Transform Domain Approach to Despeckle SAR Color image with Optimization

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ABSTRACT

High quality Synthetic Aperture Radar (SAR) images are more difficult to achieve. SAR images have wide applications like Flood Control, Bio-mass estimation, Sea ice monitoring, Crop estimation, Oil spill monitoring and Soil moisture content measurement. The images obtained from the scene either by coherently or incoherently are conceived by different types of noise, resulting with lack of its fine details. Also these noisy images are not suitable for further investigation. Hence to obtain the noise free signal the transform domain filtering is adopted. The proposed technique involves the Curvelet transform to despeckle the image and Firefly Algorithm (FA) to optimize the Quality metrics of the despeckled image. The performance of despeckling of SAR color images with this proposed method is compared with the results of despeckling using spatial filters. The experimental results show that the proposed method, Curvelet Transform with Firefly Algorithm (CTFA) outperforms the despeckling rate of SAR color images. Hence Despeckling using CTFA method is excellent than the referenced state-of-the-art methods in terms of both noise reduction and image detail preservation.

Keywords: SAR color image, Despeckling, Spatial filters, Curvelet Transform, FA and Quality metrics.

I.INTRODUCTION

Synthetic Aperture Radar plays a vital role in integrating information of the scene in all time and weather conditions with higher spatial resolution. SAR images are used to interpret information about the scene. Many techniques are adopted to obtain SAR color images of the scene. Coherently obtained images are subjected to multiplicative noise called speckle that degrades the fine details of the image to a great extent [1] [2]. Also the speckle reduces the efficiency of the post processing steps in image processing and makes it more difficult to interpret. So the first and crucial step in image processing is to remove the speckle noise so that the visual appearance of an image is improved significantly. There should be some means to suppress the speckle noise and preserve all the scene features such as textures and edges. This can be achieved by different despeckling techniques.

Speckle is multiplicative in nature, since the speckle noise increases with same amount of signal power. It can be explained with a standard deviation equal to its pixel reflectivity value. The speckle noise model can be represented in an Eq. 1 as,

$$d_{(I,\ j)} = s_{(I,\ j)} \times n_{(I,\ j)} \qquad (1)$$

where $d_{(i, j)}$ is the measured pixel level,

$s_{(i ,j)}$ is the desired pixel reflectivity,

$n_{(i ,j)}$ is the multiplicative noise and

here i, j represent the indices of the spatial location.

The speckle noise is very difficult to discard. Hence the speckled SAR signal is applied with logarithmic compression, to transform the multiplicative noise into an easily removable additive white Gaussian noise. This is given by Eq. 2 as,

$$\log [d_{(i , j)}] = \log [s_{(i , j)}] + \log [n_{(i, j)}] \qquad (2)$$

and rewritten as,

$$D (i, j) = X (i, j) + Y (i, j) \qquad (3)$$

where $\log [d_{(i ,j)}]$ is denoted as D (i, j) and the terms $\log [s_{(i ,j)}]$ and $\log [n_{(i ,j)}]$ are denoted as X (i, j) and Y (i, j) respectively. This additive noise can be easily removed.

The researchers worked for about two decades and finally developed two methods of despeckling the image (before and after image formation). One method is that, which employs multiple look processing or Equal Number of Looks (ENL) in frequency domain [3] (Tinku Acharya & Ajoy K Ray 2005, Poornachandra 2008) thereby averaging statistically dependent looks on the same scene. The ENL is defined as the square of the ratio of Mean and Standard Deviation. ENL determines the efficiency of smoothing the noise over homogeneous areas. If ENL is high, the efficiency of smoothing will also be high. This technique enhances the radiometric resolution at the expense of blurring. Later on the classical spatial filters in spatial domain like Mean filter, Median filter (Klogogriffith et al. 2013, Sandeep Kumar et. al. 2016), Lee filter [4] (Lee 1981), Kaun filter [5] (Kaun et. al. 1987), Frost filter [6] (Frost et. al. 1982) and other despeckling algorithms were tried to filter the noise effectively with less computation complexity. In these types of filtering methods, the image details are not effectively preserved resulting in blurred edges. Single scale representation (either in time or frequency) of the signal is inefficient since it is difficult to differentiate signal from noise. Also these kinds of filters are not recommended for non-stationary scene signal. However it is still an unsolved problem and there is no comprehensive method found to resolve all the constraints taken into consideration. Hence next to this, transform domain filtering techniques were introduced to overcome these limitations.

The Wavelet transform is the basic tool used to despeckle digital images [7]-[10] (Xie et. al. 2002, Dia et. al. 2005, Ranjani et. al. 2010. The powerful wavelet transform tool that acts on the denoising of SAR images because of its properties of time-frequency localization, multi-resolution, sparsity and decorrelation. It exhibits good performance in despeckling but some artifacts occur during filtering as it is not directional. Another disadvantage in wavelet domain is that it identifies only point discontinuities and is not able to diagnose the direction of any line shaped discontinuity in the image. Then Contourlet transform was applied because of its special characteristics of multi-resolution, multidirectional and speedy operation which addresses the problem of wavelet transform [16] (Do et. al. 2008). The combination of Wavelet and Contourlet transform was tried in despeckling of images. [17]

(Saevarrson et.al .2008). The extension of this is carried over by Bandelet transform [18] (Zhang et. al 2009) and then followed by the other multi-scale analysis experimented with Ridgelet transform. But the Ridgelet transform is suitable only for discontinuities along straight line and not optimal for complex images where the edges were mainly along curves.

Hence the improvement in filtering is achieved by using Curvelet Transform [11] – [14] (Schmitt et. al. 1999, Candes et. al. 1999, Candes 2004, Starck 2002) and the combination of Wavelet and Curvelet transform was tried to perform filtering [15] (Saevarrson et. al. 2004).

