...with restoration for target detection in SAR images

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Abstract—High-quality segmentation is there in a need in SAR images for appropriate target detection. In this paper, the ... Wiener filter are utilized with region of interest and ... based segmentation technique in SAR images. The ... discrete Wiener filter exhibits both linear and nonlinear characteristics. This filter compensates for the blurring due to the linear term and conserves the edges which are mainly used to distinguish the various objects with the gross representation of object of interest. The filter is defined both for edge preserving along with speckle noise cancellation in SAR images. A combination of features from two different types of multi-resolution and multi-channel filters, in general provides superior classification of SAR images. The experimental results show that the proposed boundary based and ROI technique segments the SAR image while the opted filter preserves significant features and noise removal. The fusion performance is ... on the basis of Mean square error, time, and ... ratio.

Keywords- Segmentation, Noise Removal, Signal to Noise Ratio, Picture Quality Service

I. Introduction

The key advantage of the Synthetic Aperture Radar (SAR) is that images can be acquired better because of their capacity of imaging even in case of adverse meteorological conditions. Unfortunately the poor quality of some SAR images makes it difficult to extract information and even not to guarantee a good positioning of the detection [8]. ... to great disadvantage of having multiplicative ... When analyzing SAR images, complication is made by presence of speckle, which appears as strong intensity fluctuations, even in zones of homogeneous reflectivity [1]. Many techniques have been proposed for reducing the level of speckle. The choices of the neighbourhood on which the local statistics are used in adaptive speckle filters are meant ... conventional methods. However, these methods tend to ... the edges [9] and other small features, reducing the ... of the detail. For this reason, it is necessary to ... general parameter estimation methods which must be ... to radiometrical variations and to degradations ... speckle. This paper proposes a consistent ... of segmentation [3] which is applied to SAR images. ... method consists of two passes. The first concerns ... resolution in order to obtain low resolution estimation of boundaries. The second concerns segmentation of boundary regions at high resolution. The paper is intended in the following form: Section 2 deals with the restoration techniques. Section 3 deals with the methods used for segmentation. Section 4 converses the proposed method (wiener with ROI and BB) Section 5 ends up with experimental results of the proceedings. The paper comprises of observations for future work and potential conclusion.

II. Image Restoration Techniques

Speckle noise occurs in all coherent imaging systems. Examples like Ultrasound, SAR (Synthetic Aperture Radar).Effect of interference of energy from randomly distributed scatters and it is too small to be resolved by the imaging system. It happens when object roughness is of the order of the incident radiation's wavelength. To reduce the multiplicative noise, blind deconvolution is one solution [10]. Here in this paper image restoration is handled with three filters which are shown in figure1.

Inverse filter -Inverse filter is a form of high pass filer [17]. It responds very badly to any noise that is present in the image because noise tends to be high frequency. It is only fine in noiseless case.

Wiener filter - The Wiener filtering also called regularized inverse filter is a linear estimation of the original image [18]. It removes the additive noise and inverts the blurring simultaneously.

Lucy Richardson filter - Lucy-Richardson denoising accounts on photon counting noise with a Poisson distribution. This algorithm generates a restored image through an iterative method and addresses complex image restoration tasks.

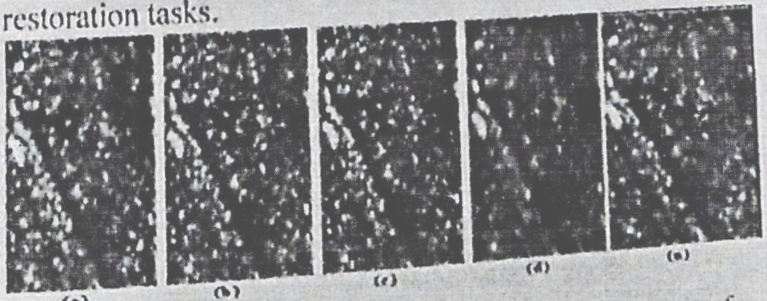


Figure 1 (a) Original image (b) Degraded image with speckle noise of mean 0 and variance 0.04 (c) Inverse filter (d) Wiener filter(e) Lucy Richardson filter

III. Image Segmentation Techniques

Ever in image processing research there is no common solution to the segmentation problem[2]. These techniques often have to be combined with preprocessing knowledge in order to effectively solve segmentation problem for a most needed domain[6]. Therefore here an approach is made for a wide variety of perspective. One of the main purpose of segmentation algorithm is to precisely segment the image without under or over segmentation. Almost all image segmentation techniques proposed so far are ad hoc in nature. These below are the following approaches of image segmentation [11][12] taken in this proposed work and they ... monstrated in figure 2.

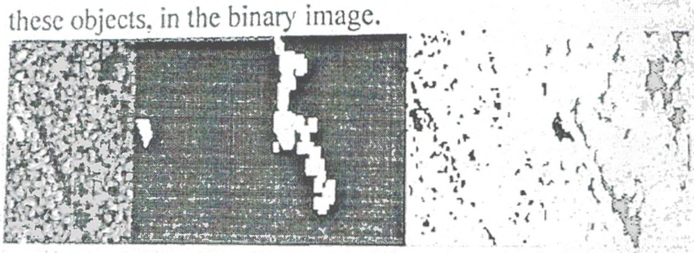
Region of interest - Filtering a region of interest (ROI) is the process of applying a filter to a region in an image, where a binary mask defines the region[4].

Connected components – This method removes from a binary image all connected components (objects) that have fewer than P (connected neighborhood) pixels, producing another binary image.

