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Edge Enhancement Using Haar Mother Wavelets for Edge Detection in SAR Images

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ABSTRACT— Satellite Borne Synthetic Aperture Radars (SAR) helps in the observation of geographical areas during the day as well as during the night. They are independent of weather effects. But SAR images represent complex reflectivity map of a scene which makes them non-meaningful for an inexperienced observer. Thus the characteristics of SAR images necessitates proper enhancement as well as the requirement of specific data analysis algorithms to ensure unsupervised and robust exploitation of SAR data. This paper presents a new method for edge enhancement in SAR images based on the exploitation of the information provided by the wavelet coefficients. The paper performs edge detection of SAR images using geodesic active contours. The comparison of existing edge detection techniques with geodesic active contour is also performed**.**

KEYWORDS— Edge detection, geodesic active contour, synthetic aperture radar (SAR), wavelet transform.

I. INTRODUCTION

Synthetic aperture radars (SARs) imaging is a kind of high resolution imaging system that generates images independent of time and weather conditions. Presence of inevitable signal dependent noise called speckles degrades the visual appearance and severely diminishes the effectiveness of automated scene. The direct application of conventional image processing tools, conceived from an optical point of view, usually gives suboptimum results on SAR data. Thus the characteristics of SAR images justify the importance of an edge enhancement step prior to edge detection. Specific data analysis algorithms are still to be provided in order to assure unsupervised and robust means for the intensive and operational exploitation of SAR data. This paper presents a robust and unsupervised edge enhancement algorithm based on a combination of wavelet coefficients at different scales. In order to complete the automatic detection chain, among the different options for the decision stage, the use of geodesic active contour is proposed.

Robust edge detection techniques are essentially based on the following two steps: edge enhancement and decision. There exists robust edge enhancement methods like Sobel filter, Prewitt filter, morphological gradients etc .But they provide a limited application in SAR images due to the presence of speckles. Thus, the paper presents a new method for edge enhancement in SAR images based on the exploitation of the information provided by the wavelet coefficients . It manages the multiscale data in a different way and does not assume any statistical distribution of the input data nor any particular type of edge. It works exclusively in the transformed domain. The proposed approach will tackle at the same time the robustness and the precision issues of edge enhancement and detection.

In Section II, the overview of the characteristics of SAR images is discussed. The proposed approach is then described in Section III. The Section IV presents the simulation results. The existing edge detection techniques are compared with the geodesic active contour in Section V. Finally, Section VI draw the conclusion of this paper.

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II. SAR IMAGES (SYNTHETIC APERTURE RADAR)

SAR is usually implemented by mounting a single beam- forming antenna, on a moving platform such as an aircraft or spacecraft, from which a target scene is repeatedly illuminated with pulses of radio waves. The wavelength can range anywhere from a meter down to millimeters. The echo waveforms received successively at the different antenna positions are coherently detected and stored .These waveforms are then post-processed together to resolve elements in an image of the target region. The complex radar data depends on and the scattering properties of the observed scene at the corresponding microwave frequency. Thus, a radar image consists of mapping of electromagnetic measurements.

A complex SAR image may be represented as the convolution of the local complex reflectivity of the observed area $\gamma(\tau, \eta)$ with the impulse response of the SAR system $u_0(\tau, \eta)$ as:

$$u(\tau, \eta) = \gamma(\tau, \eta) * u_0(\tau, \eta) \quad (1)$$

where $*$ stands for the convolution. τ and η are the azimuth and the range coordinates, respectively, employed to define the coordinate system of a SAR image.

III. PROPOSED APPROACH

The proposed method uses an algorithm [1] for edge enhancement in SAR images which relies on the difference of behavior along the wavelet scales of the speckle in front of the edges. The information provided by the wavelet coefficient [10] is utilized for enhancement of the image. This can in turn result in better enhanced image than the ones provided by other enhancement techniques. The discontinuities are highlighted by the wavelet transform, and they tend to continue over scales. The speckle is also progressively smoothen by the algorithm.

Initially the acquired image is converted to logarithmic scale to perform image compression. The image is then made to undergo two dimensional Haar wavelet transform [5] decomposition. Thus three sub bands namely horizontal, vertical and diagonal sub bands are obtained. Normalization of these sub bands is then done. The maximum pixel value of the absolute values of these sub bands is then detected. Product calculation of the maximum value of pixel finally results in enhanced image. The application of Geodesic active contour [18] model on the image then helps in obtaining edge detected image.

