A Proposed Approach to Determine the Edges in SAR images

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Abstract

Radar is the most eminent device in the prolonged scattering era. The mechanisms involve using electromagnetic waves to take Synthetic Aperture Radar (SAR) images for long reaching. The process of setting edges is one of the important processes used in many fields, including radar images, which assists in showing objects such as mobile vehicles, ships, aircraft, and meteorological and terrain forms. In order to accurately identify these objects, their edges must be detected. Many old-style methods are used to isolate the edges but they do not give good results in the determination process. Conservative methods use an operator to detect the edges, such as the Sobel operator which is used to perform edge detection where the edge does not appear well.

The proposed method which combines Ridgelet transform, Bezier curve and Sobel operator is used to detect edges very efficiently. Ridghelet transform resolves the harms in the wavelet transform and it can well detect the edges in images. Bezier curve can profit gradual variation of the data and their mutability. Hence, the efficiency of the edged image is improved and, when used with Sobel operator, the quality of the edge image become very good. The data show that the advocated method has superior fallouts over the Sobel edge detection and the wavelet method in both subjective and impartial experiments. While the Peak Signal to Noise Ratio(PSNR) values were equal to 9.3812, 9.8918, 9.6521 and 9.0743using the Sobel operator method and to10.2564, 10.7927, 10.5612and 10.8633 using the wavelet method, they were increased in the proposed method to 12.6542, 12.9514, 12.8574 and 12.3013 respectively.

Keywords: Bezier curve, Ridgelet Transform, Edge, Sobel, SAR images.

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طريقة مقترحة لتحديد الحواف في صور الرادار ذي الفتحة الاصطناعية

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الخلاصة:

الرادار هو واحد من أكثر الأجهزة استخدامًا في السنوات القليلة الماضية ، حيث تستخدم الموجات الكهرومغناطيسية لالتقاط صور SAR لمسافة طويلة. تعد عملية تحديد الحواف إحدى العمليات الهامة المستخدمة في العديد من المجالات ، بما في ذلك الصور الرادارية ، التي تستخدم لتحديد اتجاه وسرعة الأجسام الثابتة والمركبات المتنقلة والسفن والطائرات وأشكال الأرصاد الجوية والتضاريس.من أجل تحديد هذه الاجسام بدقة ، يجب الكشف عن حوافها. هناك العديد من الطرق التقليدية المستخدمة لتحديد

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الحواف ولكن لا تعطي نتائج جيدة في التحديد.تستخدم الطرق المستقيمة العملية لكشف الحواف ،
وبعضها عملية سوبل (Sobel operator) لإجراء كشف الحافة حيث لا تظهر الحافة بشكل جيد.

يتم استخدام الطريقة المقترحة التي تجمع بين التحويل القممي(Ridgelet transform) ومنحنى
بيزرBezierوعملية سوبل Sobel للكشف عن الحواف بكفاءة عالية. التحويل القممي حل الأضرار
في تحويل المويجاتWavelet ويمكن الكشف عن حواف في الصور بشكل جيد. يمكن منحنى بيزير
الاستفادة من التغير التدريجي للبيانات وتغير هذه البيانات. لذلك ، تم تحسين كفاءة الصورة ذات
الحواف وعند استخدامها مع عملية سوبل تصبح صورة الحافة جيدة للغاية.تظهر النتائج أن الطريقة
المقترحة لها نتائج أفضل على كشف حافة سوبل وطريقة wavelet في كل من الاختبارات المرئية
والمحسوبة. عندما كانت قيم قوة الاشارة PSNR تساوي (9.3812 ، 9.8918 ، 9.6521 و
9.0743) و (10.8633, 10.5612 ,10.7927,10.2564)، تم تكبيرها في الطريقة المقترحة
إلى (12.6542 ، 12.9514 ، 12.8574 و 12.3013) على التوالي.

Introduction
Images have a major influence on lives of people. Growths in image acquisition technology are facilitating us to lengthen our visual facilities beyond the boundaries of our physical existence and the conventional capacity of the eyes. Numerous authoritative building block images provide such facilitation, with the SAR being one of the prominent examples [1]. SAR is an actively and widely applied sensing system, which is used to get high resolution images. Information is composed by spreading the signal and calculating the distributed or reflected energy back from the target material, a process that should be efficient in all weather conditions. In dissimilar optical images, the SAR system brightens a ground with micro waves and records both the amplitude and the phase of the back radiation, creating a coherent imaging procedure where the waves returning from the goal material contain the influences from many independent dash points [2].Hence, SAR is a detecting system to notification objects in the images with a very high precision [3].

