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Adaptive Digital Smoothing Filter

For Speckle Image Using Gamma-Filter

LUMA MALIKE SHAQULI

Department of Physics, College of Science

Al-Mustansiriyah University

الخلاصة

من انظمة التصوير الفعالة لأجراء مسح لسطح)SARيعتبر الرادار ذو الفتحة التركيبية (
الارض ويعتمد هذا النظام في تصويره على استخدام موجات كهرومغناطيسية متشاكهة تقع
). ازدادت اهمية نظام التصوير الفضائي هذا MWضمن منطقة الموجات المايكروية (
بشكل كبير خلال العقود الاخيرة وذلك اكفاءته وعدم تأثره بالظروف الجوية وامكانية
استخدامه في جميع الاوقات مع كل ذلك فهناك عيوب تترافق عادة مع صور هذا النظام
) تنتج عن الطبيعة التشاكهية للموجات Speckleوتكون على شكل لطخ من ضوضاء بقعية (
المستخدمة في التصوير. نظرا لاهمية هذا النظام في العديد من الدراسات والتطبيقات، فقد
ظهرت الحاجة الماسة لدراسة وتحسين صور هذا النظام، وهو جوهر بحثنا الحالي.

في بحثنا هذا تم دراسة ووصف احدى طرق التنعيم والتي طبقت على صورة رادارية. وتم طرح النتائج باستخدام مرشح كاما (Gamma) بنافذة (7×7) و (9×9) ورأينا كفاءته في التقليل من تأثير الضوضاء البقعية على الصور الرادارية والمحفظة على تفاصيل الصورة.

ABSTRACT

The synthetic aperture radar (SAR) is considered as an effective scanning system for the earth surface. It is operated by using coherent electromagnetic wave (EMW) which lie in the range of microwave (MW). The importance of this system has been increased through the last few decades, because it has been found as to be very efficient scanning tool, does not affected by weather condition, and can be used

at all days time. The main shortcoming associates with this imaging system is the speckle noise (coherent fading), which is causes by the coherent nature of the EMW. Since SAR images have been found as to be an important source of visual data found very useful for various applications, therefore, recently, large attention have been devoted to study and enhance this type of images. Accordingly, this paper is considered as to one of these studies.

In present paper we describes a smoothing scheme applied to SAR images. Here we present the results of testing the Gamma speckle reduction filter with window size (7×7) and (9×9) in order to examine its ability to aid feature extraction.

Keyword: SAR images, Adaptive filter, Non-adaptive filter, Multiplicative noise, Gamma filters.

1-INTRODUCTION

Various methods had been suggested to reduce the speckle effects, these methods can be divided into two categories; the first category is concerned with the methods which improve the appearance of the speckle (SAR) images by either averaging non-correlated images obtained from non-overlapping spectra, or by averaging the non-correlated images for different signal polarization, while in the second category speckle is smoothed after the image has been reduced [1,2]. The technique to be used in this work is the second category mentioned above.

2-IMAGE SMOOTHING FILTERS

The smoothing methods can also be classified into two classes of filters, the first class is the *adaptive filters* that are dependent on image model and local image statistics (Mean, Variance and Coefficient of variation), so they preserve texture regions, and boundaries. The second class is the conventional (*non-adaptive*) filters that are independent on image model, these filters always smear the edges, and blur the texture regions [2,3].

Some of the filters are implemented in the frequency domain, while other performed in the spatial domain [1]. Filters that utilized the spatial domain are practically preferable than those utilize the frequency domain, because they are; easier, simpler and faster [2,4].

3-ADAPTIVE SMOOTHING FILTERS

Most of the known adaptive filters that are used to smooth remotely sensed speckle images depend on the local image statistics; these filters compare the statistical characteristics of the neighbourhood with the speckle ones and therefore are called adaptive filters. In these such filters, theoretical hypotheses have been assumed that the noise is multiplicative with a mean value equal to one [2,4,5]. To avoid blurring effects and retaining faint lines and structures, adaptive filters can be used more efficiently. There are too many adaptive smoothing filters that have been, recently, introduced to improve speckle image appearance, but the most often used are the Frost’s filter, Lee’s filter, Kuan’s filter, and Gamma filter [5].

In this study, we used Gamma filter to removing speckles from corrupted images, this is performed by adopting the multiplicative noise model, as a best model to represent coherent fading noise image with window of size (7×7) and (9×9).