The block diagram of the proposed approach is shown in Figure 2:

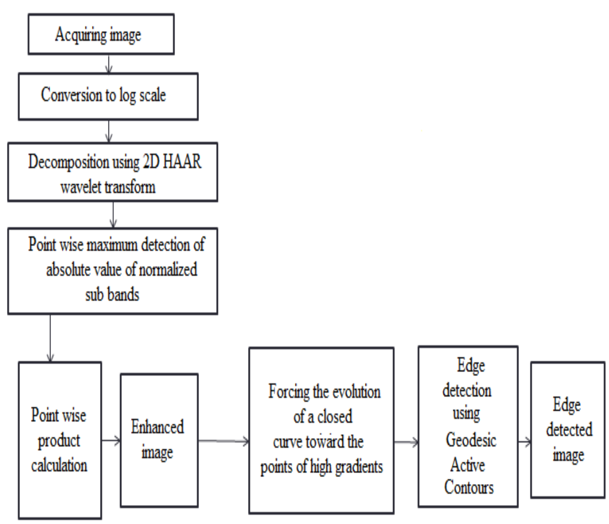

Figure 2: Block Diagram

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Due to the multiplicative nature of the speckle, SAR images tend to be irregular, presenting a lot of discontinuities. Hence, a large number of fading moments can be avoided for their analysis. Moreover, the proposed algorithm deals with enhancing edges. It utilizes the spatial coincidence of the local maxima at different scales due to the presence of discontinuities: the maxima produced by the presence of a frontier tend to continue over scales. These results in a higher inter scale spatial correlation in the presence of an edge than in the background.

In case of a 1-D wavelet transform, two frequency bands are obtained at each iteration. In the case of a 2-D transform, four sub bands are obtained. The first three bands refer to the horizontal, vertical, and diagonal details of the image. The fourth band contains the low-pass-filtered component of the image. In both cases, each component has the same size as that of the input signal. The proposed algorithm for edge enhancement is based on the combination of wavelet coefficients at different scales, and it is thus necessary for the coefficients to be combined to generate an image of the same size as the input image. This determines the choice of the wavelet transform

.

Thus, incase of SAR image processing, taking logarithm of the original image is useful in order to manage the multiplicative speckle. Thus it can be supposed as:

$$f(\tau) = \log(\sigma(\tau)\, n(\tau)) = \log(\sigma(\tau)) + \log(n(\tau)) \qquad (2)$$

where n stands for the speckle and σ stands for the useful information content of the radar signal. The transformed speckle is additive and signal independent. Moreover, its probability density distribution is also approximately Gaussian. The logarithm operation is helpful in reducing the large dynamic range of SAR data.

The contribution of speckle in each of the semi intervals counteracts with the other and hence its influence in the wavelet transform is low. More specifically, assuming the homogeneity of the speckle, the equation is given by:

$$\int_{u}^{s/2\,+u} \log(n(x))\, dx \approx \int_{s/2\,+u}^{s+u} \log(n(x))\, dx \qquad (3)$$

Low values of the speckle occur when large length intervals are taken. Moreover, due to the spatial co-occurrence of speckles, the local maxima contribute constructively when multiplying the scales. The ones produced by the presence of a meaningful edge propagate over the scales when the discontinuities that are due to the speckle do not continue,. As a result, the interscale point wise product neglects the small isolated discontinuities.

Main properties of the algorithm

The advantages of the proposed technique is its simplicity and low computational cost. The algorithm is an iterative process. It has the following two operations per iteration: the application of a single iteration of the Haar Wavelet Transform and the evaluation of the point wise maxima.

The proposed technique donot require prefiltering step. Also, the technique is independent of the statistics of the input image. One of the main interests of the algorithm is that it provides a result directly in the wavelet domain. As a result, in contrast to the conventional filters, it does not require any inversion step, which includes introducing artifacts when wavelet coefficients are processed. Since the method works on the transformed domain, differential values are considered rather than absolute ones.