Region growing method – Region growing is one of the simplest region-based image segmentation methods and it can also be classified as one of the pixel-based image segmentations because it involves the selection of initial seed points [16].

This approach to segmentation examines the neighboring ...s of the initial "seed points" and determines if the pixel should be added to the seed point or not [14]. The process is iterated as same as data clustering.

Boundary based method – This method traces the exterior boundaries of objects, as well as boundaries of holes inside these objects, in the binary image.



(a) (b) (c) (d) (e)

Figure 2. (a) Original image (b) Region of interest method (c) Connected components method (d) Region growing method (e) Boundary Based method

IV. Proposed Method

Classical problems like restoration and segmentation are known to be difficult and always in attraction for research work for target detection[5]. This paper brings the mutual support of segmentation with restoration process for joint framework and output seems to be more prospective. This effort is been validated with both subjective and objective e...ments. The important special case of this proposed work is it obtains promising results for SAR images for superior target detection. Wiener deconvolution is an application of the Wiener filter to the noise problems inherent in deconvolution. It works in the frequency domain, attempting to minimize the impact of deconvoluted noise at frequencies which have a poor signal-to-noise ratio. The Wiener deconvolution filter provides a $g(t)$. The filter is most easily described in the frequency domain in eq(1)

$$G(f)=\frac{H^*(f)S(f)}{|H(f)|^2S(f)+N(f)} \quad \text{------}$$

where

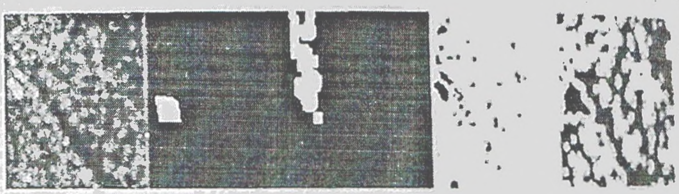
- $G(f)$ and $H(f)$ are the Fourier transforms of g and h respectively at frequency f.
- $S(f)$ is the mean power spectral density of the input signal $x(t)$
- $N(f)$ is the mean power spectral density of the noise $v(t)$
- the superscript *denotes complex conjugation.

To overcome some of the limitations of region-based methods for classification and segmentation, boundary-based methods are often used to look for explicit or implicit boundaries between regions corresponding to different object types. It is necessary to distinguish the inside versus the outside of the edge, the Laplacian operator can be used. In two dimensions, the Laplacian operator is defined as in eq2.

$$L[I(x,y)]\underline{\Delta}\frac{\partial^2}{\partial x}I(x,y)+\frac{\partial^2}{\partial y}I(x,y) \quad \text{------} (2)$$

These two methods are best fitted for SAR image segmentation even ROI competes with them.

Boundary based pushes the drawbacks that is emulated by Region based methods even it has its own uniqueness.



(a) (b) (c) (d) (e)

Figure 3. (a) Filtered image (wiener) (b) Region of interest method (c) Connected components method (d) Region growing method (e) Boundary Based method

The subjective experiments itself states that the proposed coupling method shows the improvised outcome in a principled manner.

V. Results And Findings

It is important when evaluating the performance of an algorithm to have *a priori* knowledge on the specific application it is addressing. The relative performance of different methods and proposed method were evaluated and compared using the MSE criterion, PSNR difference and elapsed time. Two more parameter like average absolute difference and image fidelity also reinforce the evaluation effort. The performance of each technique has its own uniqueness and merits on the taken images (SAR) [15]. Figure 4,5,6 demonstrates the performance evaluation of deconvolution filters for above said subjective estimation. Figure 7 estimates the concert of segmentation methods reviewed for this work.

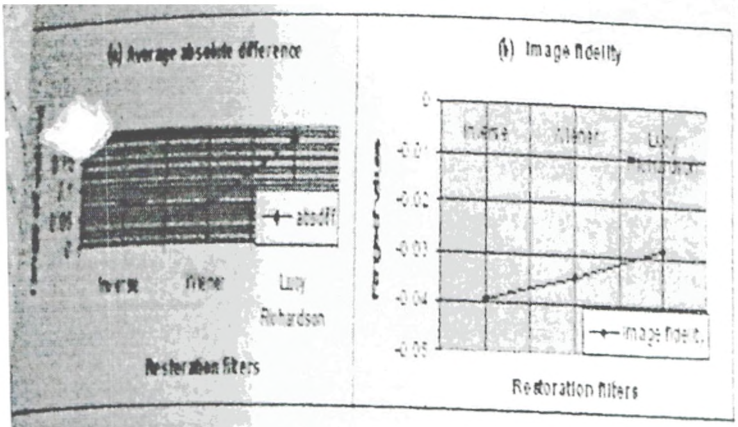
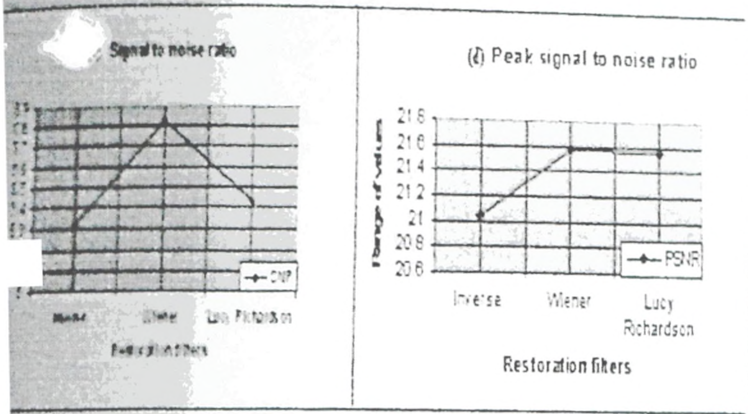


