IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 6, Issue 3, March 2019

A Review Report on Noise Reduction of High - Resolution SAR Image Over Vegetation and Urban Areas

Shyamvir Singh Sikarwar[1], Seema Shukla[2], Priya Jha[3]

M. Tech. Scholar, Electronics and Communication Engineering, Millennium Group of Institute, Bhopal, India[1]

Assistant Professor, Electronics and Communication Engineering, Millennium Group of Institute, Bhopal, India[2,3]

Abstract: Synthetic Aperture Radar (SAR) has been widely used in many civilian and military applications, and the SAR with moving targets indication is a very hot topic in recent years. As many literatures discussed, if the returns from moving targets are processed in the same way as the stationary returns, the moving target will appears as an azimuth shift due to range motion and the image of the target will be smeared in the azimuth direction due to azimuth motion .The high-resolution interferograms over vegetation or urban areas are heterogeneous, which will violate the local stationarity assumption and make it difficult to obtain a large number of independent and identically distributed samples for interferometric noise suppression.

Keywords: SAR (Synthetic Aperture Radar), DEMs (Digital Elevation Models), I.I.P (Independent and Identically Distributed)

I. INTRODUCTION

Interferometric Synthetic Aperture Radar (InSAR) can be used to measure the topography or urban subsidence with the phase difference between observations. Interferometric Synthetic Aperture Radar (InSAR) is one of the most important remote-sensing techniques to acquire terrain Digital Elevation Models (DEMs). InSAR illuminates the same ground scene to obtain two or more complex SAR images from slightly different incident angles. Also, the phases of the SAR image pair are processed in interferometric way to determine the height of each scattering element in the observed scene (i.e. each pixel of SAR image). This advanced remote-sensing technique, which can work either day or night and through cloudy cover, has numerous applications in the fields of topography, geomorphology, seismology, and so on. As is well known, interferometric phase noise suppression is a key step in InSAR processing procedures. To achieve fine performance of phase noise suppression, it is of extreme importance to obtain more filtering samples that are Independent and Identically Distributed (i.i.d.) from the adjacent pixels. The i.i.d. condition requires that the adjacent pixels must have an identical terrain height. In other words, the height difference of the adjacent pixels inevitably results in poor performance of phase noise suppression, consequently deteriorating the DEM accuracy. Therefore, the effects of neighbouring terrain changes must be removed especially for complicated topography, which is usually called topography compensation. Of course, if a prior course DEM of the observed scene is available, the effect of terrain changes on the interferograms can be removed conveniently. Therefore, the interferometric phase filtering is crucial to ensuring the measurement accuracy. Many advanced approaches have been proposed to suppress the interferometric noise. Lee et al used a group of directional windows and an additive noise model to obtain the minimum mean-square estimate of the interferometric phase, called the Lee filter. When the co-registration error is large, Li et al. takes advantage of the coherence information of neighbouring pixels to estimate the interferometric phase. Local fringe frequencies of the interferogram are estimated by the modified multiple-signal classification in and local phase unwrapping in, then the interferogram is filtered.

Synthetic Aperture Radar (SAR) has already proven its usefulness for the generation of high resolution remote sensing images. Since a SAR employs an active, coherent microwave frequency source of Electro-Magnetic (EM) illumination, it is able to operate under all weather conditions, and without daylight, thus making it an excellent imaging technology for continuous image collection. However, SAR images can suffer from a variety of distortions and artifacts resulting from the image formation process. One such distortion is that of speckle noise which results from the coherent constructive and destructive interference of the backscattered EM radiation from the scattering elements in an area of the ground target equivalent to one resolution cell. As an image artifact, speckle has a granular appearance which corrupts the SAR image information. As noise, speckle may be modelled as a correlated signal dependent random process. It is generally regarded as desirable to reduce or smooth the speckle noise occurring in SAR images.

This paper analyzes the heterogeneity of the high-resolution interferometric data over vegetation and urban areas, points out the difficulty in collecting identically distributed (i.i.d.) samples within a local window, and then propose a refined nonlocal filter. In this approach, the similarity distance between the central Pixel and other pixels in the searching window is measured by the normalized Probability Density Function (PDF) of the interferogram. Then, pixels with smaller normalized probability density than the threshold are identified as outliers and removed from the filtering process. Finally, the interferometric phase is estimated by the complex mean filter.