The remainder of this paper is organized as follows: Firstly, in Materials and Methods, the review of the Curvelet transform is described followed by the explanation about the proposed method of feature enhancement of SAR color image. Result Analysis and Discussion is dealt in the next section and finally the paper ends with conclusion.

II.MATERIALS AND METHODS

The Curvelet Transform

The preservation of edges should be definitely made while despeckling of SAR images. The Curvelet transform is very efficient in attaining enhanced edges in an image by modifying its Co-efficients. The Curvelet transform was introduced by Candes and Donoho in 2000 and it involves the analysis of Ridgelet transform in step by step procedure to obtain Curvelet. This process is slow one and researchers developed a new version by discarding the preprocessing step of Ridgelet transform so that the redundancy of the transform is reduced with improvement in speed. Another importance of Curvelet transform is that it needs only less co-efficients for representation and produces smoother edge than Wavelet edge [19] (Boubchir et.al.2005). Curvelet transform is considered to be the latest development among non adaptive transforms. It provides more space representation of the image with inspired directional elements and has better ability to represent edges and other singularities along curve than the wavelet transform. Also Curvelet transform has good geometric features and variable anisotropy. Hence the Curvelet transform overcome the problem of applying Wavelet transform, Contourlet transform and Bandelet transform in despeckling.

The Curvelet transform is implemented based on wrapping of Fourier samples. 2D image is taken as an input in the form of a Cartesian array, f (m, n) when $0 \le x < M$, $0 \le y < N$ where M and N are the dimensions of the array. As illustrated in Eq.4 , the output will be a collection of Curvelet co-efficients C^d (p,q,k_1,k_2) indexed by a scale 'p', an orientation 'q' and spatial location parameter k_1 and k_2..

$$C^d{}_{(p,q,k_1,k_2)} = \sum_{\substack{0 \le x < M \\ 0 \le y < N}} f(x,y)\ \emptyset^d{}_{(p,q,k_1,k_2)}(x,y) \qquad (4)$$

Each $\emptyset^d{}_{(p,q,k_1,k_2)}(x,y)$ is a digital Curvelet waveform and 'd ' represents digital.

This approach obeys the effective parabolic scaling law. It enables the sub bands in the frequency domain to capture curved edges within an image in more effective ways. The Curvelet becomes fine and smaller in spatial domain. It is more sensitive to curved edges. As the resolution level is increased it effectively capture curves in an image and curves singularities can be well approximated with fewer co-efficients.

The Curvelet itself will not have the ringing and radial stripe but will appear in the threshold value denoising process. It is a high dimensional generalization of the wavelet transform designed to represent images at different scales and different angles. Curvelets are superior to wavelets in the sense that they provide sparse representation of object with edges and its optimal image reconstruction.

III.FEATURE ENHANCEMENT OF SAR IMAGE

A. Improved Gain Function

- The improved gain function is deliberately achieved by shrinking and stretching the co-efficients of the Curvelet transform. Then thresholding is applied to despeckle the image. If a Curvelet sub band coefficients is smaller than a predefined threshold, it will be set to zero; otherwise it is kept unchanged, this function is known as Hard thresholding. So it is seen that the thresholding step performs the initial act of image denoising by removing the unaccepted values which are less than threshold value. Here hard thresholding is applied.
- Starck et. al introduced image despeckling using hard thresholding of Curvelet co-efficients represented in Eq. (5) and then Starck et. al. [21] proposed the modified method to enhance the edges in an image with improved gain function. Here the gain function k_a is improved by modifying the curvelet coefficients in order to enhance edges in SAR image. The gain function k_a is represented as,

$$k_{a(i,j)} = \begin{cases} 1 & ,if\ i < aj \\ \frac{i-aj}{aj}\left(\frac{n}{2aj}\right)^x + \frac{2aj-i}{aj} & ,if\ aj \le i < 2aj \\ \left(\frac{n}{i}\right)^x & ,if\ 2aj \le i < n \\ \left(\frac{n}{i}\right)^y & ,\ if\ i \ge n \end{cases} \quad (5)$$

where j = the noise standard deviation

x = the degree of non- linearity

y = the dynamic range compression

a = the normalization parameter

n = a parameter and its value under which coefficient are amplified.

The Eq. (5) works under two conditions that when,

i) n = kj where k is an additional parameter.

ii) n = þ Mc with þ < 1 and Mc – Maximum curvelet coefficient.

This foundation includes three T_1, T_2, and T_3 which meet T_1 = aj, T_2 = 2T, T_3 = n and $T_1 < T_2 < T_3$.

If n = kj, the gain function is improved effectively but by taking k as an additional parameter neither reduce the noise nor amplify the noise. Hence hard thresholding is applied in the gain function to enhance the features of SAR image and simultaneously suppressing the speckle. This is done by modifying the gain function Eq. (5) as,

$$k_{a(i,T)} = \begin{cases} 0 & ,if\ i < T_1 \\ \frac{i-T_1}{T_1}\left(\frac{T_3}{T_2}\right)^x + \frac{T_2-i}{T_1} & ,if\ T_1 \le i < T_2 \\ \left(\frac{T_3}{i}\right)^x & ,if\ T_2 \le i < T_3 \\ \left(\frac{T_3}{i}\right)^y & ,if\ i \ge T_3 \end{cases} \quad (6)$$

Thus the gain function is improved. The main disadvantage in the improvement of gain function is that it depends on proper selection of the parameters T_1,T_2,$T_{3,\ X\ \&}$ y.

