TO DESIGN A FRAMEWORK FOR REDUCTION OF SPECKLE NOISE IN SYNTHETIC APERTURE RADAR IMAGES

ABSTRACT
of
THESIS

SUBMITTED TO

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(A Central University)

Lucknow

BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY
LUCKNOW
प्रज्ञा शील करुणा
ESTABLISHED 1996

FOR THE DEGREE OF

Doctor of Philosophy

In

INFORMATION TECHNOLOGY

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2018

ABSTRACT

Image Restoration is one of the most investigated field of image processing. It is the process of taking a noisy or degraded image as input and estimating the noise-free image that is approximately equivalent to the reference image using some image restoration technique. The reason behind this degradation may be motion blur, noise, camera mis-focus etc. Image restoration is implemented by reversing the procedure that distorts the image. This is executed by imaging a point source and use the point source image, which is called the Point Spread Function (PSF) to restore the image details lost to the distorting process.

In this research work, image restoration is done on Synthetic Aperture Radar (SAR) images that are already influenced by the speckle noise. SAR is one form of radar that is fixed on the satellites and aircrafts that captures the high-resolution images of large area of the earth surface from different view angles. SAR images are formed by the consistent interaction of the emitted microwave radiation with target areas. This consistent interaction originates arbitrary constructive and destructive noisiness that results into granular pattern on captured SAR image. This granular pattern of noise is known as speckle noise. This noise is multiplicative in nature. A granular pattern of speckle noise in the SAR image corresponds to the "salt-and-pepper" kind of noisy effect. The granular pattern of speckle noise is the interference or fading pattern. Speckle is the scattering phenomenon but not the noise. The consistent interaction of high-frequency radar waves with a complex set of scatterers are possibly the restrictive aspect of SAR processing system design and application. Speckle noise creates a negative impact on the SAR image. It has adverse effect on the SAR image. Eliminating speckle noise from the SAR image is one the challenging task as SAR images are already influenced by the speckle noise. The process of eliminating or reducing speckle noise from the SAR image is called as the SAR image despeckling.

The main objective of image despeckling is to eliminate the speckle noise, preserve the important details of SAR images such as texture, edges, structures, corners, maintaining the smoothness in the homogeneous region of the image and preserving the fine details in the heterogeneous region. Usually SAR images are high dimensional images and preserving the edge and corner components is one major issue. Anisotropic diffusion also called Perona-Malik diffusion is used to reduce noise without disturbing the significant parts of the image. A homomorphic despeckling method is proposed using anisotropic diffusion in db2 based type wavelet transform. The linear and non-linear filters are applied on the approximate part

of the image to remove blurring. Method noise thresholding is used to restore the unfiltered part of the despeckled image. The proposed method is applied and tested on correlated speckle noise as well as uncorrelated speckle noise on the real dataset of SAR images. The performance of the proposed method is evaluated by its visual quality and by using other metrics such as Peak Signal-to-Noise Ratio (PSNR), Structural similarity index metric (SSIM), Universal Image Quality Index (UIQI) and Root Mean Square Error (RMSE). The performance and computational time are calculated and compared with standard filters and methods. The critical analysis of the result shows that proposed method gives the brilliant outcome in terms of structure and edge preservation and noise suppression.

This proposed method is the hybrid combination of the Bayesian method in transform domain (homomorphic filtering in wavelet domain) and non-Bayesian method (anisotropic diffusion). This unique hybrid combination presents image quality with good visual appearance. The computational cost of this method is highly efficient. The concept of method noise is implemented as the post-processing step. It enhances the quantitative results as well as visual quality of the image. If this hybrid combination and easy use of method noise can give such good results, then a way better and intelligent use of method noise can give much better results. The results of this method motivate to go for designing a new method with more intelligent use of method noise.

Theoretically, multiplicative noise is considered as the ratio of the standard deviation to the signal value. The new despeckling method works on db2 based 2D-Discrete Wavelet Transform (DWT) using wavelet thresholding, Directional Smoothing Filter (DSF) and intelligent use of method noise thresholding. The method is designed to despeckle the simulated as well as real speckled SAR images. It uses a hybrid combination of DSF, wavelet thresholding using enhanced Bayesian shrinkage rule and method noise thresholding for despeckling purpose. After DWT decomposition, the approximate component is directed to DSF followed by method noise thresholding and detailed components are directed to wavelet thresholding followed by method noise thresholding. This method validates the efficient use of method noise and explains how its intelligent use can enhance the result of the algorithm over other efficient methods. The quality assessment of the proposed method is done by visual appearance and measures such as PSNR, SSIM, UIQI, Equivalent Numbers of Looks (ENL), Noise Variance (NV), Coefficient of Variation (CV), Mean Squared Error (MSE), Correlation Coefficient (CC) and preservation of mean values before and after despeckling.

The effectiveness of the proposed method is demonstrated by matching it to well-known speckle noise removal methods on SAR images.

The post-processing operation of method noise in the first despeckling method presents decent result. This concludes with the new idea of using the concept of method noise in more intelligent way for better results. The second despeckling method is completely based on the use of method noise. The method noise is used for fine detail preservation. The other filter used in this technique is DSF that is specifically used for edge preservation. This method is an edge preserving despeckling technique. This method offers a new intelligent use of method noise in two different ways. The concept of method noise is used three times in this method. Firstly on the low frequency components, secondly on the high frequency components and lastly as a post-processing operation. This new way of implementing the method noise enhances the result. The proposed method 1 and 2 works on global filtering. According to literature available, the despeckling results using local filtering shows better result than the global filtering. In both method, the decomposition level is manually set by experimenting the method from level 1-7 and the optimal results are obtained at 3 level. The cost of second method is computationally low. The local filtering and automatic selection of decomposition level leads to design a new despeckling method.

A new despeckling technique for speckled SAR images is designed using a local correlation based fusion of high-frequency coefficients in DWT with method noise thresholding. The decomposition level is decided by analyzing the texture of the input image at each decomposition level by calculating entropy. The core idea of this proposed technique lies in the selection of decomposition level in 2D-DWT based on entropy parameter and on the fusion of high-frequency coefficients. On decomposition, the low-frequency coefficients remain untouched and the high-frequency coefficients are thresholded using two different shrinkage rules in parallel. Therefore the Bayesian and Bivariate shrinkage methods are applied to the high-frequency coefficients in parallel. After performing two different thresholding methods, the improved high-frequency coefficients are fused using local correlation based strategy. The threshold value is calculated using correlation coefficient (CC) of two improved high-frequency coefficients. Later again the CC is evaluated between the two improved high-frequency coefficients using small size mask for the fusion strategy. The CC is now compared with the threshold value for the fusion purpose. On the basis of defined fusion strategy, the average and maximum operation are applied to perform the fusion of high-frequency coefficients. The despeckling method is followed by method noise

thresholding in order to preserve the fine details of the image. The performance of the proposed method is assessed using metrics such as Signal-to-Noise Ratio (SNR), PSNR, SSIM and visual appearance of the despeckled image. The experimental results demonstrate the effectiveness of proposed work over prior works on SAR image despeckling.