Figure 4 (a) Average absolute Difference (b) Image fidelity



Figur (c) Signal to Noise ratio (d) Peak Signal to noise ratio

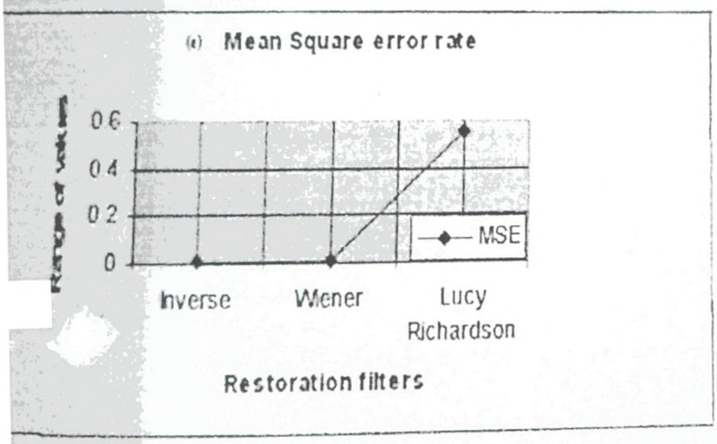


Figure 6. (e) Mean Square error rate

4, 5, 6 states the comparison of deconvulution in ve manner which depicts the necessity of wiener for itation methods.

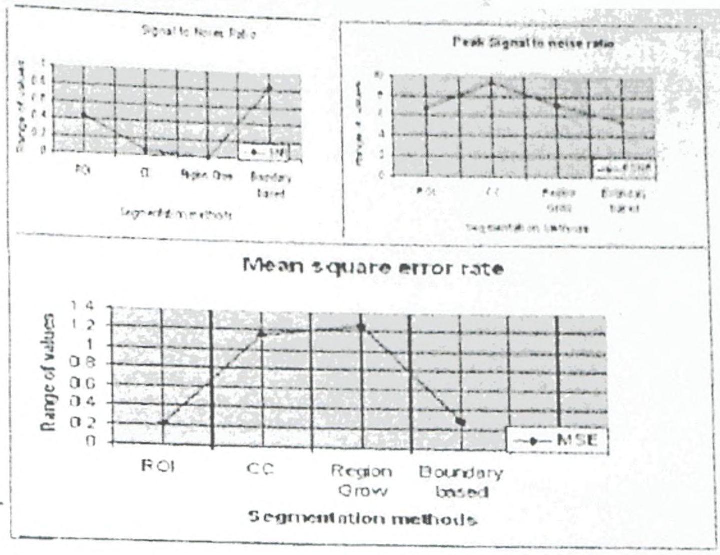


Figure 7 Before filtering the image (a) Signal to noise ratio (b) Peak Signal to noise ratio (c) Mean Square Error

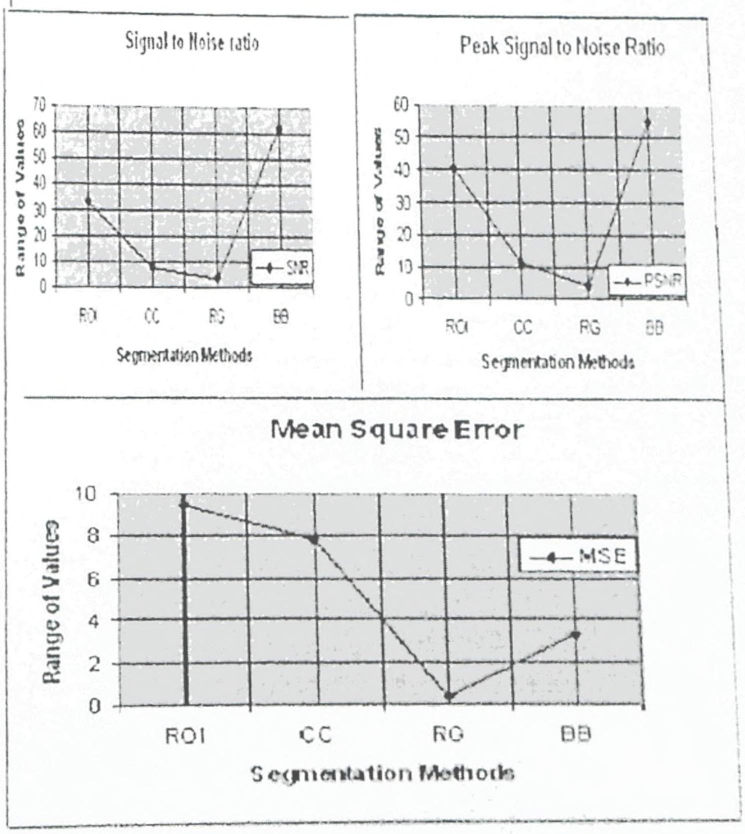


Figure 8 After filtering the image (a) Signal to noise ratio (b) Peak Signal to noise ratio (c) Mean Square Error

From the experimental results higher PSNRs and enhanced visual eminence is taken into account for proving the proposed method. Figure 8 is the objective evaluation of the proposed methods. The observation from it explains that

ROI and Boundary based is more or less articulate [illegible] performance on SAR images.