Edges of the sense images are one of the ultimate routes because these edges are the borders of objects that diverge them from the related images [4]. The verdict of the edges is arranged by making observations at the link between the pixel and its neighborhoods; if the rate of the pixel is identical to the pixel neighborhoods' values, then the pixel is not an edge. If the value of the pixel is different than that of the neighborhoods, then the pixel represents an edge [5,6].There are several old-fashioned methods that have been used to observe the edges of images, among which are the Sobel, Prewitt, Roberts and Laplacain. However, these methods produce improper outcomes with inefficient anti-noise properties [7].

Wavelets transform is a tool to distinguish edges but it has a disadvantage of poor directionality (can only be used for horizontal, vertical or diagonal).It also exterminates the geometric properties of structures and does not make advantage of the consistency of edges. Because of this drawback, variations on the angle are disregarded. However, Ridgelet transform has been proven to overcome this issue [8]. In addition, Bezier curve was able to yield gradual change and mutability of the data [9].

This paper has used a new proposed approach which combines Ridgelet transform, Bezier curve and Sobel operator to perform edge detection processing on the SAR images, which proved a very efficient edge detection ability where the edge is flat and evident.

Approaches of edge detection
Edge detection approaches can be ordered as follows:

2-1 Gradient operator detector
This method is based on the use of the slope operator. The traditional gradient operators are Sobel, Prewitt, Roberts and Laplacian operators. The edge detection by Sobel masks works by observing the edges in row and column orders. The two covers are as follows:

ROW MASK   COLUMN MASK

$$\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

The edge magnitude and the edge direction are clarified as follows:

$$\text{EDGE MAGNITUDE} = \sqrt{S_1{}^2 + S_2{}^2} \qquad (1)$$

$$\text{EDGE DIRECTION} = tan^{-1}\left[\frac{S_1}{S_2}\right] \qquad (2)$$

Where S1 represents the outcome form the row mask and S2 is the result from the column mask [10].

2-2 Transformation edge detection

Transform is particularly impeccable for edge detection and is used with thresholding. Numerous types of thresholding have been proposed, such as Hard and Soft thresholding [10, 11].

Wavelets transform was generally applied in the areas of science and engineering, It has one scaling function and one wavelet function. Furthermore, it can be negatively affected by poor directionality and rejection of the regular properties of structures, while it does not make advantage of the consistency of the edge; hence, wavelet transform is inadequate for geometric features and causes oscillations and artificial effects in the energy of the signal, while variations on the angle are disregarded. Nevertheless, Ridgelet transform was proven to overcome these issues [12]. The differences between Ridgelet and wavelet are that window corners are acknowledged and images can be more actively stated in Ridgelet [13].Therefore, the Ridgelet transform is quite the carrying out of a one dimensional wavelet transform to cuts of Radon transform where the corner variable θ is fixed and t is variable. The fast Ridgelet transform can be realized as in the following stages; Initially, two Dimensional Fast Fourier Transforms (2D FFT) are determined, then they are presented beside a few straight lines corresponding to the designated number of projections. Later, each line authorizes through the center of the 2D frequency space, with a sense to the same projection angle, and the sum of interpolation points are identical to the sum of rays, Finally, the one dimensional wavelet transform is realized. The general structure of Ridgelet transform is demonstrated in Figure-1[14].
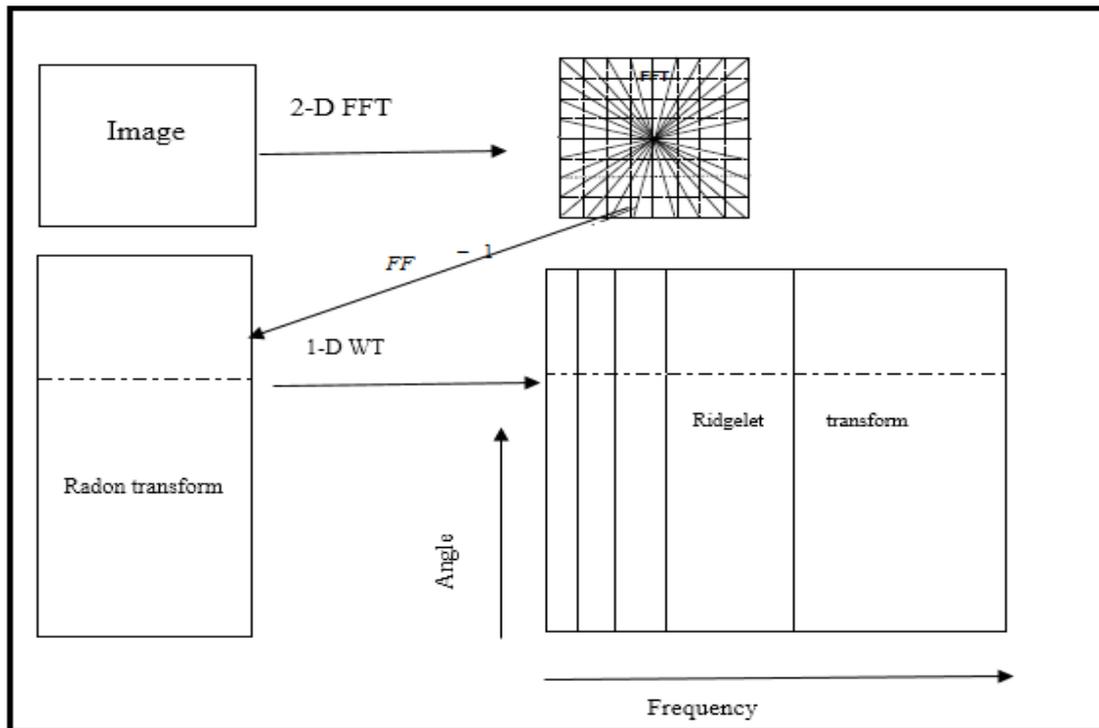
Figure 1-Ridgelet transform scheme.