B. Optimization Technique in Image Enhancement

The performance of filtering is estimated by evaluating the Quality metrics of the despeckled image. To obtain the best results, an Evolutionary Computation Technique, FA is applied. FA was developed by Xin-She Yang [22] at Cambridge University in 2007. FA is an optimization algorithm inspired by the behavior and motion of fireflies [23].

Numerous firefly species occupied in the sky produce short and rhythmic flashes in the moderate temperature region. Mostly specific species produce specific pattern. A kind of pattern formed by attraction of male and female species depends upon many factors like the rhythm of the flashes, flash rate and the flash time. Fireflies communicate with each other only at a limited distance normally few hundred meters at night. The light is observed by air and becomes weaker, also the intensity of light decreases as the distance from the light source increases.

In conjunction with the above statements, the strategy is considered below to meet the problem objectiv*e*,

1) Initial population: total number of image pixels.

2) Max. Gen: intensity variation through iteration.

3) If the previous pixel value is greater than current pixel value after considering the fitness evaluation, which is replaced, depending upon the global intensity values of the image.

4) As attractiveness varies with distance, the boundary value of the window size is considered, any value that crosses the boundary is ignored.

5) After the iteration, the global best intensity is updated. That is the highest intensity value of that iteration, replaced with the previous update. Also the rank of the firefly is updated.

6) The value of the absorption rate is considered to give a smoothing effect for the image and the attractiveness is then updated according to the rank matrix.

FA is potentially powerful than a favorable optimization tool [26]. Also FA includes the self-improving process in terms of convergence time. But FA does not have the record of previous history of better situation for each firefly and this causes them to move regardless of its previous better situation and they may ended by missing their situations.

C. Color models

The despeckling of SAR color images is proposed. The fundamental representation of color images depends upon their color models. The way of representing color as tuples of color components is defined as color models. A color model is a method of explaining the properties or behavior of color within some context. There are different color models many in process and some of them are,

- RGB model
- YIQ model
- HSV or HSI model
- CMY model

RGB Model

In a unit cube each part can be represented as 'w', weighted vector. Sum of the primary colors using unit vectors R, G, and B is represented by an Eq.7 as,

$$C(\lambda) = (R, G, B) = RR + GG + BB \qquad (7)$$

where R, G, B ranges from 0.1 to 1.0 and λ = wavelength.

In this model images are represented as three component images, each one for its primary color. RGB model is applied in our SAR color image enhancement process.

D. Algorithm description of the proposed technique to despeckle SAR color image in RGB color space

The step by step procedure of the proposed technology to despeckle SAR color image is explained as follows:-

- The original noisy SAR color image is applied to the Logarithmic transformation in which the multiplicative noise is converted into an additive Gaussian noise as discussed in Eq. 2. Thus the noisy SAR color image is converted into the image with removable additive noise.
- Divide the Log transformed input SAR color image into three different Red, Green and Blue color plates.
- Applying Curvelet transform to each of the color plates of SAR color image in order to get decomposed at each level so that the Curvelet co-efficients are achieved.
- Then thresholding of Curvelet transformed image of each color plate is performed. Thresholding is

applied to the image in order to despeckle the image by replacing each pixel in an image to a new value. If the pixel image intensity of a Curvelet sub band coefficients is smaller than a predefined threshold value it will be set to zero; otherwise the absolute value shrinks by the value of threshold. This function is known as soft thresholding. Same as soft thresholding, if a Curvelet sub band coefficients is smaller than a predefined threshold it will be set to zero; otherwise it is kept unchanged. This function is known as hard thresholding. So it is seen that the thresholding step performs the initial act of image despeckling by removing the unaccepted values less than threshold value. Here hard thresholding is applied.

- Apply the inverse Curvelet transform on each of the R, G and B color plates of the thresholded image.
- Concatenate the Red, Green and Blue plates of inverse transformed image and apply exponential transform to obtain the despeckled SAR color image.
- The parameters for the despeckled image are computed.
- Each despeckled and enhanced image is evaluated and optimized using FA.

- Repeat the steps till the stop condition of the FA is satisfied.

E. Quality Evaluation Metrics

This proposed algorithm has been implemented with MATLAB. The measurement of image enhancement is difficult to measure since there is no common algorithm used. Statistical measurement could be made to obtain the performance of the filter applied to obtain the despeckled image. The effectiveness of the proposed algorithm CTFA to SAR color image despeckling is examined quantitatively using the Quality Evaluation metrics like, Mean Square Error (MSE), Equivalent Number of Looks (ENL), Speckle Suppression Index (SSI), Speckle Suppression and Mean Preservation Index (SMPI), Edge Save Index (ESI) and Peak Signal to Noise Ratio (PSNR).

Let us consider the original image as 'G (m, n)', denoised image as 'F (m, n)' and 'N (m, n)' as noise.

Mean Square Error (MSE)

For any two images x and y [F and G], if one image is considered to be the noisy approximation of the other, the Mean Square Error is defined as,

$$MSE = \frac{1}{xy}\sum_{m=0}^{x-1}\sum_{n=0}^{y-1}[F(m,n) - G(m,n)]^2 \qquad (8)$$

Equivalent Number of Looks (ENL)

The ENL is defined as the square of the ratio of Mean and Standard Deviation and is given by,

$$ENL = \left(\frac{mean}{SD}\right)^2 \qquad (9)$$

The efficiency of smoothing noise over homogeneous area is determined by this parameter ENL. If ENL is high, the efficiency of smoothing will also be high.

Speckle Suppression Index (SSI)

Speckle Suppression Index is given by an equation as,

$$SSI = \frac{\sqrt{Var(G)}}{Mean(G)} \times \frac{Mean\ (F)}{\sqrt{Var(F)}} \qquad (10)$$

where Var is the variance of the images.