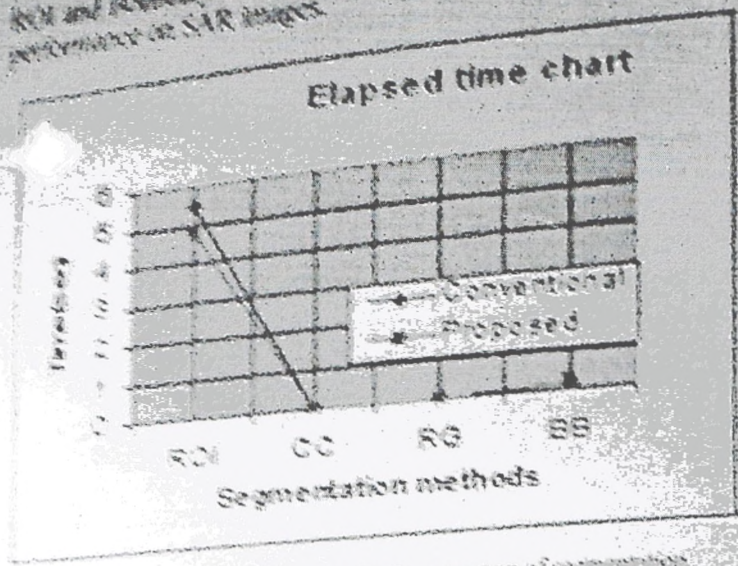


Fig 9 Elapsed time (in sec) taken for the execution of segmentation methods before and after applying filter

From the performance evaluation including the time parameter (figure 9) explores the clear scenario of coupling convolution with segmentation and highlights two important fusion: Wiener with ROI and Wiener with Boundary Based.

VI. CONCLUSION

This paper converse the significance of segmentation in SAR image analysis and the need of restoration for segmentation technique to attain faultlessness. The evaluation of image segmentation techniques is a key field of the study. The assessment can be categorized as objective and subjective based on whether a priori information is available or not. Region of interest and boundary based with the fusion of wiener filter with the analysis on SAR image have given encouraging results. Wiener filter is also effective for segmenting speckle noise images. It provides closely related centroid values for noisy images. The results indicate that the proposed approach is more robust and accurate than conventional segmentation methods. The combination of restoration and segmentation is an interesting alternative in SAR where weather or light conditions make it difficult to acquire optical images regularly. The computational time and the iteration can be fairly reduced by using Artificial Neural network in this effort.

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A combined preprocessing scheme for texture based Ice classification from SAR images

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Research on ice conditions in the lakes and rivers ... important role in the study of Climate change and Global warming. Satellite images can improve the possibilities for classification of ice as they cover large areas. Numerous researches have shown classification based on texture features can improve the precision of the interpretation. This paper presents a preliminary study of image processing on the ice patterns in synthetic aperture radar (SAR) imagery. Here, analysis is done on performance of texture features derived from the gray-level co-occurrence matrix based on image enhancement methods. The discrimination ability of the proposed method for texture computation is examined and compared by objective parameters. All experiments are conducted on several SAR images to provide ... of the results. This experiment concludes that the ... implementation in representing ice texture is one that utilizes the output derived from fusion of filter and smooth by means of using both kuan and median filters.

Keywords Texture, SAR, Filters, Feature Extraction, Image Quality Metrics

INTRODUCTION

... of the major problems with Synthetic Aperture Radar (SAR) imagery is that an image pixel may contain energy reflected from adjacent objects causing noisy speckled-filled imagery. Even in the shadow area where no energy return should be expected, energy from adjacent target and clutter areas spill over into the shadow area causing a speckled shadow area. The noisy shadow makes edge detection difficult. Even for a human observer, the edge may be difficult to locate. A second problem with the SAR imagery is that no sufficient model for the exact edge location exists making evaluation of the results difficult. The focus of the research work here is overcoming these two problems by providing a combined scheme for the SAR shadow area and by providing an approach to evaluate the texture segmentation results.

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to SAR images[8]. This henceforth reduces the image contra... which leads to direct negative effect on texture based analysis. ... solve the problem of noisy SAR images, a fusion of kuan a... median filter is proposed and then segmentation is done us... texture based techniques. This increases the need for prop... selection of filter and smoothing techniques to avoid maximu... degradation of images[2][9]. Here the effect of kuan filter w... median smoothing is tried on the SAR images for better textu... classification. The expertise to categorize ice texture in S... imagery is extremely significant in analysis, classification, ... interpretation. Statistical texture analysis is comparatively be... then the analysis based on intrinsic gray levels[5]. Few w... proves that textural measurements provide better descriptors ... ice covers, but on literature a need for better preproces... method is required henceforth.

A comprehensive experiment is carried out here based on ... evaluation parameters and quantifiable metrics [12]. sThis ... evaluates the objective parameters and emphasizes the nee... preprocessing combination methods for texture b... classification. This paper introduces a new approach, w... incorporates the kuan filter and smoothing technique (me... altogether, to achieve the goal of smoothing uniform area... preserving the edges. The paper is structured as: Section 2 ... with the image preprocessing scheme with subjective evalu... process. Section 3 comprises the texture based feature extra... Section 4 converses the comparison of filtering methods ar... experimental results of the approach. The paper ends ... remarks on possible future work in this area and ... conclusions.

2. IMAGE ENHANCEMENT

Synthetic Aperture Radar (SAR) takes advantage of long propagation characteristics of radar signals and the c... information processing capability of modern digital electro... provide high resolution imagery. Physical parameters rel... the earth's surface and atmosphere behave differently ... observed at different space-time scales. Monitoring tech... either remote or ground-based, rely on the princip... alterations in land cover will result in concurrent change... spectral signature of the affected land surface. The accurac... result is strongly dependent on the processing pr... consisting mainly of geometric correction, image class... and spectral enhancement.

