Use of SARAS in post-processing techniques

Maurizio Migliaccio ♣, *IEEE member*, **Daniele Riccio ◊**, *IEEE member*

♣ Istituto Universitario Navale, Via Acton 38, 80133 Napoli, Italy.

◊ C.O.R.I.S.T.A., Ple Tecchio 80, 80125 Napoli, Italy.

ABSTRACT

A SAR raw signal simulator can be very useful in post processing techniques. In the following paper we deal with a first application of SARAS (Synthetic Aperture Radar Advanced Simulator) in edge-detection procedures. In particular, SARAS appropriately simulates the raw signal received on board of the sensor, then we process it in order to produce the relative image. Henceforth post-processing techniques can be applied to the simulated image. Experiments are here shown: visual and quantitative inspections are in very good agreement with results obtained on real SAR images. Such outcomes encourages future work on such field.

INTRODUCTION

In Synthetic Aperture Radar (SAR) framework the minimal idea to filter the raw data collected by the sensor in order to produce an image is now overwhelmed by the well established concept to enrich such basic information through post-processing techniques [1]. In other words additional information extraction techniques must accompany the pure processing of the raw signal. A wide and interesting work has been accomplished to help the interpretation of SAR images (see for example Refs.2 and 3). On such line a SAR simulator is an appropriate and interesting tool; in fact desired and perfectly controlled scenarios can be appropriately "built". Hence, it is possible, as well as desired, control system-processor parameters.

A SAR raw signal simulator (SARAS) [4] has been developed at IRECE-CNR, Napoli, Italy. It relies on the fundamental idea to evaluate the backscattered function $\gamma(\cdot)$ by means of a sound physical model. Such simulator allows to produce the raw signal pertinent of an extended three-dimensional scene. In fact, the height profile is modelled through planar facets and the pertinent backscattering field is evaluated. Although geometrical effects are taken into account, we emphasize that SARAS is by no means a geometrical simulator.

Furthermore the radar system function is correctly included in its two-dimensional analytical expression [4] so to improve time and accuracy requirements. A full two-dimensional FFT code procedure is performed. Last but not least correct and efficient inclusion of noisy speckle is implemented in our simulation code [4]. Such features propose SARAS as an helpful tool.

In this paper we present some experiments performed on images obtained by simulated data, in order to assess again the importance of such a tool in developing post-processing techniques. In particular we examine the edge-detection problem.

GENERAL DESCRIPTION

The preparation of the experiment relies on three macro phases.

The first phase is the simulation one: the raw signal is generated by means of SARAS [4].

The second phase takes care to process the raw data and to obtain the corresponding image. It is the processing phase.

The third phase is the post-processing one. Such step depends obviously on the final goal to be reached but also on the nature of image involved and on the cost-functions taken into account [3]. Hence, for a fixed goal, some quality parameters may suggest one algorithm in spite of another. Moreover a procedure casted for some class of images may turn out to be not appropriate for a different image set. An interesting and wide literature scan the issue, see for example Refs.[5,6].

In order to recognize the edges present in a image the use of local operator can be pursued [5-7]. Hence, a quite general edge-detection post-processing algorithm can be casted in such an essential four step procedure:

(a) image prefiltering
(b) filtering
(c) thresholding
(d) contour following

The (a) step is able to reduce the image noise impact, in particular it reduces the multiplicative noise present on the image. An efficient and modern technique is the one proposed by Jong-Sen Lee [8]. This is the one here considered.

The (b) step is the heart of the entire post-processing algorithm: the image is filtered by means of local operators. They may possibly rely on an assumed noise model [3,9]. Such filter can be also characterized by their kernel form and dimensions, indeed the filters can be roughly classified in space varying and space invariant, as well as gradient like or differently. In the present paper we consider gradient like and CFAR filters. Since, it has been recognized that traditional gradient like edge detector are inappropriate when SAR images are considered. In fact, because of the multiplicative noise here present, such edge detectors treat differently brighter and darker regions of the image [9]. Specifically, it has been theoretically proved that the number of errors is higher in the brighter zones. Hence a different class of edge detector must be taken into account: the CFAR edge detectors. Among them a new CFAR edge detector has been proposed and successfully tested: the ratio edge detector [9].