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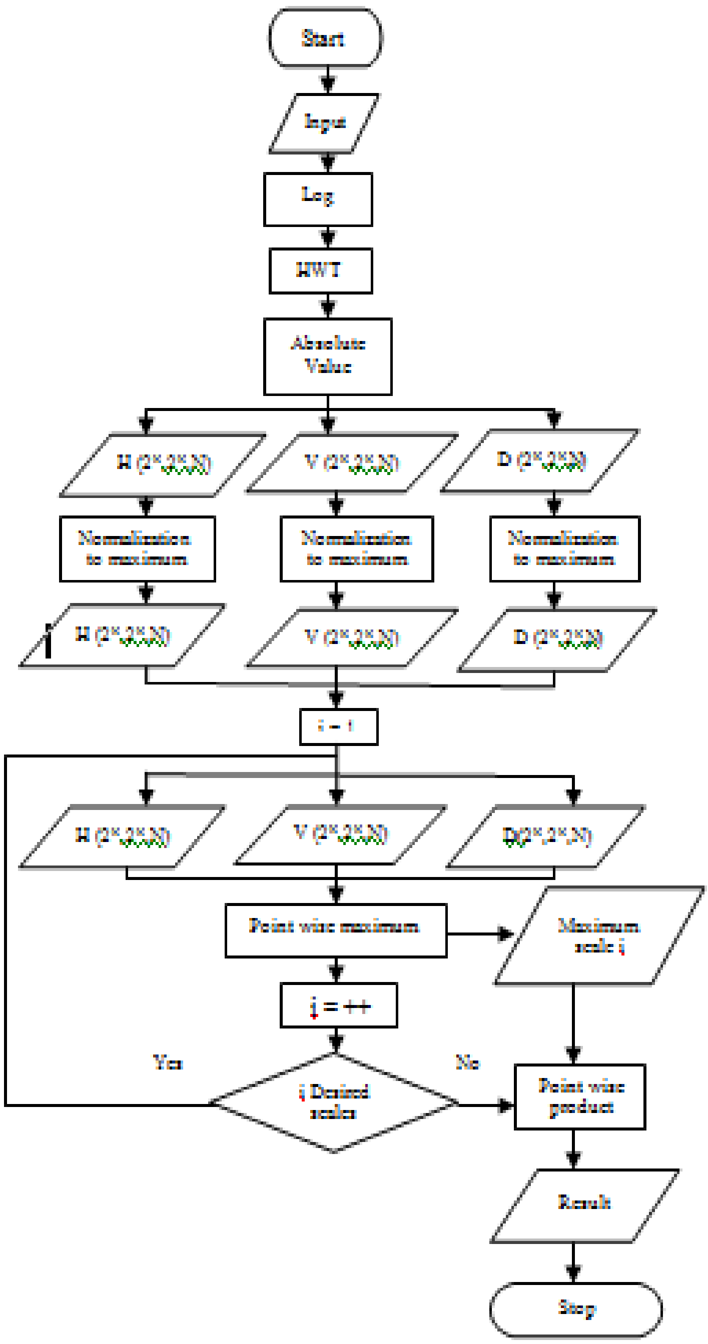

Figure 3: Flowchart to perform edge enhancement

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A. Geodesic Active Contour

The unsupervised edge detection consists of segmentation of the input image which can be done either using gradient binarization through thresholding or using geodesic active contours. The straightforward method for segmentation is gradient binarization through thresholding. But this option has several disadvantages. Mainly, the threshold is difficult to define automatically. Furthermore, noise and artifacts may appear, and contours may not be closed.

As an alternative to thresholding, the use of active contours is preferred, even if they are computationally costly. Essentially, a geodesic active contour or snake consists of forcing the evolution of a close curve toward the points of high gradients.

More specifically, let the geodesic length (GL) be defined as

$$GL = \int g(\nabla x)\, ds \qquad (4)$$

where g is a function of ∇x, which is the gradient estimated through the edge enhancement algorithm

$$g(\nabla x) = 1/\left(1 + \|\nabla x\|^{p}\right) \quad \text{with } p \in \mathrm{R}. \qquad (5)$$

p is set to one by default. Hence, the objective of the snake is to find the curve $C(s)$ such that GL is minimum. If C *is* considered to be a function of time t, the Euler–Lagrange equations yield the curve evolution equation as:

$$\partial C/\partial t = g\,\kappa\,\vec{N} - \langle \nabla g, \vec{N} \rangle \vec{N} \qquad (6)$$

where κ is the Euclidean curvature, $\vec{N}$ is the unit inward normal, $\langle .,. \rangle$ stands for the scalar product, and ∇ stands for the gradient operator. The level set method is preferred incase of practical implementation. In such cases, a 2-D surface u is evolved. C is then the zero level set of u, and u is said to be a known representation of C.