Table1 :SAR images

			
(Land)	(Sea)	(Thin ice)	(Thick ice)

Image enhancement improves the quality (clarity) of images for human viewing [6]. Removing blurring and noise, increasing contrast, and revealing details are examples of enhancement operations. Hence reducing the noise and blurring and increasing the contrast range are handled to enhance the SAR image. In this case the mean intensity, contrast, and sharpness (amount of blur moval) is adjusted based on the pixel intensity statistics in various areas of the image.

2.1. Proposed Enhancement method

The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observation [6]. During this process one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. Moreover observer-specific factors such as the human visual system and the observer's experience will introduce a great deal of subjectivity into the choice of image enhancement methods. Based on the image data representation space here image enhancement techniques are divided into two processes. Firstly, images were processed according to a filtering approach. The Kuan filter is used primarily to filter speckled radar data. It is designed to smooth out noise while retaining edges or shape features in the image. Kuan filter also smoothes the image without removing edges or sharp features in the images[3]. It is only applicable for radar intensity image. Kuan filter first transforms the multiplicative noise model into a signal-dependent additive noise model[8]. Then the minimum mean square error criterion is applied to the model. The resulting filter has the same form as the Lee filter but with a different weighting function as the Kuan filter made no approximation to the original model[3]. The resulting images were then filtered again with median filter to achieve further smoothing.

It is a nonlinear operation used in smoothing to reduce speckle noise. It is more effective than convolution when the goal is to simultaneously reduce noise and preserve edges.

Subjective assessment tests are used to evaluate the picture quality of ice SAR images. However careful subjective assessments of quality are experimentally difficult and lengthy and the results obtained may vary depending on the test conditions. Further subjective assessments provide no constructive methods for performance improvement and are difficult to use as part of the design process. As of it, objective measures of picture quality are also carried and the results are carried down in section 4 in performance evaluation.

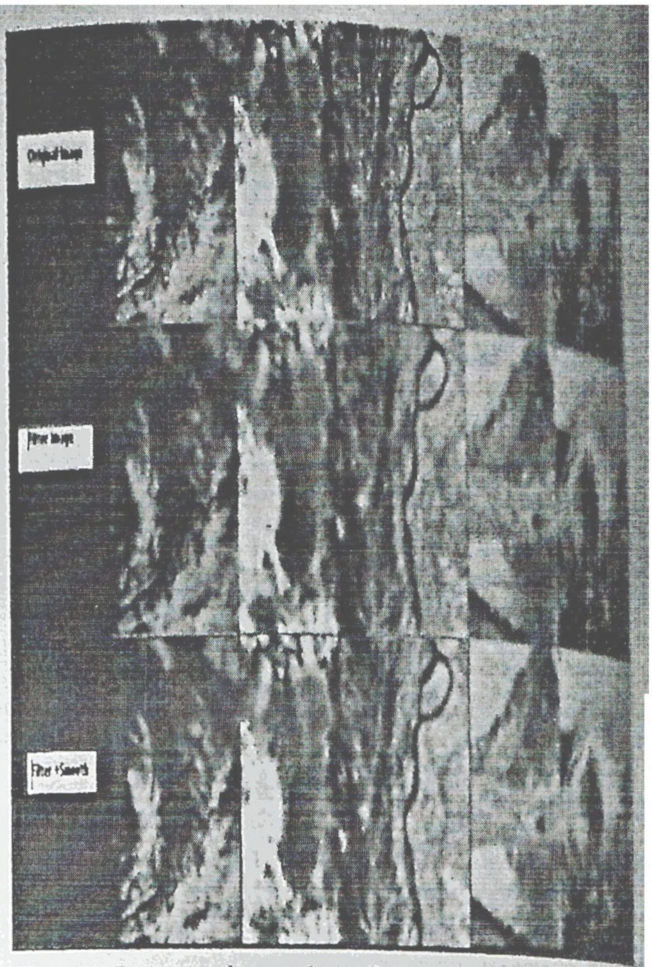

Figure 1: Preprocessing results(a) Original image (b) Filtered image (c) Filtered + Smoothed image

In the figure 1, the background is smooth; there is very little variation in the gray-level values. In the foreground, the surface contours of the ice exhibit more texture. In these experimental images, foreground pixels have more variability and thus higher range values can be achieved. Fusion process makes the edges and contours of the ice area more visible. This analysis attempts to quantify intuitive qualities described by terms such as rough, smooth, silky, or bumpy as a function of the spatial variation in pixel intensities. In this sense, the roughness or bumpiness refers to variations in the intensity values i.e gray levels. This subjective source therefore will yield better results in texture segmentation

3. TEXTURE BASED SEGMENTATION

Several robust segmentation schemes for SAR images have been proposed over the last few years There are two segmentation methods (1) edge detection and (2) region growing. First we compute an edge strength map using the multiresolution *Ratio Of Averages* (ROA) operator. Next is simple and efficient thresholding method. The over-segmentation is reduced by thresholding the basin dynamics. All the segmentation corresponding to different thresholds may be represented hierarchically in an edge dynamics image. In order to detect all significant edges, we must in many cases set a relatively low threshold and thus accept the detection of some false edges as well. In the final step, we reduce the number of false edges by merging adjacent regions whose mean values are not significantly different according to *likelihood ratio* criteria for homogeneous textured zones. These criteria allow us to eliminate false edges efficiently without merging regions that are visibly different. They are therefore well suited for applications which need a partition in semantic regions, eg classification. The order in which the regions are merged has a great influence on the final result. Here the ... relay on tecture based segmentation,which is a locally ... approach that requires no time-consuming sorting of ... region ...