Speckle Suppresion and Mean Preservation Index (SMPI)

The SMPI is determined by the equation,

$$SMPI = H \times \sqrt{\frac{Var(G)}{Var(F)}} \qquad (11)$$

where $H = J + |Mean(G) - Mean(F)|$ and

$$J = \frac{Max(Mean(G)) - Min(Mean(G))}{Mean(F)} \qquad (12)$$

Good noise reduction occurs when SMPI value is low. The SMPI parameter is utilized when ENL and SSI are not reliable and when the filter overestimates the mean value.

Edge Save Index (ESI)

The ESI parameter gives an ability to save the edges of the image while doing the despeckling both in horizontal (ESI - H) and in vertical (ESI - V) directions.

The Edge save ability in Horizontal direction is given as,

$$ESI-H=\frac{\sum_{m=1}^{x}\sum_{n=1}^{y-1}|G(m,n+1)-G(m,n)|}{\sum_{m=1}^{x}\sum_{n=1}^{y-1}|F(m,n+1)-F(m,n)|} \quad (13)$$

$$ESI-V=\frac{\sum_{m=1}^{x}\sum_{n=1}^{y-1}|G(m+1,n)-G(m,n)|}{\sum_{m=1}^{x}\sum_{n=1}^{y-1}|F(m+1,n)-F(m,n)|} \quad (14)$$

where, F is the original image

G is the reconstructed image

x – Number of rows in an image

y – Number of columns in an image

Peak Signal to Noise Ratio (PSNR)

The quality of the image after despeckling is evaluated by this factor PSNR which can be defined as,

$$PSNR=20log_{10}\left(\frac{Max_i}{\sqrt{MSE}}\right) \quad (15)$$

If Max_i^2 is considered as Maximum Intensity of noisy image and MSE is Mean Square Error then the higher quality image is obtained for higher values of PSNR.

IV.RESULT ANALYSIS AND DISCUSSION

Three SAR color images of Ice loss in Glacier, National Park, and LANDSAT image of Novarupta, North America and Barstow, California are taken for implementation of despeckling. After despeckling the despeckled images are considered for interpretation and the effect of natural calamities are determined. The performance of filtering methods adopted for despeckling purpose is analyzed with their resultant images and their Quality metrics. The simulation is carried out using MATLAB tool with 2007 version. The despeckled images using spatial filters like Lee, Kaun, Frost, Hybridization filters like FIR, Hybridization Mean Median (HMM) filter and Improved Hybridization Mean Median (IHMM) and Transform domain filter CTFA are presented. Fig.1 shows the despeckled SAR color images of Ice loss in Glacier, National Park. Fig. 2 and Fig.3 represents the despeckled SAR color images of LANDSAT image of Novarupta, North America and Barstow, California respectively.

The Quality metrics of the despeckled SAR color images are determined and tabulated. Table.1 denotes the Quality metrics of Ice loss in Glacier, National Park. Table.2 and Table.3 represents the different Quality metrics of the despeckled SAR color images of LANDSAT image of Novarupta, North America and Barstow, California respectively.

