IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-6, Issue-6, June 2018 E-ISSN: 2347-2693

Oil Spill Detection from Synthetic Aperture Radar Image through Improved Edge Detection Method

Dhrisya Krishna[1*], Keerthi Krishnan K[2]

[1] ECE, NSS College of Engineering, APJ Abdul Kalam Technological University, Palakkad, India
[2] ECE, NSS College of Engineering, APJ Abdul Kalam Technological University, Palakkad, India

**Corresponding Author: dhrisyaswiss@outlook.com*

Available online at: www.ijcseonline.org

Accepted: 20/Jun/2018, Published: 30/Jun/2018

Abstract— The oil spills are one of the major pollutions in the marine environment which needs to monitor exactly. The satellite remote sensing especially the synthetic aperture radar (SAR) is the method used to check oil spills for wide area coverage. The edges of an image play an important role to detect the oil spill in water. The existing method has some drawbacks in terms of correctly extracting the oil spills from synthetic aperture radar (SAR) images, where speckle noise exists. Due to this heterogeneous background noise, the existing edge detection techniques, not able to detect the accurate edges of oil spills in water. This paper proposes an alternative method of an edge detection that first, pre-processes the oil spill SAR image and then acquires the threshold by gray value statistics. The oil can be separated from water by using the threshold that was attained. After the threshold segmentation, region growing method is applied in the segmented image and then the edge can be extracted completely by using the Canny edge detection to extract oil spill information more accurately. The perfect extraction of edges of oil spill gathers significant benefits, in terms of monitoring automatically for the risk management.

Keywords— SAR, ENVISAT, RADARSAT-I, speckle noise

I. INTRODUCTION

Oil spill events have caused serious damage to the ocean environment in the past decade. Frequent oil spill accidents become a huge threat to marine environment and ecosystems. The risk of crude oil spillage to the sea becomes a great threat to the marine environment and ecosystems when it is compared with other kinds of pollution in the ocean. Therefore, it is really important and essential in response to marine oil spills rapidly and controls marine oil spills effectively. Oil spills should detect as early as possible and find out the main cause of pollution sources in time and calculate the area and quantity of the oil spills correctly. In order to finish all these works, an effective tool must be found. There are two methods for oil spill monitoring, SAR and optical method [1]. Remote sensing is considered as an effective method to detect oil spills. Among satellite sensors, the optical method is used to detect oil floating below the sea surface in terms of the changes of wavelength and sea surface reflectance. SAR is the most useful for detecting oil spills due to its wide area coverage and day/night capabilities. SAR is well suited for the detection of oil slicks because oil slicks which are depending on the exact hydrocarbon content and type will modify the surface roughness, which produces a strong impact on short waves measured by SAR [16]. The boundary information from an image plays an important role in recognizing objects via human visual system. Edge detection involves the identification and differentiation of the objects in an image; therefore it is an essential tool for detecting the edges of an image. It is well-known that the radar image is mainly proportional to the surface roughness, and the image is a representation of the backscatter return. In the image, the information is regularly described by the pixel. The dark regions in the image mean that it is the low backscattering coefficient area, and the bright regions in the image mean that it is a high backscattering coefficient area. Simple edge detection and the adaptive threshold method cannot extract spills information accurately enough; the boundary of certain oil slicks may not be closed by using simple edge detection method, which causes the loss of oil information [12]. Generally, oil spill image from SAR contains geometric distortions and multiplicative noise (speckle noise), which would corrupt the resulting image. The classical edge detection techniques cannot directly apply to raw SAR images due to noise and false edges [17]. To settle this issue, this paper proposes a new method which includes threshold segmentation, region growing techniques before the edge detection method. First, pre-process the oil spill SAR image, and then acquires the threshold by gray value statistics. The oil can be separated from water by using the threshold that acquired. After the segmentation, region growing method is applied in the segmented image and then the edges can be extracted completely by using the Canny edge detection to extract oil spill information more accurately. This method can offer greater reliability in terms of representing the oil film edge information. This paper is structured as follows. The remote sensing images and the method of extracting oil spill information are described (Section II) followed by the results of the analysis with a focus on discussing the advantages of the new algorithm proposed herein (Section III). Finally, some conclusions and scope of future research are discussed (Section IV).

II. MATERIAL AND METHODS OF PROPOSED CODE

A. Dataset

The remote sensing images are acquired from the ENVISAT-1 satellite, which was launched by the European Space Agency (ESA) on March 1, 2002, and carries an active microwave instrument advanced synthetic aperture radar (ASAR). The remote sensing image of the Bohai Sea (Figure 1), the Gulf of Dalian (Figure 2) and the Mediterranean Sea (Figure 3) is presented.