Texture segmentation is the partitioning of an image into regions, each of which contains a single texture distinct from its neighbors[1], [7]. Mathematically, image segmentation can be well-defined. Texture is one or more basic local patterns that are repeated in a periodic manner. Texture can also be termed as a pattern that has been scaled down to measure the variation of the intensity of a surface, quantifying properties such as smoothness, coarseness and regularity[5]. It's often used as a region descriptor in image analysis and computer vision. The three principal approaches used to describe texture are statistical, structural and spectral. Statistical techniques characterize texture by the ... properties of the gray levels of the points comprising a ... ically, these properties are computed from the gray level histogram or gray level co-occurrence matrix of the surface. Structural techniques characterize texture as being composed of simple primitives called "texels" (texture elements), that are regularly arranged on a surface according to some rules. These rules are formally defined by grammars of various types. Spectral techniques are based on properties of the Fourier spectrum and describe global periodicity of the gray levels of a surface by identifying high-energy peaks in the spectrum. It is a spatial concept indicating what, apart from color and the level of gray, characterizes the visual homogeneity of a given zone of an image[4].

T... the work is to use texture segmentation or texture analy... based on the pixel values that provides standard statistical measures[12]. These statistics can characterize the texture of an image because they provide information about the local variability of the intensity values of pixels in an image. Similarly, calculating the standard deviation of pixels in a neighborhood can indicate the degree of variability of pixel values in that region. This proves that enhanced results can be given by texture segmentation than the other intrinsic methods.

4. PERFORMANCE EVALUATION

It is important when evaluating the performance of an algorithm ... *priori* knowledge on the specific application it is addressing. The performance expansion would result from the systematic determination of objective measures for the comparison of coded images and also from the possibility of successive adjustments to improve or optimize the picture quality for a desired quality of service.The relative performance of different methods were evaluated and compared using the MSE criterion, PSNR difference effectively. The performance of each technique has its own uniqueness and merits on the taken images. The figure 2 and figure 3 demonstrates the performance evaluation of kuan filter and kuan combined with smooth filter performance for above said subjective estimation.

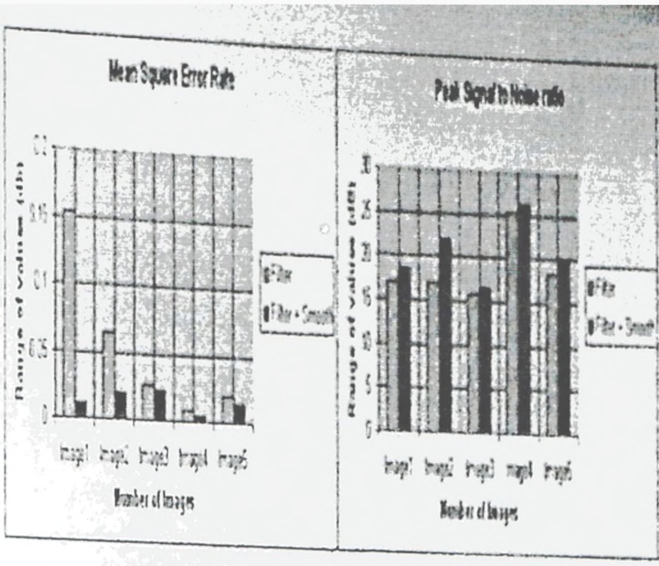

Figure 2: Preprocessing objective evaluation (a) Original image (b) Filtered image (c) Filtered + Smoothed image

Mean Square Error:

$$MSE=\frac{1}{MN}\sum_{j=1}^{M}\sum_{k=1}^{N}(x_{j,k}-x'_{j,k})^2 \text{ ---------- (1)}$$

MSE measures the average of the square of the "error." The error is the amount by which the estimator differs from the quantity to be estimated. The difference occurs because of randomness or because the estimator does not take into account for the information that could produce a more accurate estimate.

Peak Signal to Noise Ratio:

$$PSNR = 10\log\frac{(2^n-1)^2}{MSE} \text{ ---------- (2)}$$

Peak signal-to-noise ratio, often abbreviated PSNR, 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.

To achieve the best image quality, noise and artifacts are generally removed at the cost of a loss of details generating the blur effect. To control and quantify the emergence of the blur effect, blur metrics has been taken here for objective evaluation of the filtered images. By associating the blur effect with these PSNR and MSE metrics the presence of noise can be evaluated objectively. Based on the observation the proposed is distinguish then the classical filter methods.

The figure 3 shows the blur metric analysis of various output of the filtered image using kuan and kuan + median filter process. It is a means to compare the quality of restoration methods or scaling methods[11].