A conventional moving target detection methodology utilizes multi-antennae system, but it generally requires a calibrated and time-invariant radar system, and in practice they are so complex that both high hardware and computation effort are needed in implementation. Recently many GMTI methodologies based on a single antenna SAR or a single complex-valued SAR image, such as auto-focusing, antenna beam pattern transforming, and SAR stacks etc. were developed and got many effective results. Most of them are based on the moving-target-originated azimuth phase history which is characterized only by two parameters the Doppler shift and the Doppler rate. The former depends on the slant-range velocity component and has been studied deeply before whereas the latter is determined by the azimuth velocity component and is required for correct focusing.

In auto-focusing J. R. Fienup proposed an algorithm to detect along track moving targets in a single SAR imagery by focusing technology used in spotlight SAR. The algorithm divides a complex-valued SAR image into many small patches, and on each patch an auto-focus technique named Phase-Gradient Algorithm (PGA) is utilized to maximize the sharpness of the corrected SAR image. The ratio of the sharpness of the corrected image patch to that of the original patch is adopted as a feature to indicate the presence of a moving target. The computational requirements of the algorithm are dominated by the 1-D FFTs used to transform back and forth between the range-compressed signal history and the image, thus it consumes much time to indicate the targets when the SAR image is in a large scale. Furthermore, the feature value is severely affected by SINR and the selected patch parameters such as the size, background and location. Furthermore, it requires that in each range bin, there is only one moving target and the moving target must exactly be located at centre of the patch, otherwise the indicator will give an inaccurate result. D. Weihinget al. constructed a stack of SAR images varying with Doppler frequency modulation rates, and gets a series of FM-azimuth slices in each range bin along range direction of the SAR image to indicate moving targets by comparing the changes of the slices.

II. LITERATURE SURVEY

Jin-wei Li et.al.[1] “Noise Filtering of High-Resolution Interferograms Over Vegetation and Urban Areas With a Refined Nonlocal Filter”**,** In this the high-resolution interferogram over vegetation area is heterogeneous due to open canopy gaps, visible ground, and different plant structure, whereas the interlaced different scattering media are responsible for the heterogeneity of urban areas. The heterogeneity will break the local stationarity assumption and degrade the performance of traditional filters. The refined nonlocal filter proposed in this letter can identify the outliers and remove them from the filtering process. The experimental results show that the proposed method could reduce the interferometric noise effectively and make the edges between different scattering media well preserved. In addition, the reason for the better performance of the pseudo coherence defined as maybe that it can mitigate the effects of the amplitude heterogeneity in the window, and the reason will be investigated further in the future.

Jiao Guo et.al. [2] “Improving the accuracy of local frequency estimation for interferometric synthetic aperture radar interferogram noise filtering considering large co-registration errors” in this a new method to estimate the local frequencies of interferogram considering large co-registration errors has-been presented. Based on the construction of the joint pixel vector and the covariance matrix, the proposed method adopts the separation extent of the signal and noise subspaces as the criteria, optimized to determine the estimates of local frequencies. In the experiments, the simulated data as well as the real ERS-1/2 data has been employed to investigate the performance of the method. The two experiments carried out demonstrate that the proposed method has the ability to acquire accurate estimation of local frequencies even if the co-registration error reaches one pixel. For future InSAR systems with higher spatial resolutions, for example, 1 m × 1 m or even higher [1, 17], it is more difficult to increase the accuracy of image co-registration, so the proposed method would achieve more satisfactory results.

Gaohuan Lv et.al.[3] “Synthetic Aperture Radar Based Ground Moving Target Indicator Using Symmetrical Doppler Rate Matched Filter Pairs”, in this presented an SDRM filters based GMTI scheme to detect the presence of moving targets and estimate their azimuth velocities in a single complex SAR image. The scheme works fast and effectively during our experiment. A feature criterion to determine the presence of the moving target is defined by the sharpness ratio in a patch in the two derivative SAR images. Simulations showed that the sharpness ratio threshold labeled ft should satisfy 1:2 6 ft 6 1:5 to indicate a moving target. If the ft is lower than 1:2, then false alarming happens; if the ft is larger than 1:5, then false dismissal happens. From our experience, such a condition as ft = 1:2 is a fairly appropriate choice. The algorithm determines the target area automatically so that the moving target will just be located in the center of detected patch, and the background will be excluded as much as it can, therefore the estimate is more accurate when the original SAR image is corrupted by strong noise and strong stationary scatters. The azimuth velocity estimator is established by using an SDRM filter bank. This estimator gives an accurate result when the azimuth velocity is more than 6 m/s and the range velocity component does not lead to the Doppler ambiguity. However, when the azimuth velocity is less than 6 m/s or the Doppler ambiguity happens, the AVE may not come to our expectations. We will try to solve this problem in the future.