The (c) step produces a binary output image. Fundamentally it is a labelling algorithm: according to a prescribed threshold the pixels are considered belonging or not to an edge. Such threshold value choice is delicate aspect to be considered and some theories have been developed [10,11]. Such an image is not yet to be considered as the desired one, in fact edge lines are often broken and not continuous as expected.

The (d) step allows to recognize the broken lines as a unique edge. As detailed referred in [12] such step can be seen as three subsequent ones: cleaning, dilatation and thinning algorithms. This step can alternatively be based on different approach such as the Hough Transform [13].

RESULTS

Some examples are hereafter presented. A simulated raw signal pertaining a four field scene has been simulated and the corresponding image has been obtained; correct mission parameters have been adopted (see fig.1). In addition, to the simulation and processing phases, only a moderate spatial averaging has been performed.

Although in the simulation run we used a multiplicative speckle model, we additionaly tested it on the final image (fig.1); the convenient identification method [3] confirmed such behaviour.

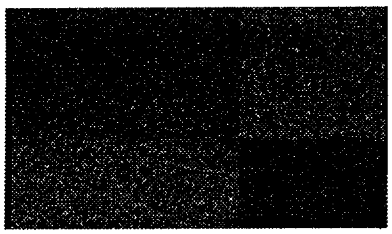


fig.1: *Image relevant to a simulated four field area.*

Followingly such image has been post-processed by means of a classical Sobel filtering [7]; the kernel dimension was 7x7. The result of such post-processing is shown in fig.2 together with the grey level distributions of the fields present in the figure.

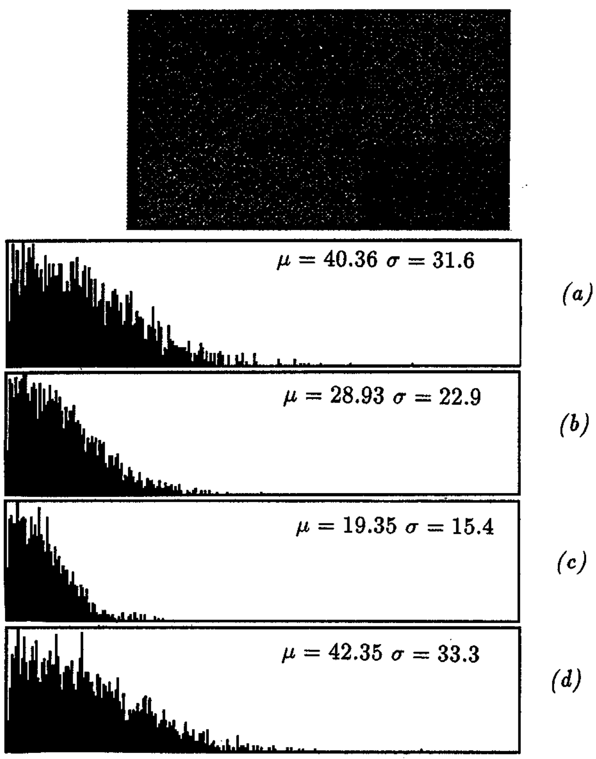


fig.2: *Post-processed image by means of a Sobel filter (7x7 window size). (a) Grey level distribution relevant to the top right patch of the image. (b) Grey level distribution relevant to the top left patch of the image. (c) Grey level distribution relevant to the bottom right patch of the image. (d) Grey level distribution relevant to the bottom left patch.*

As addressed by Touzi et alii [9] the gradient egde detectors are sensitive to the mean power of the image and the false alarm probability is higher in the homogeneous part of the image with higher mean power. Such analytical predicted results [9] are confirmed (see fig.2).

Analogously we have filtered the same previous image by means of the ratio CFAR one; the filter window size was again 7x7. The corresponding image is referred in fig.3; once again the grey level distributions pertaining the four fields are shown. It must be stressed that no discrimination in favour of darker or brighter zones has been operated, now. In fact, the grey level standard deviations is constant over the different macroscopic homogeneous patches. Such quantitative results are consistent with the ones reported in Ref.[9].