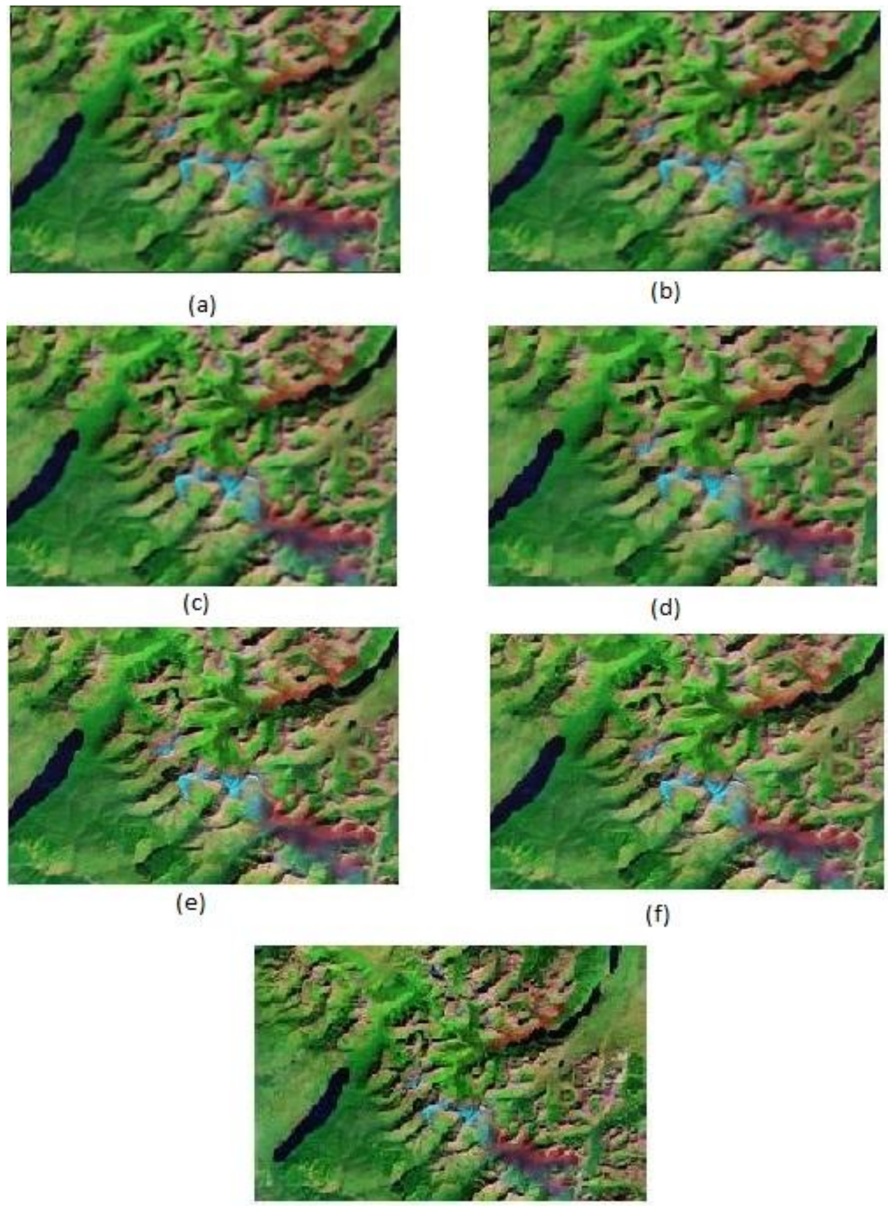


Fig.1 FiDespeckled SAR color images of Ice loss in Glacier, National Park using (a) Lee Filter (b) Kuan Filter

(c) Frost Filter (d) FIR Filter (e) HMM Filter (f) IHMM Filter and (g) Proposed CTFA Filter

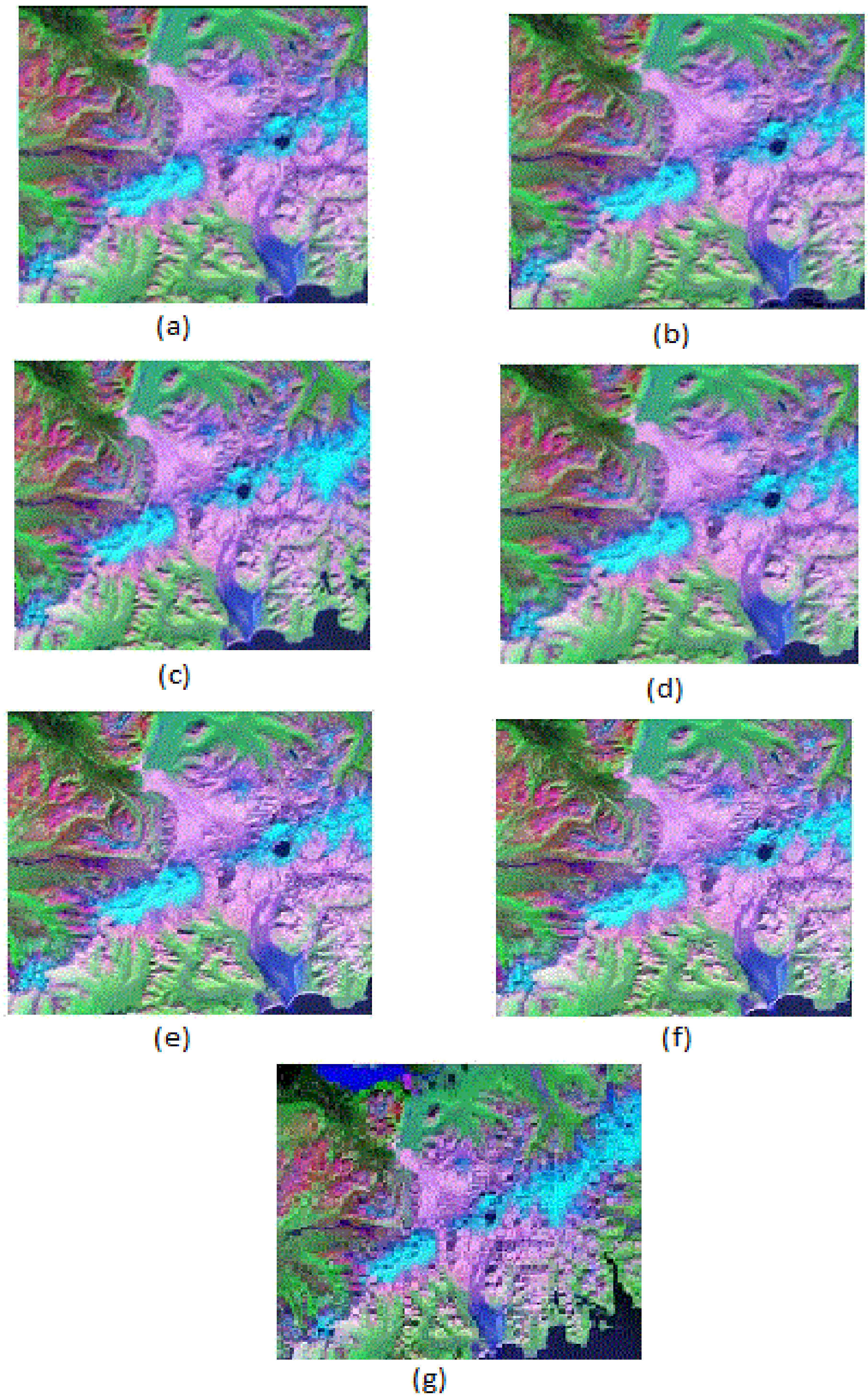


Fig.2 Despeckled SAR color images of LANDSAT Novarupta, North America using (a) Lee Filter (b) Kuan Filter

(c) Frost Filter (d) FIR Filter (e) HMM Filter (f) IHMM Filter and (g) Proposed CTFA Filter