4-SAR IMAGES

Primary Radar (Radio Detection and Ranging) is an active system, it used for aircraft involves a similar pulse-echo technique except that it uses electromagnetic wave (EMW) which, like light, travel with a speed of 3×10m/s [1], which in its simplest form, relies upon the time of-flight of microwave echoes to reveal the presence and range of remote radio-opaque objects. Although it has many non-imaging applications (e.g. collision avoidance for cars), there has always been a strong desire to use this sensing strategy to acquire images of remote objects. Such images are commonly achieved by using a rotating antenna to scan the emitted microwave energy across the field-of view to be imaged [6]. Imaging radar date are being used in a variety of applications, including geologic mapping, ocean surface observation, polar ice tracking, and vegetation monitoring. Most of these applications are still in a developmental stage because our knowledge is still limited on how to extract information for radar image data and how to use the normal combination of radar parameter. Qualitatively, SAR images can be interpreted using the same photo interpretation techniques used with visible and near infrared imaging [2].

In a SAR image the brightness of the pixels is proportional to the intensity of the energy of the return echo, or backscatter, from that point in the scene. Just as in optical images, the intensity of SAR image depends on the surface inclination and roughness (relative to the incident wavelength) of the target [7].

SAR processing requires that the microwave pulses must be coherent, this brings with it the inherent problem of “speckle” which is highly descriptive term for the effect that this type of noise has on the image. The amount of speckle is inversely proportional to the square root of the number of looks whilst the increase in size of the resolution cell is directly proportion [2].

SAR images invariably contain a high level of image noise or speckle and this complicates the segmentation process. This speckle, associated with a homogeneous distributed target area, is due to the coherent nature of the SAR system. The presence of speckle, which can be modelled as a strong, multiplicative noise, makes the usual different edge detectors inefficient [3].

Generally, SAR image, is consider as a very important tools that can be used to image the earth surface with high spatial resolution, and this system can be used in various weather conditions and in all day time. Three types of SAR image format, these are: amplitude images format, intensity images format, and square root of intensity images format [1,4]. In fact in both: the square-root-method, and the amplitude method, a similar results has been obtained, because of the fact that $I=A^2$ [8,9], where the amplitude SAR images can be presented by [4].

$$A_y = \frac{1}{L}\sum_{k=1}^{N}\left[I_{ijk}\right]^{\frac{1}{2}} \qquad \text{.........................(1)}$$

In some digital SAR imaging techniques, the dynamic range of the SAR intensity is compressed, using the square-rooted values of the averaged intensity values, given by the form [5]:

$$S_i = \sqrt{\frac{1}{L}\sum_{k=1}^{N} I_{ik}} \qquad \text{.........................(2)}$$

Where: I=intensity, L=number of looks, and the distribution function of N looks intensity SAR image is represented by convoluting N negative exponential distribution functions

5-SAR IMAGE MODEL

The multiplicative model is given by:

$$I(x,y) = R(x,y).F(x,y) \text{.........................(3)}$$

Where $I(x,y)$ and $R(x,y)$ represent respectively, the observed signal, real signal, and $F(x,y)$ represent the multiplicative noise. This kind of noise makes visual and automatic interpretation very difficult task. Images corrupted by multiplicative noise have the characteristic that the brighter the area the noise it is. For more information see [5,10].

6-GAMMA-FILTER

Kuan, adopt Gaussian distribution as powerful model for homogenous image region, then estimate the effective filter eq. (4) to remove image noise [11]:

$$\hat{R}(x,y) = I(x,y).w(x,y) + \hat{I}(x,y)\big(1 - w(x,y)\big) \text{................(4)}$$

Where the weighting function w is given by:

$$w(x,y) = \frac{\left\{1 - \frac{C_F^2}{C_I^2(x,,y)}\right\}}{(1+C_F^2)} \quad ....(5)$$

Kuan filter was developed for 1-look intensity SAR image and by considering the underlying texture (i.e. the noise-free signal) of a surface pattern as having a Gaussian pdf model. But the distribution of homogenous image region in speckly images; obey to Gamma distribution, so that Lopes et. Al. Exploit this truth, and develop Maximum-A-Posteriori (MAP) filter to run efficiently in removing speckly noise. In fact, the Gamma MAP filter estimates the real signal by [10]:

$$\hat{R}(x,y) = \frac{(\alpha - L - 1)\bar{I}(x,y) + \sqrt{I^2(x,y)(\alpha - L - 1)^2 + 4\alpha L I(x,y)\bar{I}(x,y)}}{2\alpha} \quad ...(6)$$

Where $\alpha = \frac{1+C_F^2}{C_I^2(x,y) - C_F^2}$ = controller parameter, $C_I^2(x,y)$ =is the local coefficient of variation, C_F^2=is the coefficients of variation for the speckle, *I*= is the observed signal, $\bar{I}$=is the local mean, and *L*= is the number looks [12].