Bezier Curves

Bezier curves are the most commonly used curves in computer graphics, with experts' agreement that it represents smooth surfaces with curves. Over it uninformed precision curve can be mask with trivial numeral of cubic curve segments are necessary to estimate a given larger degree curve. A cubic Bezier has only four control points. The opening and the latter points are inserted by the curve, but the other two are approximated by it. Examples of Bezier curves are explained in Figure-2 [15]. The third order Bezier curves uses four points (P0, P1, P2 and P3). The measured model of Bezier curve of the third order is as follows [16]:

$$\mathbf{x} = \mathbf{a}t^3 + \mathbf{b}t^2 + \mathbf{c}t + \mathbf{d}$$

$$\mathbf{a} = \left(-\mathbf{p}_0 + 3\mathbf{p}_1 - 3\mathbf{p}_2 + \mathbf{p}_3\right)$$
$$\mathbf{b} = \left(3\mathbf{p}_0 - 6\mathbf{p}_1 + 3\mathbf{p}_2\right)$$
$$\mathbf{c} = \left(-3\mathbf{p}_0 + 3\mathbf{p}_1\right)$$
$$\mathbf{d} = \left(\mathbf{p}_0\right)$$

And in matrix form:

$$\mathbf{x} = \begin{bmatrix} t^3 & t^2 & t & 1 \end{bmatrix} \cdot \begin{bmatrix} \mathbf{a} \\ \mathbf{b} \\ \mathbf{c} \\ \mathbf{d} \end{bmatrix} \qquad \begin{bmatrix} \mathbf{a} \\ \mathbf{b} \\ \mathbf{c} \\ \mathbf{d} \end{bmatrix} = \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} \mathbf{p}_0 \\ \mathbf{p}_1 \\ \mathbf{p}_2 \\ \mathbf{p}_3 \end{bmatrix}$$
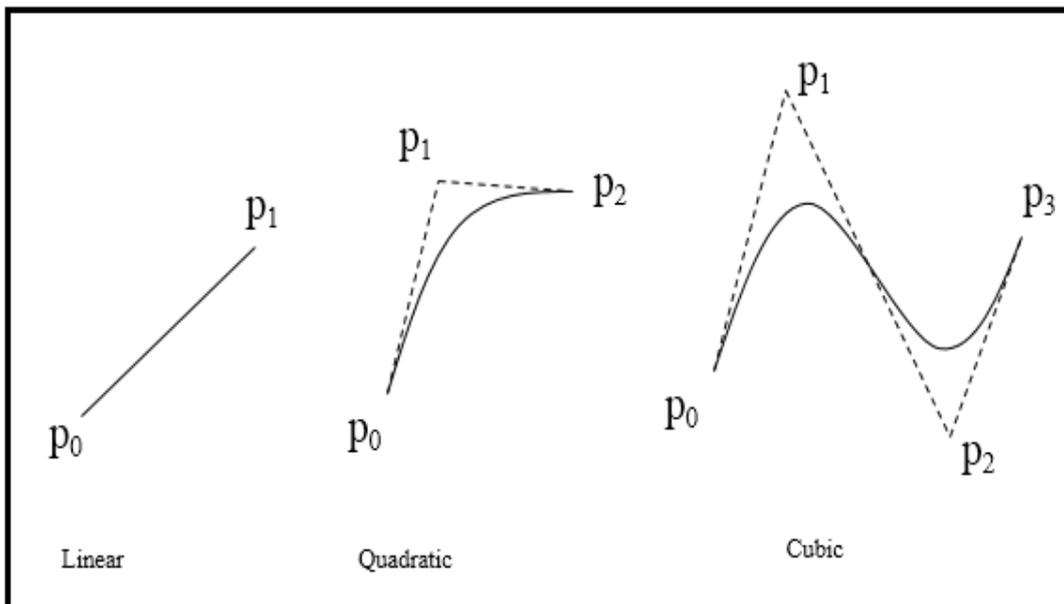
Figure 2-Bezier curves examples.