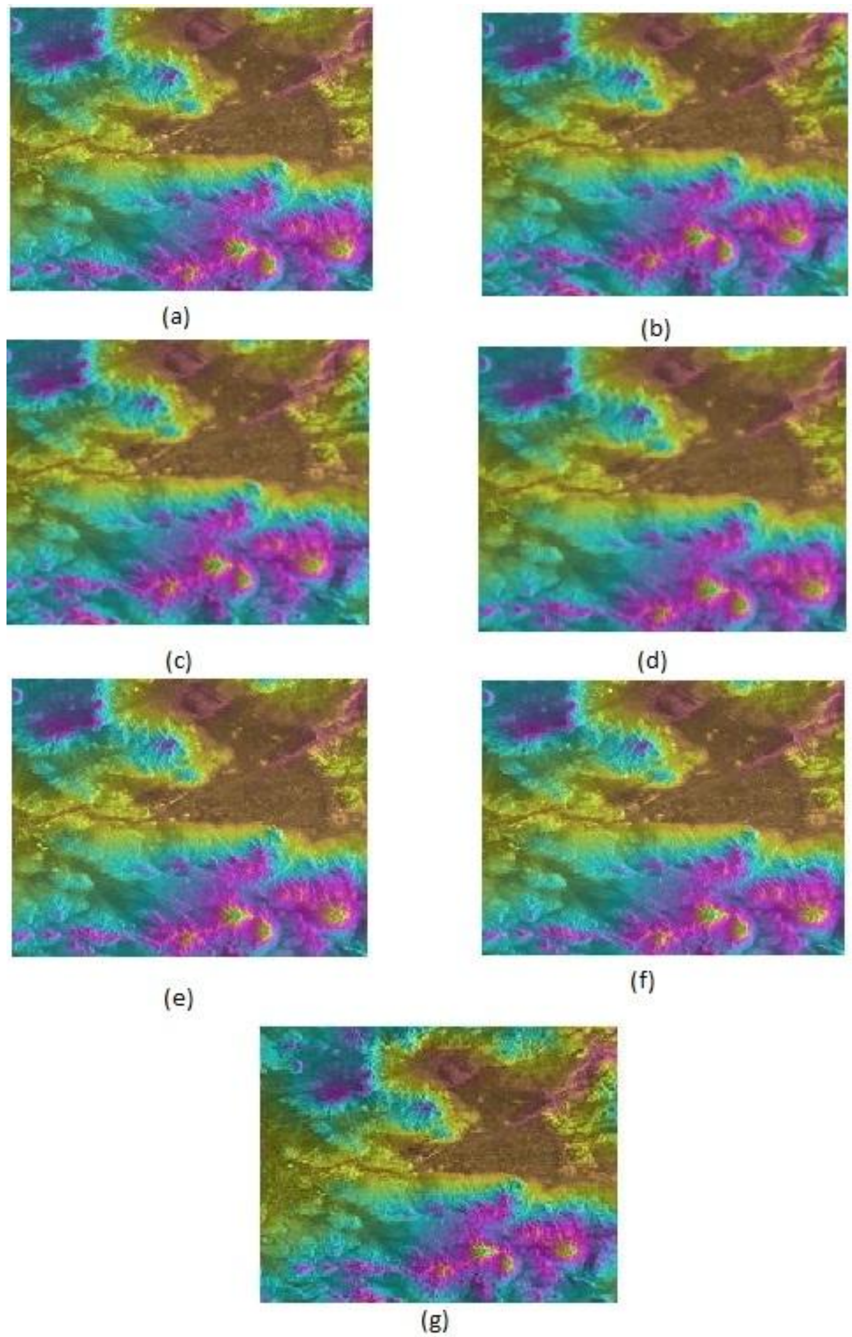


Fig.3 Despeckled SAR color images of Barstow, California using (a) Lee Filter (b) Kuan Filter (c) Frost Filter

(d) FIR Filter (e) HMM Filter (f) IHMM Filter and (g) Proposed CTFA Filter

Table 1 Performance Metrics of the Spatial and Transform based filters on SAR color image of Ice loss in Glacier, at National park.

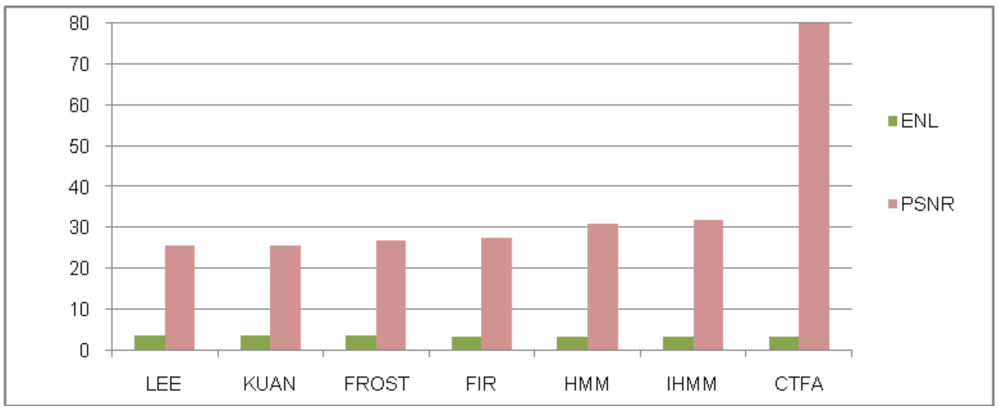
Quality Metrics	LEE	KUAN	FROST	FIR	HMM	IHMM	CTFA
MSE	**0.0724**	**0.0724**	**0.0645**	**0.0587**	**0.0401**	**0.0356**	**0.00053**
ENL	3.6774	3.6772	3.8129	3.4950	3.4639	3.5950	3.5499
SSI	0.9033	0.9033	0.9141	0.9266	0.9307	0.9182	1.0820
SMPI	0.8961	0.8961	0.9175	0.9306	1.0191	1.0164	0.9416
ESI_H	0.6255	0.6255	0.9156	0.9156	0.9515	0.9343	0.9865
ESI_V	0.9899	0.9899	0.9560	1.0000	0.9999	0.9969	0.9066
PSNR	**25.8112**	**25.8109**	**26.8186**	**27.6361**	**30.9484**	**31.9725**	**82.6515**