Alper Basturk et.al. [4] "Adaptive neuro-fuzzy Inference System for Speckle Noise Reduction in SAR Images", in this ANFIS based method for filtering of speckle noise in SAR images is presented. The fundamental advantage of the proposed method over other operators is that it efficiently removes speckle noise while successfully preserving the details and texture in the original image. The superiorities of the proposed ANFIS method over other operators in the literature may be summarized as follows It has a very simple structure. Its fundamental building block is a 3-input 1-output first order Sugeno type ANFIS. This greatly simplifies implementation. Its performance does not depend on any parameters that are heuristically determined and externally supplied by the user. It is trained by using a very simple artificial image, which can easily be generated in a computer. It uses a 3-by-3 filtering window. Some other operators in the literature use filtering windows with larger or dynamically changing sizes. It provides an even better performance when repetitively applied to the noisy image. The increase in performance varies depending on image properties and/or noise density. It is concluded that the proposed method can be used as a simple but powerful tool for efficient removal of speckle noise in SAR images without distorting useful information within the image.

G. Ramponi et. al.[5] "Smoothing Speckled Images Using an Adaptive Rational Operator", in this presents results of smoothing speckle noise in Synthetic Aperture Radar (SAR) images using the multiplicative point estimator, a locally adaptive form of the homomorphism filter. While the filter does not take account of the SAR speckle noise correlation and encounters some difficulty in obtaining accurate local estimates over small masks, it does perform well in both noise smoothing and edge preservation. Tailoring the filter mask to the image may improve the estimation of the local statistics at end hence the overall filtering performance..

III. METHOD

A conventional moving target detection methodology utilizes multi-antennae system, but it generally requires a calibrated and time-invariant radar system, and in practice they are so complex that both high hardware and computation effort are needed in implementation Synthetic aperture radar interferometry (InSAR) is one of the most important remote-sensing techniques to acquire terrain Digital Elevation Models (DEMs). InSAR illuminates the same ground scene to obtain two or more complex SAR images from slightly different incident angles. Also, the phases of the SAR image pair are processed in interferometric way to determine the height of each scattering element in the observed scene (i.e. each pixel of SAR image).

Synthetic Aperture Radar (SAR) has already proven its usefulness for the generation of high resolution remote sensing images. Since a SAR employs an active, coherent microwave frequency source of electromagnetic (EM) illumination, it is able to operate under all weather conditions, and without daylight, thus making it an excellent imaging technology for continuous image collection. The SAR images are coarsely co-registered using the existing methods. The allowance errors of co-registration can be up to one pixel, thus greatly decreasing the complexity of co-registration. Terrain phase compensation: For the pixel pair (i, j) of the images and each searched value pair of t_a and t_r, the local frequencies t_a and t_r are utilized to compute the compensation phase according to. And then the phases of the neighboring pixels are compensated by subtracting the computed phase, which is equivalent to remove the interferometric phase caused by the terrain changes. Joint covariance matrix computation: The compensated neighboring pixels are selected to estimate the joint covariance matrix. Synthetic aperture radar (SAR) is a form of radar which is used to create images of objects, such as landscapes-these images can be either two or three dimensional representations of the object. SAR uses the motion of the radar antenna over a targeted region to provide finer spatial resolution than is possible with conventional beam-scanning radars. Synthetic aperture radar (SAR) has been widely used in many civilian and military applications, and the SAR with ground moving targets indication (GMTI) is a very hot topic in recent years. If the returns from moving targets are processed in the same way as the stationary returns, the moving target will appears as an azimuth shift due to range motion and the image of the target will be smeared in the azimuth direction due to azimuth motion. so moving target detection and moving status estimation are the two main tasks of GMTI in SAR. And then the phases of the neighboring pixels are compensated by subtracting the computed phase, which is equivalent to remove the interferometric phase caused by the terrain changes. Joint covariance matrix computation: The compensated neighboring pixels are selected to estimate the joint covariance matrix.