The Proposed Edge System

This part demonstrates the proposed edge method (which combines Ridgelet transform, cubic Bezier curve and Sobel operator) performed on SAR images (each SAR image is resized to 128×128) as can be observed in Figure-3. Firstly,Ridgelet decomposing was achieved onto the resized SAR image, then it was spread over Soft thresholding on the follow-on coefficients with the changed threshold values. The coefficients inferior to the threshold are fixed to zero, while the coefficients above the threshold are decreased by a threshold value. Then these coefficients are scanned via Hilbert scan which converts the two dimensional coefficients into one dimensional gray level sequence. The one dimensional gray level sequences are allocated into several parts, each part holds a number of gray levels which represent a point, and these points are used to be a Bezier curve (In this paper cubic Bezier curve is used which takes four points at a time).

The decomposition process is antithetical of the above composition process. The resultant is decomposing every partition serially, inverse Bezier, Hilbert scan and inverse Ridgelet transform, then perform Sobel operator on the decomposed SAR image which convolutes with every pixel of the image to become the gradient and the gradient amplitude. Then the edge detection of this image is acquired. Finally the image was accustomed using RMSE and PSNR capacities. The algorithm of this proposed system can be realized in algorithm1
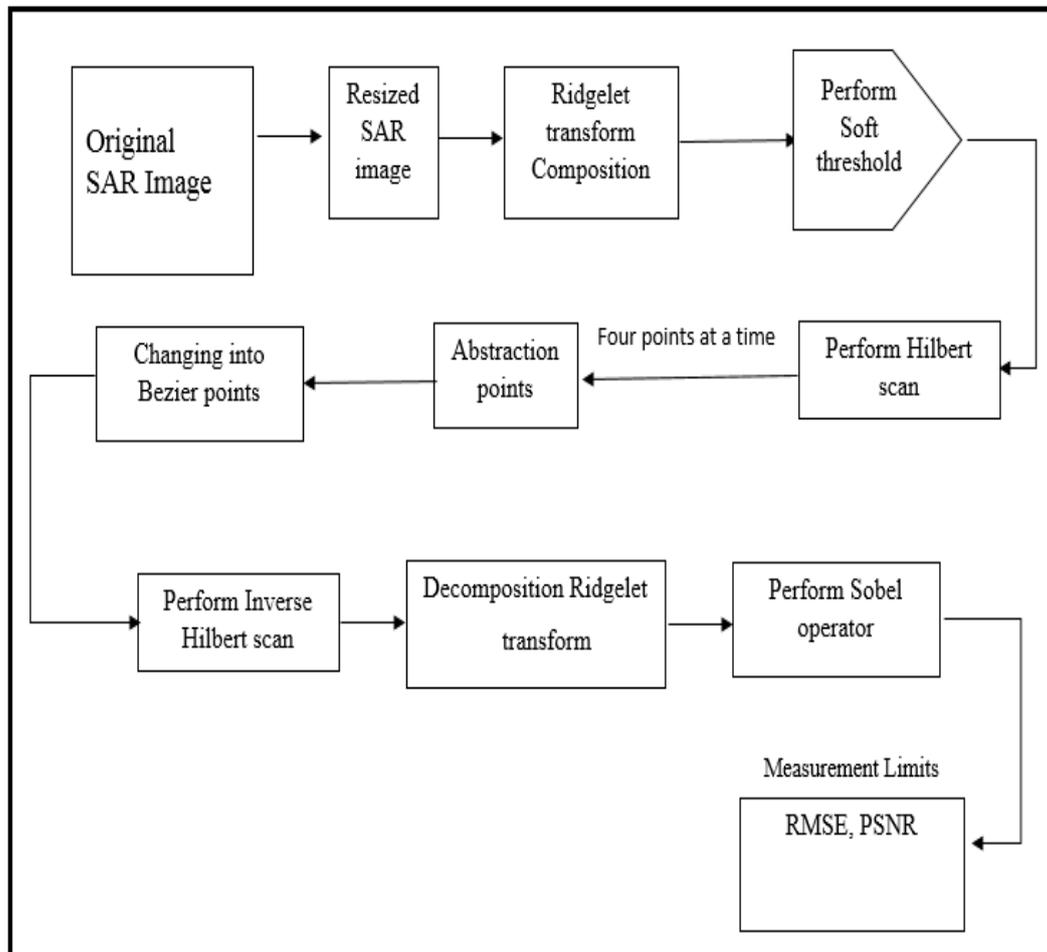
Figure 3-Architecture of the proposed edge method.