Quality Metrics	LEE	KUAN	FROST	FIR	HMM	IHMM	CTFA
MSE	**0.0055**	**0.0056**	**0.0645**	**0.0639**	**0.0445**	**0.0385**	**0.00053**
ENL	6.5625	6.5289	6.1782	6.4892	6.4514	6.5722	5.2620
SSI	0.9288	0.9312	0.9331	0.9341	0.9368	0.9282	1.0402
SMPI	0.9247	0.9265	0.9352	0.9410	1.0093	1.0052	0.9827
ESI_H	0.5769	0.5769	0.6923	0.7692	0.8846	0.7692	0.9885
ESI_V	0.8571	0.8571	0.9286	0.6429	0.7857	0.7857	0.9806
PSNR	**20.0965**	**20.707**	**27.322**	**27.9069**	**30.0399**	**31.2997**	**80.8608**

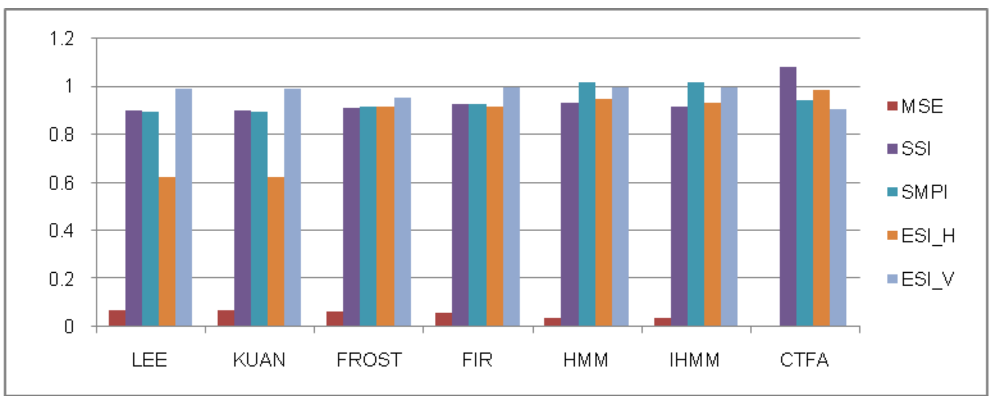
Table 2 Performance Metrics of the Spatial and Transform based filters on LANDSAT Color image of Navarupta, North America.

Table 3 Performance Metrics of the Spatial and Transform based filters on SAR color image of Barstow of California.

Quality Metrics	LEE	KUAN	FROST	FIR	HMM	IHMM	CTFA
MSE	**0.0507**	**0.0507**	**0.0389**	**0.0372**	**0.0224**	**0.0199**	**0.00026**
ENL	5.9904	5.9904	6.0647	6.0985	6.0010	6.0270	3.4835
SSI	0.9676	0.9676	0.9615	0.9590	0.9668	0.9647	1.0427
SMPI	0.9607	0.9607	0.9640	0.9528	1.0141	1.0197	0.9754
ESI_H	0.4286	0.4286	0.5714	0.8095	1.0000	0.9524	1.0000
ESI_V	0.9990	0.9999	1.1000	0.9555	1.0000	1.0000	1.0005
PSNR	**28.9049**	**28.9049**	**31.2147**	**31.6015**	**36.0172**	**37.0404**	**83.8762**

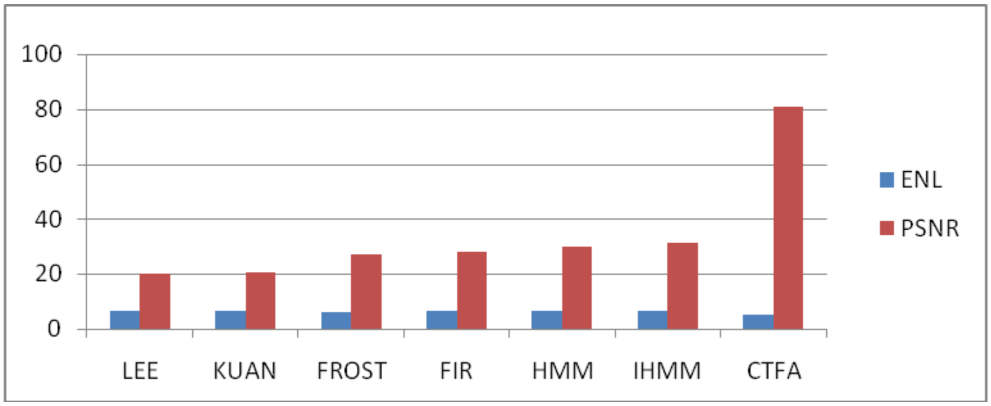


(a)