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Vol. 6, Issue 3, March 2019

$$\hat{C}_{js}(i,j)=\frac{1}{(2p+1)(2q+1)}\sum_{u=-p}^{p}\sum_{v=-q}^{q} js^{'}(i+u,j+v)\times js^{'}H(i+u,j+v)$$

where (2p + 1) and (2q + 1) are the number of azimuth and range samples of the local window.
Step four: Joint covariance matrix eigen decomposition: The joint covariance matrix Cˆ js(i, j) assumed with the dimensions of M×M can be eigen decomposed into from

$$\hat{c}_{js}(i,j)=\sum_{k=1}^{K}\lambda_k\beta_{sjc}^{(k)}\beta_{sjc}^{(k)H}+\sum_{k=K+1}^{M}\lambda_k\beta_{njc}^{(k)}\beta_{njc}^{(k)H}$$

which, we can obtain M eigen values as

$$\lambda_1>\lambda_2>\lambda_3>...........>\lambda_k>>\lambda_{K+1}>......>\lambda_M$$

The proportion optimization: Maximizing the proportion of λ_K to λ_{K+1}, the corresponding values of t_a and t_r are the accurate estimation of local frequencies. The estimation of local frequencies can be obtained by performing the five steps above for each pixel pair of the interferogram regardless of the co-registration error, which will be verified in the following section. With the joint covariance matrix eigen decomposition in the optimal case, the joint subspaces (i.e. the joint noise subspace and the joint signal subspace) can be derived. Finally, the interferometric phase can be determined by projecting the joint signal subspace onto the joint noise subspace. Interferometry is a family of techniques in which waves, usually electromagnetic, are superimposed in order to extract information about the waves. Interferometry is an important investigative technique in the fields of astronomy, fiber optics, engineering metrology, optical metrology, oceanography, seismology, spectroscopy (and its applications to chemistry), quantum mechanics, nuclear and particle physics, plasma physics, remote sensing, bio molecular interactions, surface profiling, micro fluidics, mechanical stress/strain measurement, and velocimetry. Interferometers are widely used in science and industry for the measurement of small displacements, refractive index changes and surface irregularities. In analytical science, interferometers are used in continuous wave Fourier transform spectroscopy to analyze light containing features of absorption or emission associated with a substance or mixture. An astronomical interferometer consists of two or more separate telescopes that combine their signals, offering a resolution equivalent to that of a telescope of diameter equal to the largest separation between its individual elements. Basic principle of interferometry: - Interferometry makes use of the principle of superposition to combine waves in a way that will cause the result of their combination to have some meaningful property that is diagnostic of the original state of the waves. This works because when two waves with the same frequency combine, the resulting pattern is determined by the phase difference between the two waves—waves that are in phase will undergo constructive interference while waves that are out of phase will undergo destructive interference. Most interferometers use light or some other form of electromagnetic wave. Typically (see Fig. 2, the well-known Michelson configuration) a single incoming beam of coherent light will be split into two identical beams by a beam splitter (a partially reflecting mirror). Each of these beams travels a different route, called a path, and they are recombined before arriving at a detector. The path difference, the difference in the distance travelled by each beam, creates a phase difference between them. It is this introduced phase difference that creates the interference pattern between the initially identical waves. If a single beam has been split along two paths, then the phase difference is diagnostic of anything that changes the phase along the paths. This could be a physical change in the path length itself or a change in the refractive index along the path. Synthetic Aperture Radar (SAR) filtering is a crucial processing step in topography reconstruction and deformation measurement. An SDRM filter pair processes a given SAR imagery and achieves two defocused SAR images that have the same defocused background but different defocused moving targets, and then by comparing the sharpness of the two images, the moving targets are determined adaptively and automatically.