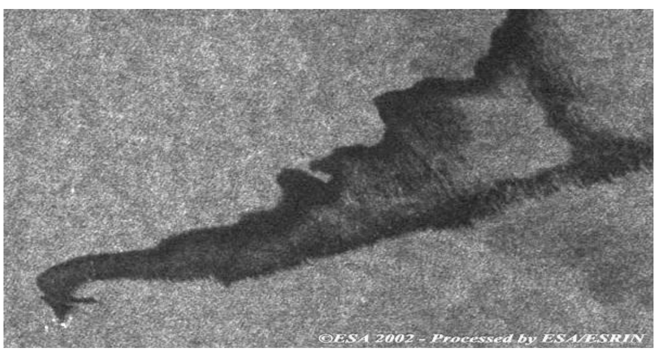


Figure 1. Slick positions observed by ENVISAT-1 ASAR on June 11, 2002, of the Bohai Sea.

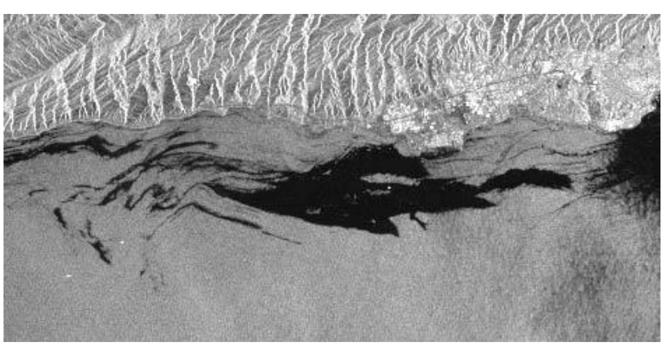


Figure 2. Slick positions observed by ENVISAT-1 ASAR on July 17, 2010, of the Gulf of Dalian.

B. Image Preprocessing

Normal resolution of the SAR image is not sufficient to resolve individual oil spill spots within the resolution pixel; the speckle appears in the SAR images. The pre-processing phase was required to prepare for the next work. There are two main reasons for doing the pre-processing to an original SAR image. First, speckle noise in the image can be removed

Figure 3. Slick positions observed by ENVISAT-1 ASAR on Mediterranean Sea.

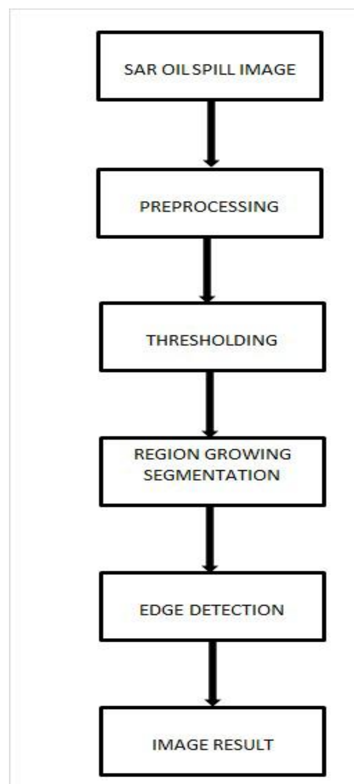


Figure 4. Flow chart of proposed method.

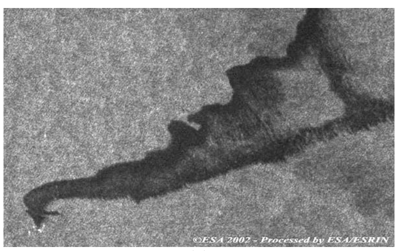
Second, image values can be smoothened [12]. When it is applied to oil spill SAR image, the mean filter [3] should suppress speckle noise, but still, preserve small and thin oil spills at the same time.

C. Threshold acquiring and image segmentation

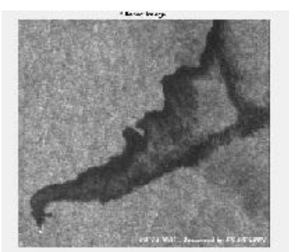
After filtering, the SAR images are segmented into two classes: one has pixels intensity values below a user-defined value (threshold) and one has pixels above it [2] [18]. This results to image dark regions extraction. This will partition the oil and water in the image into areas classified as dark and bright. All pixels corresponding to the intensity values lower than the threshold value were register as the pixel of a dark region. The threshold method can express as follows:

$$f(x, y) = \begin{cases} 0, & \text{if} \quad f(x, y) \leq T \\ 1, & \text{if} \quad f(x, y) \geq T \end{cases} \tag{1}$$

In the formula, "T" represents the threshold. The gray value statistical histogram is used to determine the threshold value [2] [3]. Generally, the minimum value between the two peaks is selected as the threshold value in the gray level histogram. Figure 5 shows the expected results of an oil spill image after filtering and a then canny algorithm is applied without threshold segmentation. It had been studied that edge detection method can be improved by thresholding which is shown in Figure 6.

