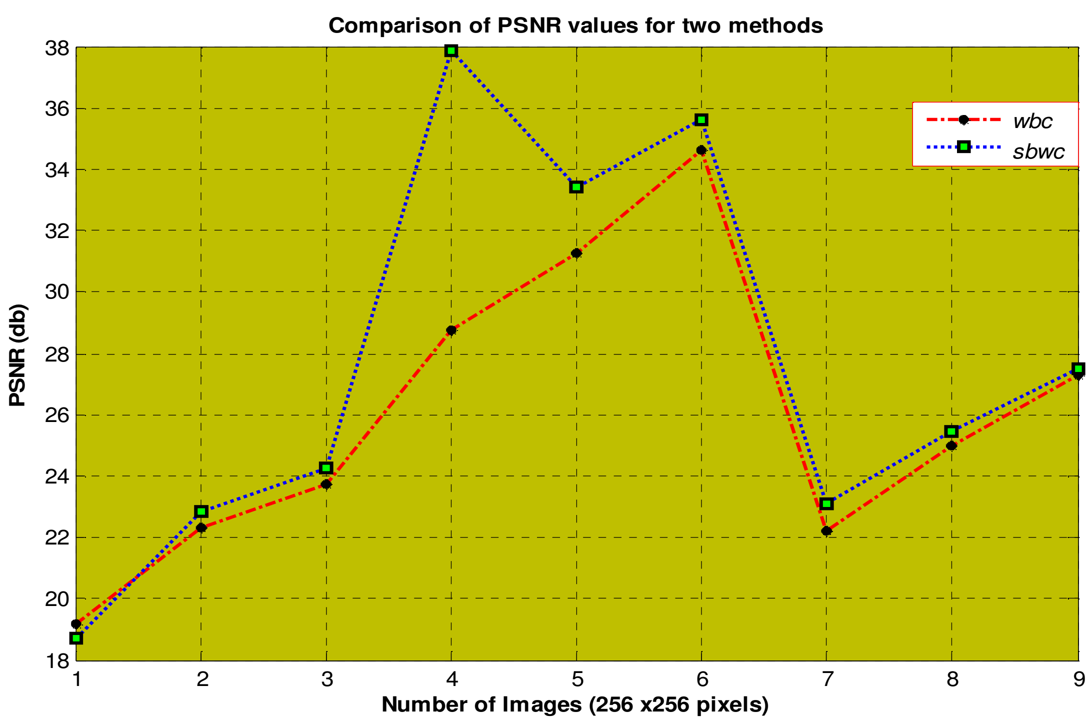


**FIGURE 4:** Comparison of PSNR for WBC and SBWC

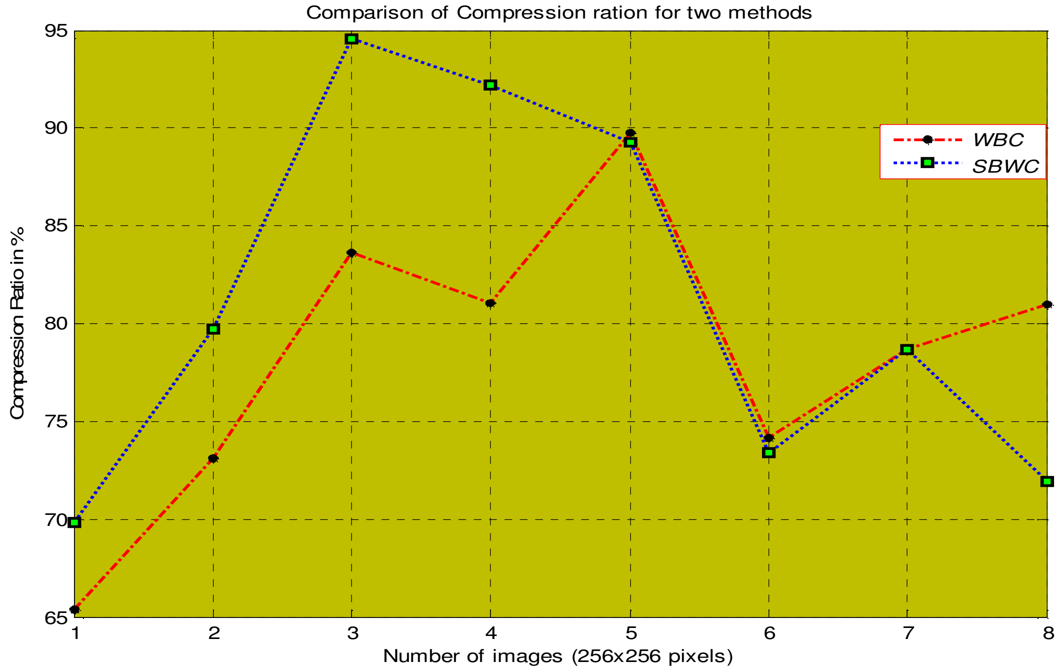


**FIGURE 5:** Comparison of CR for WBC and SBWC

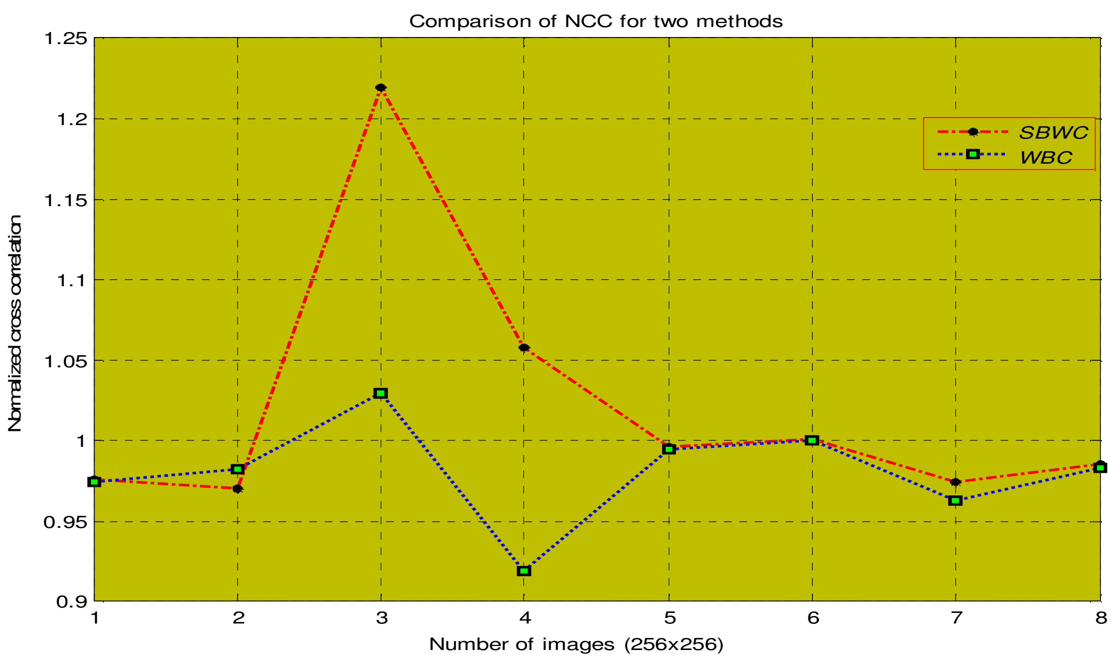


**FIGURE 6:** Comparison of NCC for WBC and SBWC

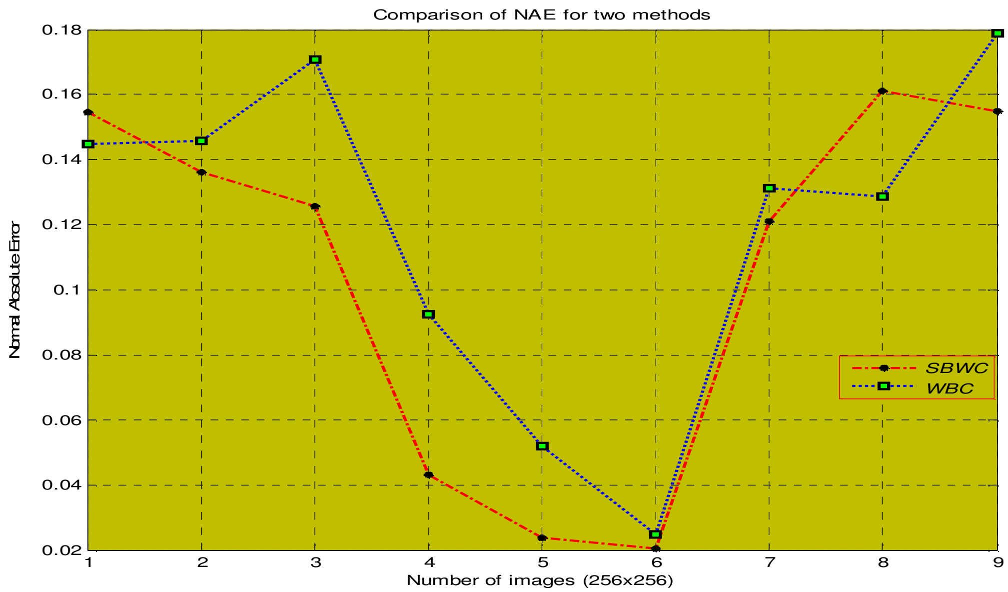


**FIGURE 7:** Comparison of NAE for WBC and SBWC

## 6. CONCLUSION

The objective specified is clearly evaluated by segmentation based image compression performance, in accounting compression ratio, PSNR and time needs. It is oriented toward the operational naval application intelligent imagery system. The images were evaluated quantitatively and qualitive assessments are done by metrics in order to establish the impact of wavelet and the need of segmentation based approach for image compression. The experimental analysis is mainly performed on SAR data from various satellite projections. Thus, images were processed in two different ways, analysis shows SBWC makes images smoother and conserves object edges without affecting the resolution. In ending, the Segmentation based wavelet compression technique allows output as expertly compressed image, with different operative importance without changing the pixel accuracy and image resolution or size. The analysis presented here will prove useful in studies of nonstationarity in time series, and the addition of statistical significance tests will improve the quantitative nature of wavelet analysis.

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