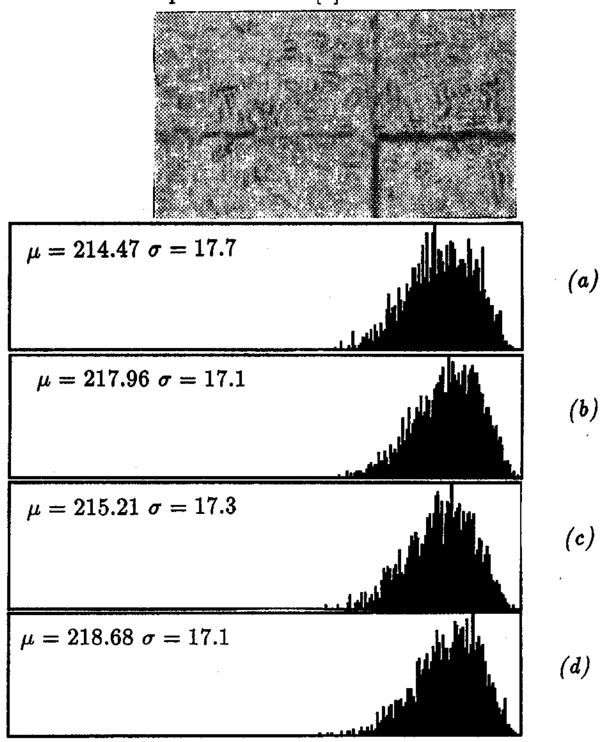


fig.3: *Post-processed image by means of a Ratio CFAR filter (7x7 window size). (a) Grey level distribution relevant to the top right patch of the image. (b) Grey level distribution relevant to the top left patch of the image. (c) Grey level distribution relevant to the bottom right patch of the image. (d) Grey level distribution relevant to the bottom left patch.*

Unfortunately, we note that both figs. 2 and 3 are not able to identify the edges present in the simulated SAR image.

Hence, formerly, an opportune procedure step must be accomplished in order to smooth the speckle noise present on the image shown in fig.1. The speckle reduction procedure proposed in Ref.[8] has been applied and the corresponding image is depicted in fig.4. We also show the pertinent grey-level distribution (see fig.4), evaluated over the entire image, aiming at emphasizing the possibility to detect the desired feature, now.

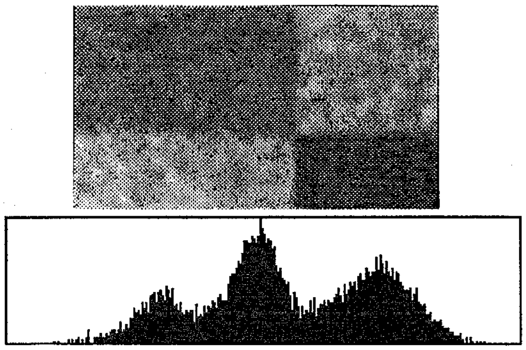
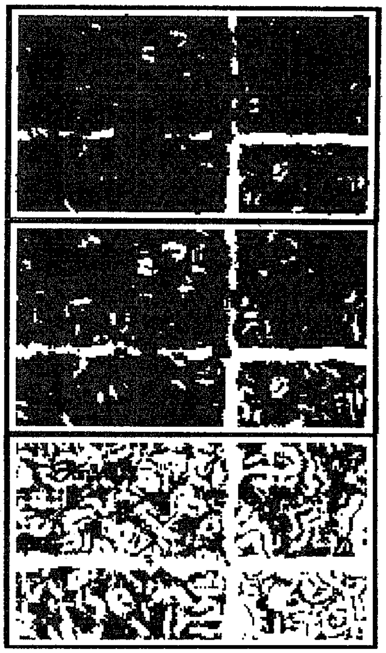


fig.4: *Smoothed image and its grey levels.*

In order to assess the validity of the casted edge-detection technique we applied the CFAR filter on such an image (fig.4). Followingly, in such latter case, a thresholding phase has been performed and the corresponding result is shown in fig.5. Such a figure is, actually, composed of three examples which differ only for the employed threshold value. The (a), (b), and (c) cases correspond, respectively, to such threshold values: T=0.75, T=0.80, T=0.90.