MAP restoration is a Bayesian approach which has already been in coherent light imaging, under Gaussian additive noise model and Gaussian image intensity. It can be shown that $\hat{R}(x,y)$ is a non-linear function of the observation *I*(*x*,*y*) and $\bar{I}(x,y)$, while in the local liner minimum mean square error (LLMMSE), Kuan's filter $\hat{R}(x,y)$ is represented as a linear function of *I*(*x*,*y*) and $\bar{I}(x,y)$. Several adaptations added to this filter by Baraldi and Parmiggiani [13] to make this filter work efficiently in preserving straight lines, and edges [13,14].

7-EXPERIMENTAL RESULTS AND CONCLUSION

The original image used is a (Amplitude SAR) (ASAR), image, polarization, amplitude data, three nominal look and resolution of approx., obtained on 9/26/96. The gray levels ranged between 0 to 255 pixel. It is presented in figure (1-a). The image is from the surrounding of the Tapajo's National Forest/Para', Brazil. In this sit, several forest area have been cleared and converted into pasture and agricultural fields or abandoned. The equivalent number of looks was estimated as 4.76, using samples selected from homogeneous areas [15]. Also figure (1) show the smoothing result obtained by performing Gamma filter. It should be noted that; the mentioned filter have been performed by utilizing a smoothing window of size (7×7) and (9×9).

The quantitative test for the image quality is carried out, by adopting two quantitative measures (Equivalents number of look (ENL), Signal to noise ratio (SNR)) applied for homogenous image regions from the original image and smoothing images with window size (7×7) and (9×9). The results are shown in figure (2).

When comparing the image histogram shown in figure (1-a), (1-b) and (1-c) for the original and smoothed images, respectively, it can be seen that the main peak in the original histogram is splitted into two smaller peaks which represent a dark and bright regions in the smoothed image histogram. Consequently, one can conclude that a highly smoothing operation is performed.

A according to the quantitative measures given in figure (2) of the homogenous regions were considered. A high equivalent number of looks values are produced some times approach the original image or may be slightly smaller.

8-REFERENCES

1-Gonzales R., and Woods R., "Digital Image Processing", Pearson Education International Prentice Hall, Inc. 3rd Edition, (2008).

2-Jason L. M., Marwan Y. A. And Evan H., "Advanced Image Processing With DirectX®9 Pixel Shaders", 3D Application Research Group ATI Research, From ShaderX^2-Shader Programming Tips and Tricks with DirectX9, edited by Wolfgang Engle. (2003).

3-Awcock G. J, " Technology and Applications of Radar, and Tomographic Medical Image Acquisition System", Electronics and Communication Engineering Journal, June (1998).

4-Fjqrtoft R., Lopes, A. J. B., and Marthon P., "Optimal Edge Detection and Edge Localization In Complex SAR Image With Correlated Speckle", IEEE Transactions on Geosciences and Remote Sensing, Vol. 73, No. 5, September, (1999).

5-Al-Zuky A. A. D., "Quantitative Analysis of Synthetic Aperture Radar Images", Ph.D Thesis Physics Dept., College of Science, Baghdad Univ. , (2000).

6-Al-Amrri S. J. K., "Maximum A Posteriori Filter For Restoration Speckle Images", Ms.C. Thesis, Physics Dept., College of Science, Baghdad Univ., (2000).

7-Umbaugh S. E., "Computer Vision and Image Processing: A Practical Approach Using CVIP Tools", Prentice Hall PTR, Upper Saddle River, NJO7458, (1998).

8-Sloan A., "Image Recognition With Poor Quality imagery ", Advanced Imaging, Vol. 18, pp. 8-9, and 37, March, (2008).

9-Goodman J. W., "Speckle Phenomena in Optics: Theory and Application", J. Opt. Soc. Am., (2007).

10-Baraldi A. And Parmiggiani F., "A Refined Gamma MAP SAR Speckle Filter With Improved Geometrical Adaptivity", IEEE

Transaction on Geoscience and Remote Sensing, Vol. 33, No. 5, September, (1995).

11-Lopes A. Etal, "Speckle Filtering In SAR Image ", INT J. Remote Sensing, Vol. 14, No. 9, pp. 1734-1758, (1993).