Algorithm (1): Proposed Edge method.
Input: SAR images.
Output: Edge SAR images.
Step1:- Start
Step2:- The original SAR image is resized into 128×128 image.
Step3:- The resized SAR image is decomposed by Ridgelet transform to yield low and high frequency coefficients.
Step4:- Perform Soft threshold on the frequency coefficient.
Step5:- Perform Hilbert scan which converts it to one dimensional gray level series.
Step6:- Perform Cubic Bezier on points occasioning from step five by using four points at a time.
Step7:- Perform inverse Hilbert Scan.
Step8:- Perform inverse Ridgelet transform.
Step9:- Perform Sobel operator.
Step10:- Compute measurement limits (RMSE and PSNR).
Step11:- End.

Experiments Results

This paper uses SAR images reserved from Google SAR images, where common edge methods (Ridgelet transform, Bezier curve and Sobel operator) used a number of check SAR images to clarify the success of this proposed method. Initially, the old edge method (Sobel operator) was achieved to detect edges of these images. The discrete wavelet method was then used to conclude the edges of these images. Moreover, an anticipated method was used to the matching images. Figure-4 shows the visual results of the completed methods. Primarily, the radar images were read and then a traditional Sobel method and wavelet transform were used to detect the edges of the images. The shape shows that the edges are not clear and discrete in Sobel method, they are more pronounced and somewhat improved in wavelet method, while the visual results achieved through the proposed method were more improved; with clear edges and clearly connected lines. This was because of the use of more than one stage to determine the edges.