(a)

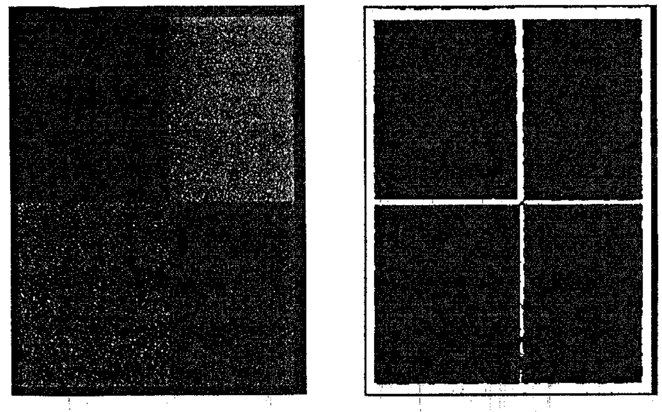
(b)

(c)

fig.5: *Binary ratio images relevant to different threshold values: T=0.75, T=0.80, T=0.90, respectively.*

An accurate analysis on such final results shows that the false alarm probability is no more constant over the four zones. In particular we note that filtering CFAR performances are worse in the bottom right darker field. We believe to charge it to the smoothing algorithm [8]. In fact, the prefiltering here used rely on an assumed and tested a priori noise statistic, henceforth such step affect the multiplicative noise feature. Such result has been confirmed by an appropriate test [3].

Moreover we considered a different but similar scene. We simulated the corresponding raw signal and obtained the pertinent SAR image (fig.6a). An inchorent averaging was performed on it. The multiplicative noise nature was tested [3] and finally the CFAR ratio filtering and thresholding was performed. The result is shown in fig.6b. We note how the CFAR procedure is effective, now.



(a) *(b)*

fig.6: *(a) SAR simulated image and (b) its Binary ratio image (T=0.80).*

CONCLUSIONS

A simple but interesting application of a new SAR raw signal simulator has been presented. The results are in very good agreement with the ones found theoretically and successfully tested on real SAR images. Heceforth it can be once again, stressed the relevance of such a simulation tool in order to appropriately "build" desired scenarios.

REFERENCES

[1] F. W. Leberl, **Radargrammetric Image Processing** , Artech House, 1990.

[2] F.T.Ulaby, F.Kouyate, B.Brisco,T.H. Lee Williams, " Textural Information in SAR Images ", **24** , *IEEE Trans. Geosci. Remote Sensing,* 235-245, 1986.

[3] J.M.Durand, B.J.Gimonet, J.R.Perbos, "SAR Data Filtering Classification", **25**, *IEEE Trans. Geosci. Remote Sensing,* 629-637, 1987.

[4] G. Franceschetti, M. Migliaccio, D. Riccio, G. Schirinzi, "SARAS: a SAR Raw Signal Simulator", **30**, *IEEE Trans. Geosci. Remote Sensing,* 000-000, 1992.

[5] A.Rosenfeld and J.S.Weszka, " Picture Recognition ", in **Digital Image Processing for Remote Sensing**, R. Bernstein Ed., IEEE Press, 1978.

[6] L.S.Davis, "A Survey of Edge Detection Techniques", **4**, *Computer Graphics and Image Processing,* 248-270, 1975.

[7] F.M. Wahl, **Digital Image Signal Processing**, Artech House, 1987.

[8] Jong-Sen Lee, "A Simple Speckle Smoothing Algorithm for Synthetic Aperture Radar Images", **13**, *IEEE Trans. Syst., Man, Cybern.,* 85-89, 1983.

[9] R.Touzi, A.Lopes, P.Bousquet, "A Statistical and Geometrical Edge Detector for SAR Images", **26**, *IEEE Trans. Geosci. Remote Sensing,* 764-773, 1988.

[10] N.Ahuja and A.Rosenfeld, "A Note on the Use of Second-Order Grey -Level Statistics for Threshold Selection", **8**, *IEEE Trans. Syst., Man, Cybern.,* 895-898, 1978.

[11] N.Otsu, "A Threshold Selection Method from Grey-Level Histograms", **9**, *IEEE Trans. Syst., Man, Cybern.,*62- 66, 1979.

[12] T.Paulidis, "A Thinning Algorithm for Discrete Binary Images" , *Computer Graphics and Image Processing,* **9** , 1980.

[13] J.Wang and P.J.Howarth, "Use of the Hough Transform in Automated Lineament Detection", **28**, *IEEE Trans. Geosci. Remote Sensing,* 561-566, 1990.