The evolution of u can be expressed as:

$$\partial u/\partial t = g(\kappa + c)\|\nabla u\| + \langle \nabla g, (\nabla u/\|\nabla u\|) \rangle \|\nabla u\| \qquad (7)$$

where c is a constant erosion parameter and κ is defined as

$$\kappa = div(\nabla u/\|\nabla u\|) \qquad (8)$$

where div is the divergence operation. Hence, the minimization is done by initially setting a default surface u_0 (that is, u at $t = 0$) and then by actualizing it iteration after iteration (each iteration represents a differential of time dt), according to the equation (8) as:

$$u_t(x, y) = u_{t-1}(x, y) + dt \cdot \beta \qquad (9)$$

where,

$$\beta = g(x, y) \cdot (\kappa + c)\|\nabla u\| + \langle \nabla g, (\nabla u/\|\nabla u\|) \rangle \|\nabla u\| \qquad (10)$$

The default surface u_0 is calculated as the distance of every point of the surface to the frame of the image. Hence, the curve that is constituted by u_0 evaluated at level 0 is the external contour of the input image. It must be noted that this default initial contour often requires a large number of iterations before convergence to the targeted edge. Therefore, in order to save the computational cost, the initial contour should be as close as possible to the final result.

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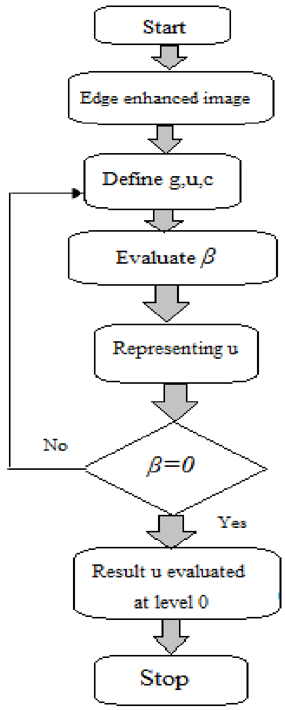

Figure 4 : Flowchart of Geodesic Active Contour

IV. SIMULATION RESULTS

Figure 5:Input image

The figure 5 shows the original SAR image of a coastline. The complexity of the process depends on the characteristics of the SAR image. The presence of speckles in the image makes the process tedious. Speckles refer to multiplicative noise like components that may severely degrade visual appearance of the SAR images.

Figure 6 shows decomposed images using Haar Wavelet Transform. As the figure shows, the decomposition results in three sub bands namely horizontal, vertical and diagonal sub bands. When using wavelet tools for signal processing purposes, it is critical to choose conveniently the type of transform as well as the mother wavelet according to the nature of the signal to be analyzed and according to the type of characteristic to be highlighted.

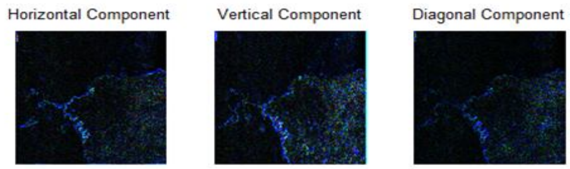

Figure 6: Image decomposition using HAAR wavelet transform

The initial edge enhanced image is obtained in figure 7 based on the level of decomposition performed. Three levels of decomposition are performed for two dimensional images. Thus the better enhanced image is obtained at the third level. The level of decomposition becomes five when the image is one dimensional. In this case, better enhanced image is obtained at the fifth level.

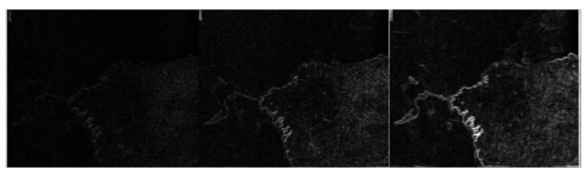

Figure 7: Edge enhanced image

The figure 8 is a cropped version of the initial edge enhanced image. Since the level of decomposition is three, third order cropped version is obtained. When the level is five, the cropped version of the fifth level is taken.