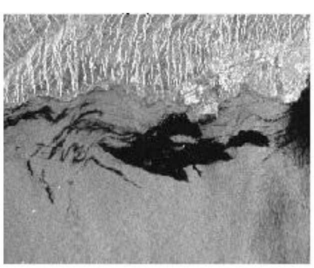


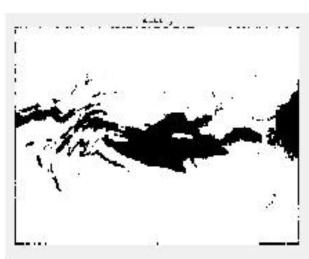
(a)



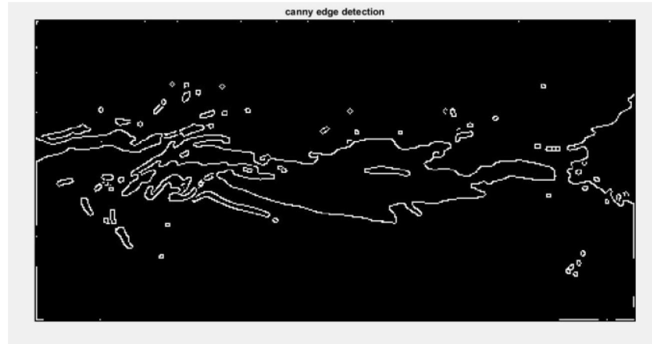
(b) (c)

Figure 5. Edge detection using canny algorithm without thresholding (a)Original SAR image, (b) Image after filtering, (c) Image after processed by canny algorithm without thresholding.





(a) (b)



(c)

Figure 6. (a) Original SAR image, (b) Image after Thresholding, (c) Edge detection after thresholding.

D. Region Growing

Region growing is the process of grouping neighbouring pixels or a collection of pixels of similar properties into larger regions [6] [7]. The most common approach to achieve this is through pixel aggregation. In this approach, first starts with a set of "seed" pixels and from these seed point grows the regions by appending to each seed pixels to those neighbouring pixels that have similar properties such as gray level, texture, or colour. The process starts by assigning the first pixel of the image under consideration as the first seed pixel. This seed pixel would be compared to its 8-connected neighbours (eight neighbouring pixels of the seed pixel). Any of the neighbouring pixels that satisfy a homogeneity function would be assigned to the first region and its pixel value would change to the seed pixel value. This neighbour comparison step would be repeated for every new pixel assigned to the first region until the region is completely bounded by the edges of the image or by pixels that do not satisfy the homogeneity function. The next seed pixel for the second region would be determined by choosing the first unassigned (to the previously grown region) pixel while moving through the image in a right-to-left and bottom-to-top fashion. The above-mentioned steps for growing a region would once again be applied until the second region becomes complete. This process would be repeated until every pixel in the image would belong to a region.

The basic formulation is:

1) $\bigcap_{i=1}^{n} R_i = R$
2) R_i is a connected region, i=1, 2, n
3) $R_i \bigcap R_j = \varphi$
4) P (R_i) = True, for i=1, 2 ...n.
5) P($R_i \bigcup R_j$) = False, for any adjacent region R_i and R_j.

P (R_i) is a logical predicate defined over the points P in the set R_i and is the null set.

1) Means that the segmentation must be complete (every pixel must be in a region).

2) Requires that points in a region must be connected in some predefined sense.

3) Indicates that the regions must be disjoint.

4) Deals with the properties that must be satisfied by the pixels in a segmented region.

5) Indicates that region R_i and R_j are different in the sense of predicate P.

Advantages:
Region growing methods can correctly separate the pixel whose threshold values are different. It provides good segmentation results. The concept is simple. It only needs a few seed points to represent the property of the desired location of the oil spill, and then grows the region.

Disadvantage:
It is a local method with no global view of the problem and is more sensitive to noise.

E. Edge extraction of SAR images

CANNY EDGE DETECTION ALGORITHM:

The other edge detection techniques like Sobel operator consists of poor localization (trigger response in multiple adjacent pixels) of an image and is very highly sensitive to noise. Another limitation of Sobel operator is that it can miss oblique edges more than horizontal or vertical edges [10]. To overcome this limitation, canny edge detection was used [9] [14]. It contains certain criterions:

- Good Detection: It minimizes the probability of false positive and false negative.
- Good Localization: Detected Edges must be close as true edges.
- Single Response Constraints: There will be one edge at each point.