12-Gisela K., "Skeletons in Digital Image Processing", Centre for Image Technology Pobotics, CITR-TR-112, New Zealand, July, (2002).

13-David F. And Hertzmann A., "Computer Graphics Lecture Notes", Computer Science Department University of Toronto Version, (2005).

14-Gounzalez C., Woods R. E., and Eddins S. L.,"Digital Image Processing Using Matlab", Parson Prentice-Hall, (2004).

15-Frery A. C., Yanasse C. F., Vieira P. R., Sidnei J. S., and Renno C. D.,"A User-Friendly System for Synthetic Aperture Radar Image Classification Based on Gray scale Distributional Properties and Context", Anais do X SIBGRAPI, pp. 1-8, (1997).

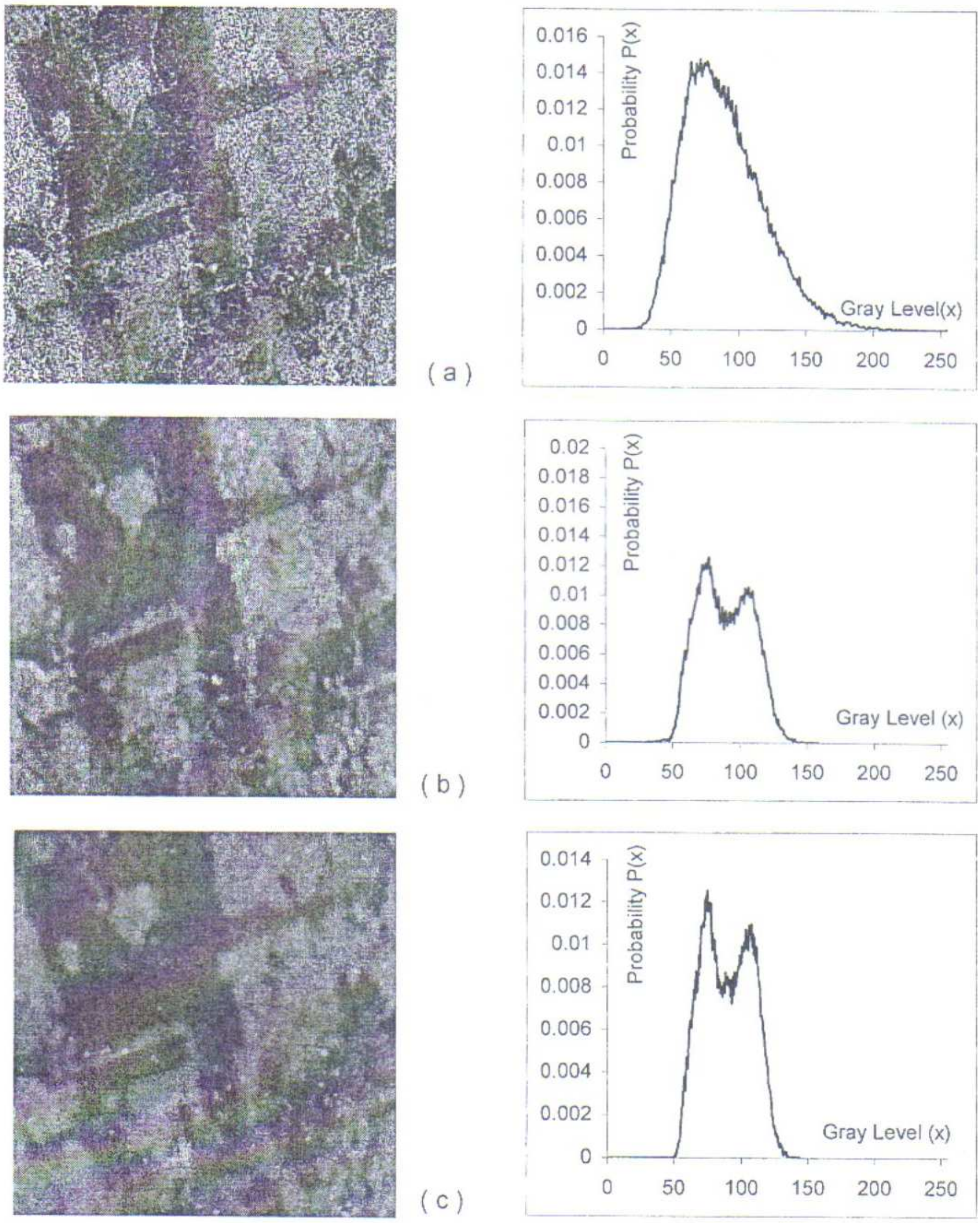

Fig.(1): The smoothing result of the ASAR image

(a)- The original image.