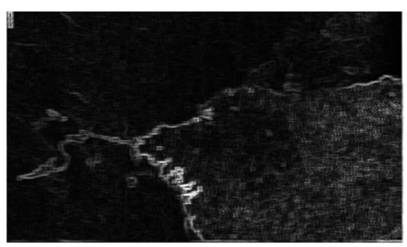

Figure 8: Third order or cropped version of edge enhanced image

Figure 9 shows a better enhanced image of the input images. Enhancement here refers to the improvement in the intensity of the image in order to properly detect the edges in the image.

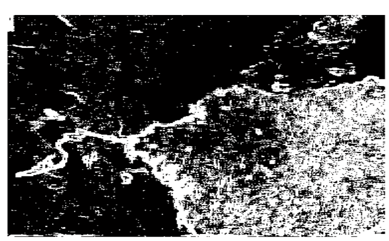

Figure 9: Enhanced image

The figure 10 shows the edge detection process of geodesic active contour. The computational time increases according to the number of iterations performed.

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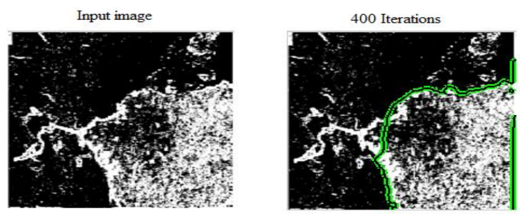

Figure 10: Edge detection using GAC

Thus, figure 11 is the final detected edge of the coastline SAR image. This shows the result of geodesic active contour.

Figure 11: Final detected edge

V. COMPARISON BETWEEN EXISTING EDGE DETECTION TECHNIQUES

There exist various edge detection techniques [15] for the purpose of edge detection of images. Among them, three types of detection techniques has been chosen for comparison between the geodesic active contour technique. They are sobel edge detection technique, prewitt edge detection technique and canny edge detection technique. The most efficient technique between these three is found to be canny edge detection technique.

A group of techniques is based on the evaluation of the ratio of averages over a sliding window. These methods present a low computational load, but they are highly dependent on the dimensions of the window and are not robust in noisy scenes. There also exists an edge detector based on a threshold operation of wavelet coefficients. Despite a low computational cost and a good contrast, detected edges are too thick.

In case of SAR images, these techniques have provided limited efficiency due to the presence of speckles. Geodesic active contours ,on the other hand prove to be highly efficient in detecting the edges . They are not only accurate, but also perform automatic edge detection of SAR images.

The figures 12, 13 and 14 shown above are the edge detected images using sobel, canny and prewitt edge detection methods. From the results, it can be inferred that, Geodesic active contours results in accurate edge detection than the other techniques which results in detection of false edges of the image.

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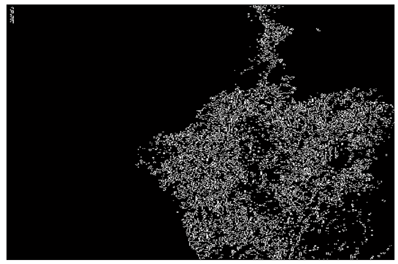

Figure 12: Sobel edge detection

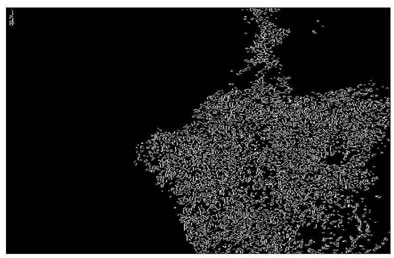

Figure 13 :Canny edge detection

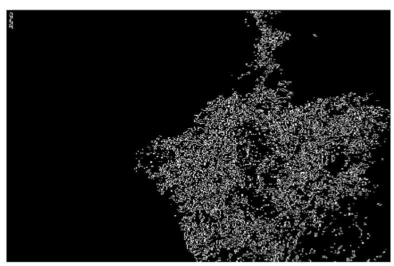

Figure 14: Prewitt edge detection

VI. CONCLUSION

This paper deals with an algorithm for the unsupervised extraction of the most significant edges.The proposed method describes about a robust edge enhancement directly implemented in the wavelet transformed domain, followed by an edge detection based on the application of a geodesic active contour algorithm. The edge enhancement phase has been proven to be a good solution to deal with heterogeneous SAR images.It does not require any type of prefiltering of data, and it is independent of the statistics of the input image. Comparison of various edge detection techniques has also been performed.The experimental results prove the efficiency of the edge detection using Geodesic Active contours over the existing ones.