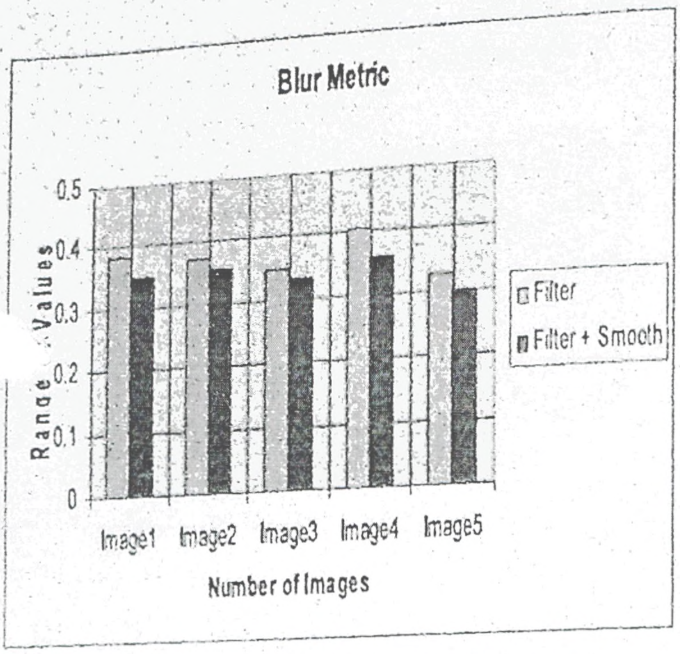

Figure 3: Blur metric calculated for the SAR images

...e features have been detected, a local image patch around the ...ure can be extracted. This extraction may involve quite considerable amounts of image processing techniques. The result is known as a feature descriptor or feature vector. The Gray level co occurrence matrix(GLCM) is used for feature extraction module. It computes gray level features of a byte sequence. Texture measures were calculated from the GLCM and compared with identity scale and directional structural differences between the images. Four texture features were extracted and the performance of the texture based method is analyzed with these four parameters namely contrast, homogeneity, correlation, energy.

And also evaluate its performance, we compared this metric with ...bjective tests done in section 2. There is vast significance ...een no-reference blur metric and the human estimation.

Five SAR images set are taken as the test bed for implementing the combined preprocessing scheme:

Contrast

Returns a measure of the intensity contrast between a pixel and its neighbor over the whole image. The contrast level should be high so that an object can be easily detected in an image.

$$F_{Con}^{Har} = \sum_{g=0}^{G-1} g^2 \left(\sum_{g=1}^{G}\sum_{g'=1}^{G} p(g', g'')\right) \text{ --(3)}$$

Homogeneity

Returns a value that measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal. The distribution parameter is also high when compared with the evaluated method indeed this helps in better segmentation.

$$\sum_{i=1}^{Ng}\sum_{j=1}^{Ng}\frac{p_d(i,j)}{1+|i-j|}$$

Retained Energy

Returns the sum of squared elements in the GLCM. Ma... the image are calculated highly which helps in clearly seg... the tissues based on the texture.

$$E = mc^2 = \frac{m_0 c^2}{\sqrt{1-\frac{v^2}{c^2}}} \text{ --(5)}$$

Correlation

Returns a measure of how correlated a pixel is to its neighbor ... the whole image. Correlation of the pixel through this proposed method is high when compared to boundary based method

$$F_{Cor}^{Har} = \frac{1}{\sigma_x \sigma_y}\left(\sum_{g=1}^{G}\sum_{g'=1}^{G}(gg')p(g,g')\right) \text{ --(6)}$$

Eqn 3,4,5,6 is the representation of the selected texture features. As real textures usually have so many different magnitudes, these texture properties are not independent of each other.