(b)- The smooth image by use Gamma filter with window size (7×7).

(c)- The smooth image by use Gamma filter with window size (9×9).

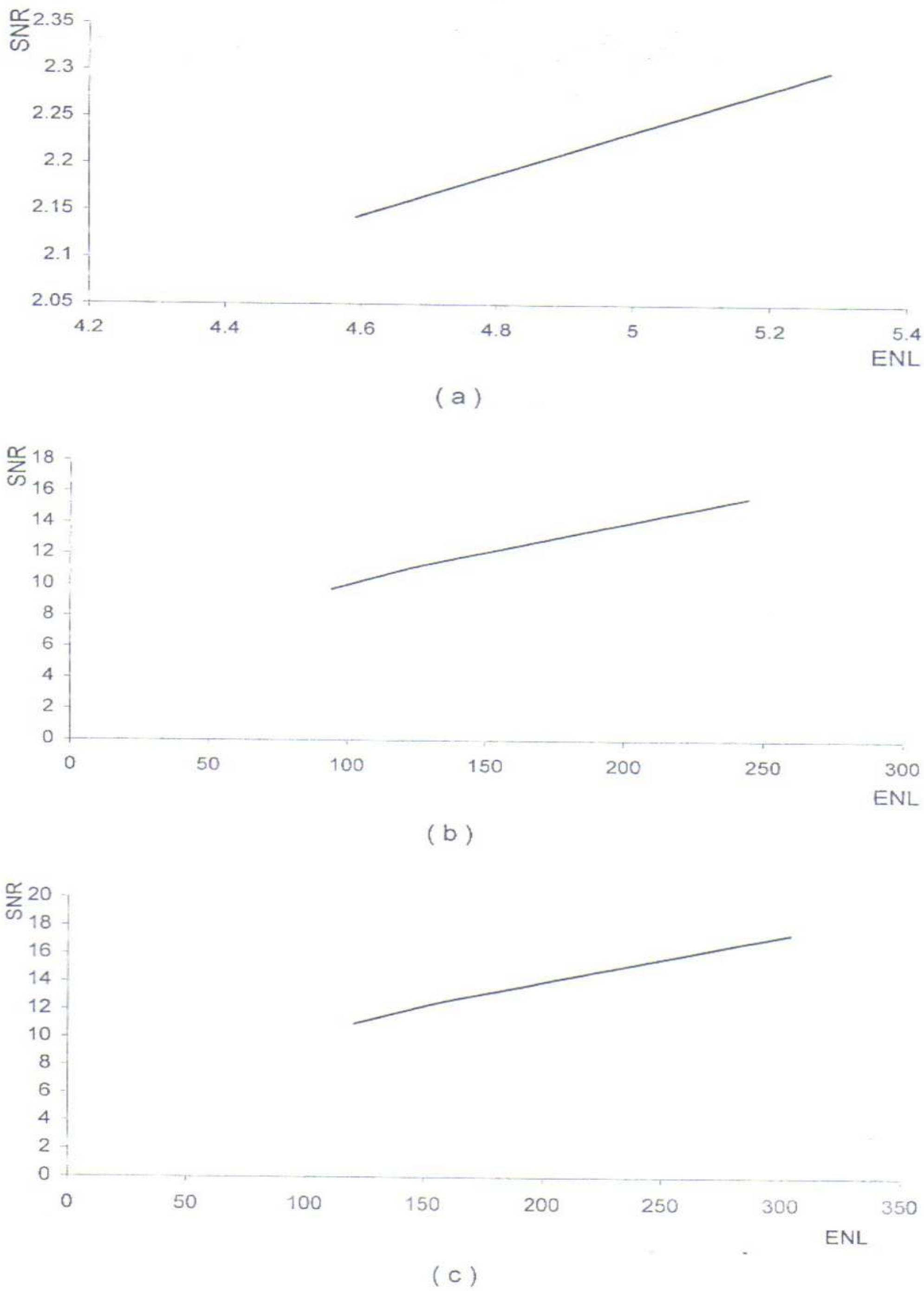

Fig.(2): The relationship between (ENL and SNR) from: (a)- Original SAR image.

(b)- Smoothing image with window size (7×7). (c)- Smoothing image with window size (9×9).