These transforms are very exciting where the signal image is switched from time domain to frequency domain. Therefore, the image and its modules can be embedded in a concentrated frequency domain, and then the frequent data are somewhat transitive. Bezier curve was used to solve this variant, all the above methods are deciphering and doing previously applying Sobel edge. The visual results for the edges are shown in Figure-4.
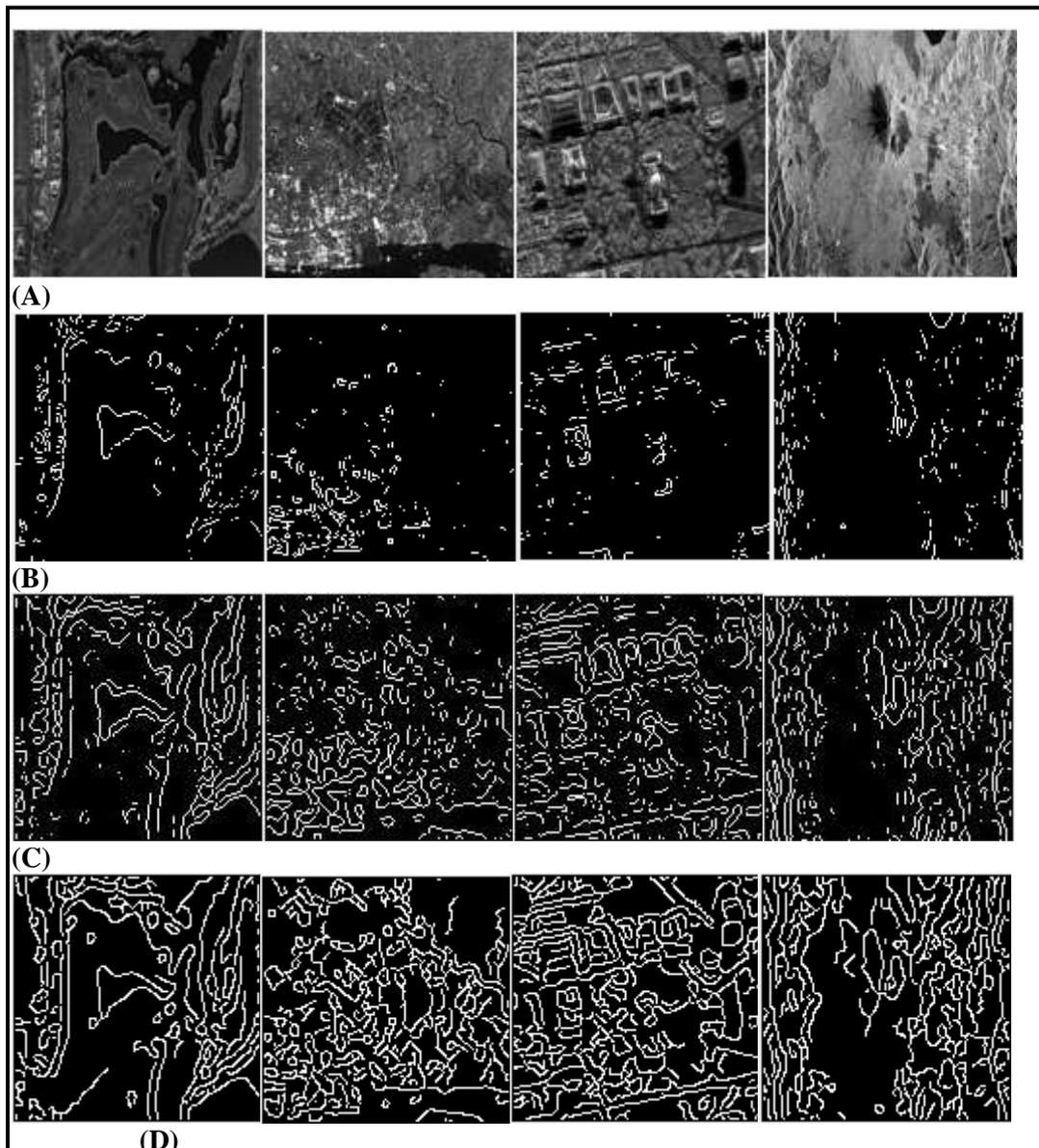
Figure 4-Applying edge image methods A) Original SAR images B) Edge images using Sobel method   C) Edge images using Wavelet method D) Edge images using the proposed method.

The outcomes of the measurement are illustrated in Table- 1, which match among three methods initially by using Sobel method, then wavelet method and moreover hand by using the proposed edge approach.

As exposed in Table- 1, the Root Mean Square Error (RMSE) shrunk whereas the Peak Signal to Noise Ratio (PSNR) puffed-up in the proposed method. This indicates an improvement in the image of the signal as well as maintaining the edges of the image which appeared as clear and connected and at the end of the method, the amount of error was decreased very clearly, as clarified in Table-1.

Table 1-The RMSE and PSNR obtained by applying SAR image edge methods.

Edge methods	images	RMSE	PSNR
Sobel edge method	image 1	0.4503	9.3812
	image 2	0.3988	9.8918
	image 3	0.4265	9.6521
	image 4	0.4901	9.0743
Wavelet edge method	image 1	0.3902	10.2564
	image 2	0.2576	10.7927
	image 3	0.3867	10.5612
	image 4	0.3491	10.8633
Proposed method	image 1	0.2301	12.6542
	image 2	0.1637	12.9514
	image 3	0.2115	12.8574
	image 4	0.2803	12.3013

Conclusions

The Sobel operator method of edge detection does not reserve features and edge, while the wavelet method is better but it also has problems. Therefore, the proposed method(Ridgelet transform, Bezier curve and Sobel operator)with Ridgelet transform was used in this study and showed better results than wavelet transform; it removes the noise by using soft thresholding with Ridgelet transform before the process of detecting edges. Bezier curve can return gradual change of the data and mutability of these data. Hence, the efficiency of the edged image is improved.

The results of this investigation, in terms of RMSE and PSNR, showed that the proposed method realizes the edges better than Sobel and wavelet methods, where the RMSE is reduced and PSNR is increased in the proposed method.

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