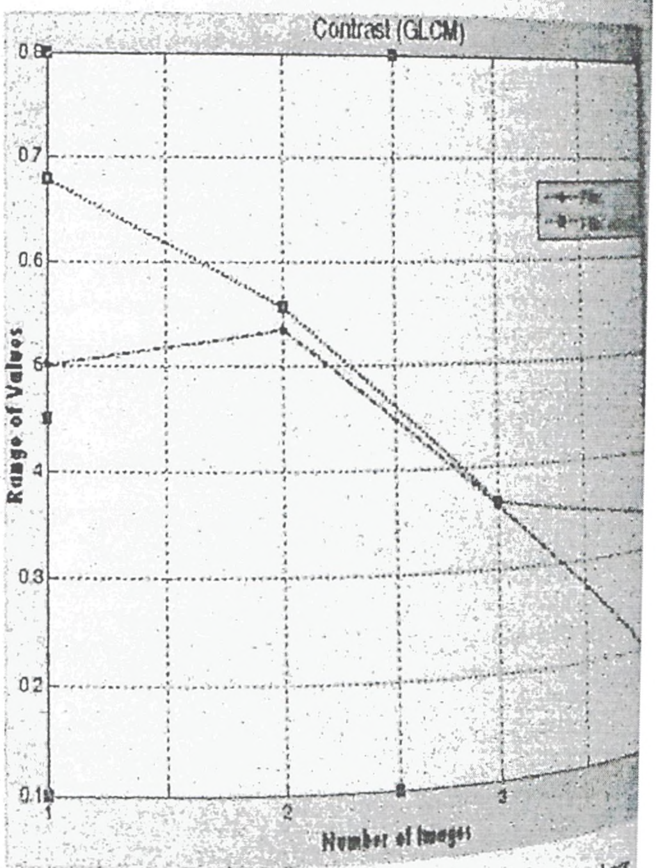

Figure 4: Comparison of contrast for the two compared pre processing scheme

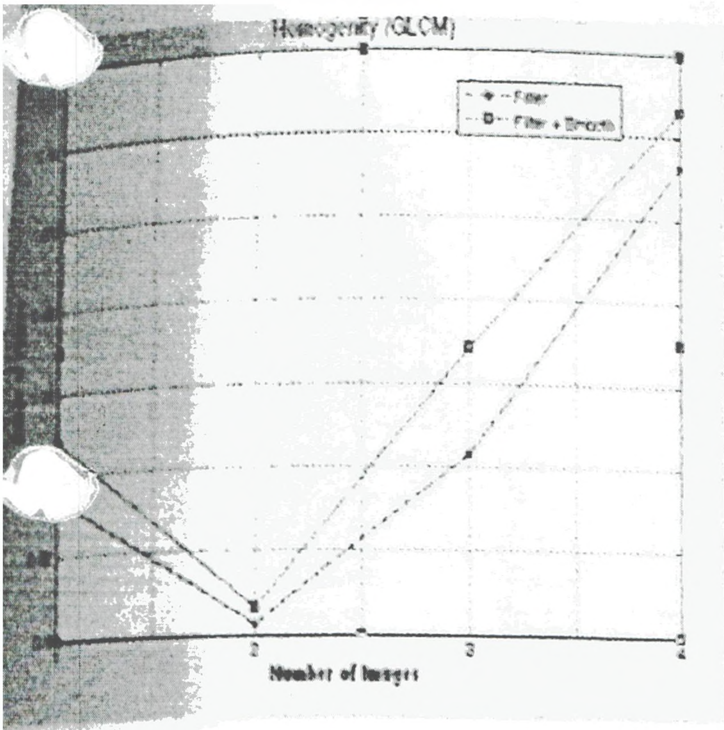

Figure 5: Comparison of Homogeneity for the two compared pre processing scheme

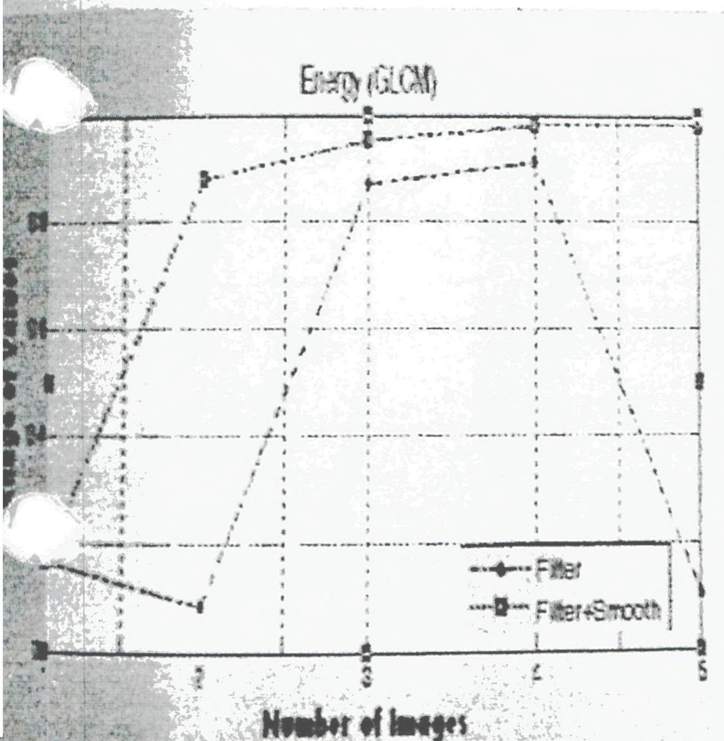

Figure 6: Comparison of energy for the two compared pre processing scheme

The results of two methods shows that initializing the co[...]ion of preprocessing scheme using pixels is better then the [...]mmon filter method. Contrast and Homogeneity of the two resulting methods are shown in the top two rows in figure 4 and 5. The retained energy and correlation are shown in the bottom two rows of figure 6 and 7. Therefore, texture feature extraction by combination of filter + smooth is robust and proved by the experimental results.

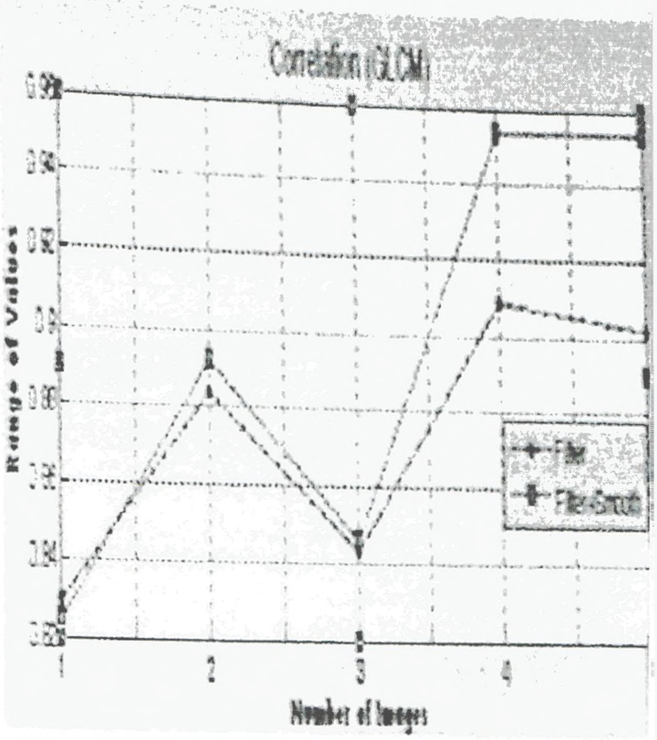

Figure 6: Comparison of correlation for the two compared pr processing scheme

5. CONCLUSION

The proposed preprocessing scheme applies both kuan median filtering on the corrupted images to reduce the blur results shows that this method removes speckle noise, simultaneously preserves edges at higher levels of noi evident from comparison with existing filters. Experim results also show that the proposed scheme is superior ov state-of-the-art of filters in transforming higher peak sig noise ratio (PSNR), as well as maintaining less Mean Squa Error (MSE) and lower blur. On the conclusion, this s perfectly outfits the texture analysis based feature ext which produces a better classification system. I development is on the segmentation methods to impro computational time of the feature extraction process.

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