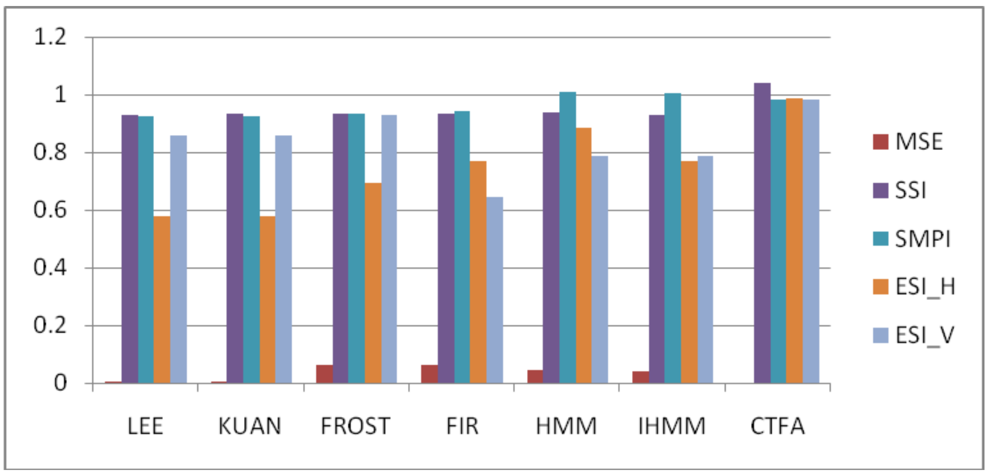


(b)

Fig.4 Filter performance of Ice Loss Glacier, National Park SAR color image against Quality Parameters (a) ENL and PSNR (b) MSE, SSI, SMPI, ESI_H and ESI_V

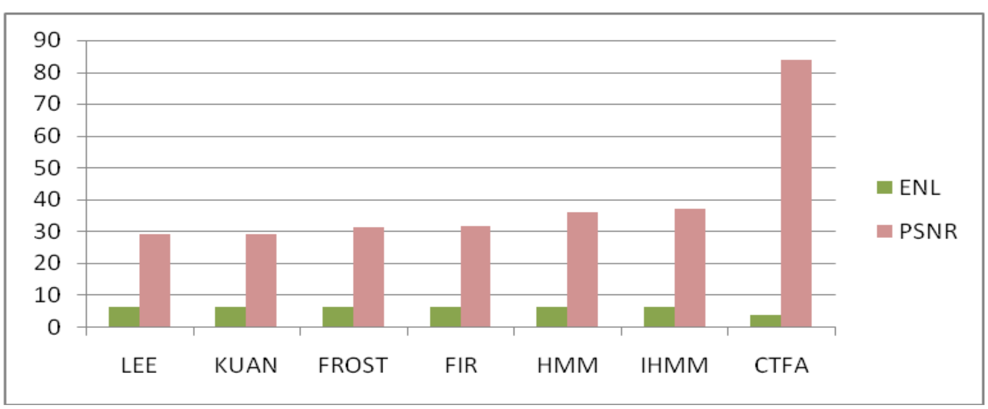


(a)

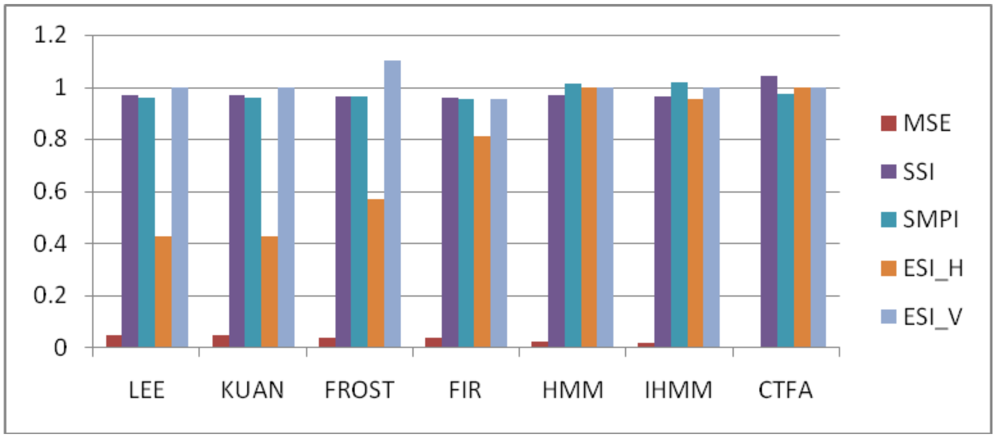


(b)

Fig.5 Filter performance of LANDSAT Novarupta, North America SAR color image against Quality Parameters (a) ENL and PSNR (b) MSE, SSI, SMPI, ESI_H and ESI_V



(a)



(b)

Fig.6 Filter performance of Bartstow, California SAR color image against Quality Parameters (a) ENL and PSNR (b) MSE, SSI, SMPI, ESI_H and ESI_V

With reference to the Quality metrics obtained the performance of the filtering techniques are evaluated and graphically represented. Fig.4 shows the graphical representation of the performance of different filters for the SAR color image, Ice Loss Glacier, National Park. Likewise Fig.5 and Fig.6 show the graphical representation of the performance of different filters for the SAR color images of Novarupta, North America and Barstow, California respectively.

From the result analysis, of all the three SAR color images it is observed that after simulation, the transform domain CTFA produces best result in despeckling when compared to other techniques adopted. It is also obvious that the Quality metrics MSE is well reduced to 0.00026 and PSNR is well improved to 83.8672 with our proposed technique of CTFA in despeckling of SAR color images.

V.CONCLUSION

In this paper, an adaptive method of speckle reduction and feature enhancement for SAR color images based on spatial filtering, Hybridization filtering and transform domain filtering are adopted. An improved Quality metrics of the image is developed to integrate the speckle reduction with feature enhancement, by non- linearly shrinking and stretching the co-efficients of curvelet transform and the process is extended to optimize the results using FA. The FA is applied to make the speedy convergence and avoid premature convergence in optimizing the parameters. After the analysis of the results it is concluded that the CTFA provides excellent performance of despeckling the simulated and real SAR color images with feature enhancement. These despeckled images may be considered for the analysis and investigation to determine the effect of natural calamities existed. Our proposed method is computationally expensive due to iterative operation of FA and improved version may be adopted by parallel operation which will reduce the computation time effectively and can be taken as future work.

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