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REFERENCES

[1] Mariv Tello Alonso,Carlos Lpez-Martnez,Jordi J. Mallorqu and Philippe Salembier, ”Edge enhancement algorithm based on wavelet transform for automatic edge detection in SAR images” IEEE Transaction. .Geoscience .Remote Sensing., volume. 49, no. 1, January 2011.

[2] Huihui Song ; Bo Huang ; Kaihua Zhang,”A Globally Statistical Active Contour Model for Segmentation of Oil Slick in SAR Imagery”, in Applied Earth Observations and Remote Sensing, IEEE Journal of volume 6., January 2013.

[3] Melgar, J. Fombellida, J. Gomez, and J. Seijas, “Edge detection algorithms in intensity SAR images: Empirical comparison of performances and proposed improvements”, in Proceeding. WAC, September 2008, pp. 17.

[4] J.W. Goodman, “Speckle Phenomena in Optics: Theory and Applications”. Englewood, CO: Roberts Company, June 2007.

[5] J. Kuo and K.-S. Chen, “The application of wavelets correlator for ship wake detection in SAR images”, IEEE Trans. Geoscience. Remote Sensing., volume. 41, no. 6, pt. 2, pp. 1506-1511, June. 2003.

[6] R. Touzi, “A review of speckle filtering in the context of estimation theory”, IEEE Transaction. Geoscience. Remote Sensing., volume 40. no,. 11, pp. 2392- 2404, November. 2002.

[7] K. J. Langenberg, M. Brandfass, K. Mayer, T. Kreutter, A. Brll, P. Felinger, and D. Huo, “Principles of microwave imaging and inverse scattering”, EARSEL .Remote Sensing., vol. 2, no. 1, pp. 1631-86, January. 2007.

[8] Y. Xu, J. B. Weaver, D. M. Healy, and J. Lu, ‘Wavelet transform domain filters: A spatially selective noise filtration technique”, IEEE Transaction. Image Processing., vol. 3, no. 6, pp. 747-758, November. 2004.

[9] H. Arsenault and G. April, “Properties of speckle integrated with a finite aperture and logarithmically transformed, J.Opt”., volume.66, no.11, pp. 1160-63, November. 2002.

[10] S. Madchakham, P. Thitimajshima, and Y. Ragsanseri, “Edge detection in speckled SAR images using wavelet decomposition”, in Proceeding. ACRS, November. 2001, volume. 2, pp. 1307-1310.

[11] J.M. S. Prewitt, “Object enhancement and extraction, in Picture Processing and Psychopictorics”, B. S. Lipkin and A. Rosenfeld, New York: Academic, June 1970,pp. 751-49.

[12] R. Fjortoft, A. Lopes, P. Marthon, and E. Cubero-Castan, “An optimal multiedge detector for SAR image segmentation”, IEEE Transaction. Geoscience. Remote Sensing., volume. 36, no. 3, pp. 793-802, May 1998.

[13] G. Cuartero, V. Meas-Yedid, V. Galy, U. Nehrbass, and J.-C. Olivo- Marine, “Three dimensional spot detection by multiscale analysis”, in Proceeding. International. Conference. on Image Processing, 710, October 2001, volume. 1, pp. 317-320.

[14] S. R. Cloude and K. P. Papathanassiou, “Polarimetric SAR interferometry”, IEEE Transaction. Geoscience. Remote Sensing., volume. 36,no. 5, pp. 1551-1565, September. 1998.

[15] C. J. Oliver, D. Blacknell, and R. G. White, “Optimum edge detection in SAR”, Proceeding. Institute of. Electrical. Engineers, Radar, Sonar, volume. 143, no. 1,pp. 3140, February. 1996.

[16] R. G. White and C. J. Oliver, “Change detection in SAR imagery”, in Proceeding. IEEE International. Radar Conference., May. 1990, pp. 217-222.

[17] B. M. Sadler and A. Swami, “Analysis of multiscale products for step detection and estimation”, IEEE Transaction. Information. Theory, volume. 45, no. 3, pp. 1043-1051, April. 1999.

[18] V. Caselles, R. Kimmel, and G. Sapiro, “Geodesic active contours”, International. J. Computer. Vision., volume. 22, no. 1, pp. 61-79, February. 1997.