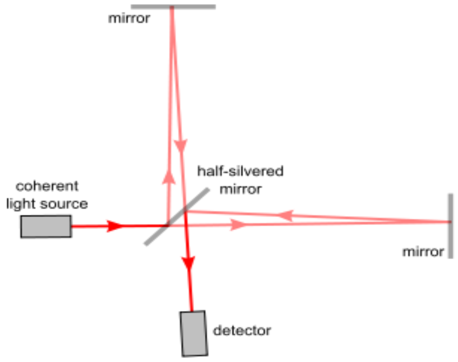

Fig 2:-The light path through a Michelson interferometer.

DOI 10.17148/IARJSET.2019.6323

IV. CONCLUSION

The high-resolution interferograms over vegetation or urban areas are heterogeneous, which will violate the local stationarity assumption and make it difficult to obtain a large number of independent and identically distributed samples for interferometric noise suppression. Given coherence, topography phase, and expected SAR intensity of the pixel to be filtered, the similarity distance between the central pixel and other pixels in the searching window is measured by the normalized probability density function of the interferogram.

REFERENCES

[1]. Jin-wei Li, Zhen-fang Li, Zheng Bao,Ying-long Hou, and Zhi-yongSuo, "Noise Filtering of High-Resolution Interferograms Over Vegetation and Urban Areas Witha Refined Nonlocal Filter" IEEE Geos. Remote Sensing Lett. vol. 12, no. 1, pp. 77-81, Jan. 2015.
[2]. Jiao Guo, Weitao Zhang, Yanyang Liu, Longsheng Fu, "Improving the accuracy of local frequency estimation for interferometric synthetic aperture radar interferogram noise filtering considering large co-registration errors" IET Radar Sonar Navig., vol. 8, iss. 6, pp. 676–684, 2014.
[3]. GaohuanLv, Junfeng Wang, and Xingzhao Liu, "Synthetic Aperture Radar Based Ground Moving Target Indicator Using Symmetrical Doppler Rate Matched Filter Pairs", IEEE pp.962-967,2012.
[4]. Alper Basturk, M. Emin Yuksel, "Adaptive NEURO-FUZZY Inference System for Speckle Noise Reduction in SAR Images" IEEE 2007.
[5]. C. Moloney, G. Ramponi,: 'Smoothing Speckled Images Using an Adaptive Rational Operator', IEEE signal processing letters, vol. 4, no. 3, march 1997
[6]. E.Trouvé, M.Caramma, & H.Maître, "Fringe detection in noisy complex interferograms," Appl. Opt., vol. 35, no. 20, pp. 3799–3806, Jul. 1996.
[7]. Monti Guarnieri, A.: 'Using topography statistics to help phase unwrapping', IET Radar Sonar Navig., 2003, 150, (3), pp. 144–151
[8]. Stoica, P., Nehorai, A.: 'MUSIC, maximum likelihood, and Cramer–Rao bound: further results and comparisons', IEEE Trans. Acoust. Speech Signal Process., 1990, 38, (12), pp. 2140–2150
[9]. Li, Z.F., Bao, Z., Li, H.: 'Image auto-co-registration and InSAR interferogram estimation using joint subspace projection', IEEE Trans. Geosci. Remote Sens., 2006, 44, (2), pp. 288–297
[10]. Li, H., Li, Z.F., Liao, G.S., Bao, Z.: 'An estimation method for InSAR interferometric phase combined with image auto-co-registration', Sci. China, Ser. F, 2006, 49, (3), pp. 386–396
[11]. Liu, N., Zhang, L.R., Liu, X.: 'Multibaseline InSAR height estimation through joint covariance matrix fitting', IET Radar Sonar Navig.,2009, 3, (5), pp. 474–483
[12]. Wu, N., Feng, D.Z., Li, J.X.: 'A locally adaptive filter of interferometric phase images', IEEE Geosci. Remote Sens. Lett., 2006, 3, (1), pp73–77
[13]. Lee, J.S., Papathanassiou, K.P., Ainsworth, T.L.: 'A new technique for noise filtering of SAR interferometric phase images', IEEE Trans. Geosci. Remote Sens., 1998, 36, (5), pp. 1456–1465
[14]. Z. F. Li, Z. Bao, H. Li, and G. S. Liao, "Image auto co-registration and InSAR interferogram estimation using joint subspace projection," IEEE Trans. Geo sci. Remote Sens., vol. 44, no. 2, pp. 288–297, Feb. 200697.