The procedure of canny edge detection method is described below:

1) Noise Reduction:
The initial step is to filter out any noise in the original image. The Gaussian filter used to reduce the noise by convoluting the sample masks with the kernels of the original image which is Gaussian distributed. As a result, the mask is slide over the image and is similar to mean filter. Noise removal using Gaussian distribution is shown in Figure 7

$$g(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-x^2}{2\sigma^2}} \qquad (2)$$

where σ is a standard deviation.

2) Compute Gradient Magnitude:
After reducing the noise from the original image, the next step is to find the edge strength by taking the gradient of the image. Computation of gradient magnitude and the angle is similar as Sobel operator [10].

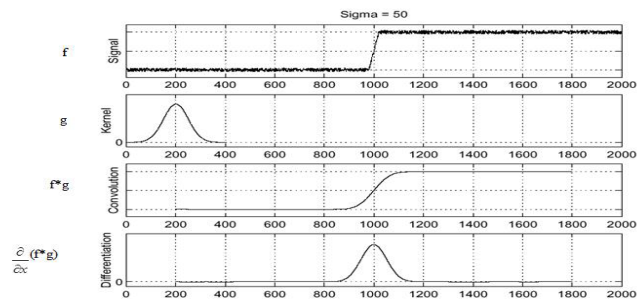


Figure 7. Noise removal using Gaussian distribution.

$$Gx = \left(\frac{\partial f}{\partial x}\right)$$
$$Gy = \left(\frac{\partial f}{\partial y}\right) \qquad (3)$$
$$g(x, y) = [Gx^2 + Gy^2]^{\frac{1}{2}}$$

3) Compute Angle:
The edge direction is calculated using the gradient in the x and y directions. The formula for finding the edge direction is

$$\theta = \text{invtan}\left(\frac{Gy}{Gx}\right) \qquad (4)$$

4) Non-maximum suppression:
Non-maximum suppression will trace along the edges in the edge direction computed by gradient method and suppress any pixel value that is not considered to be an edge resulting a thin boundary in the output image. Only local maxima are marked as edges and minimizing the false edges. This will keeps only those pixels on an edge with the highest gradient magnitude which appears as edge boundary in an output.

5)Hysteresis Thresholding:
If the gradient magnitude of each pixel computed is above "High" (user-defined threshold value) as given in Figure 8, then declare it as an edge pixel [18]. If the gradient magnitude of each pixel computed is below "Low" (user-

defined threshold value), then declare it as a non-edge pixel. If the gradient magnitude of each pixel computed is in between "Low" and "High" threshold value, then relate each pixel with its neighboring pixels iteratively. And if the threshold value between the neighboring pixels is almost connected to each other and if that pixel's threshold value is above "High" gray level, then declare it as an edge pixel, otherwise declare it as a non-edge pixel.

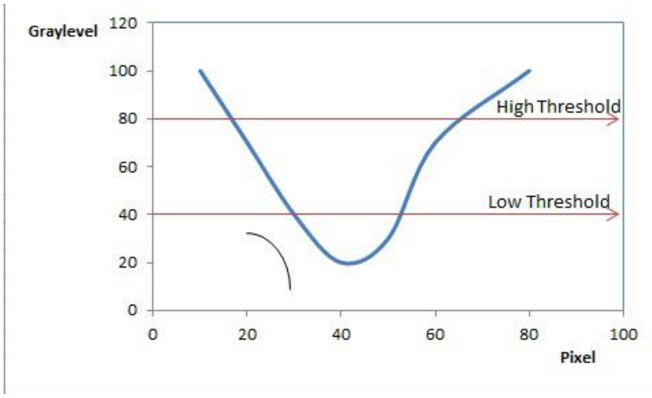
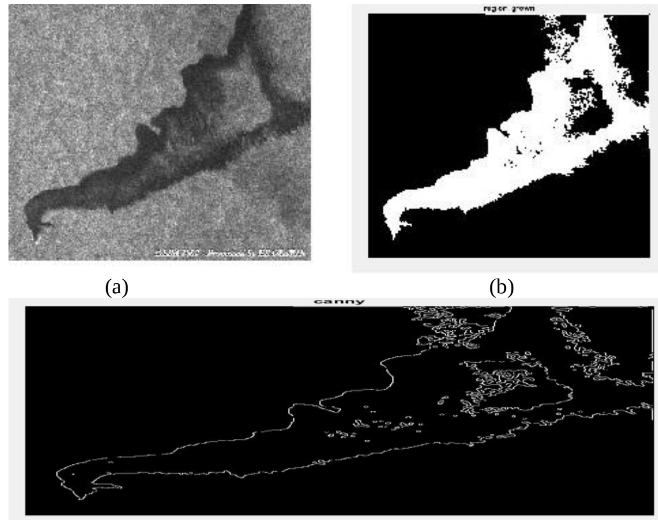


Figure 8. Hysteresis thresholding

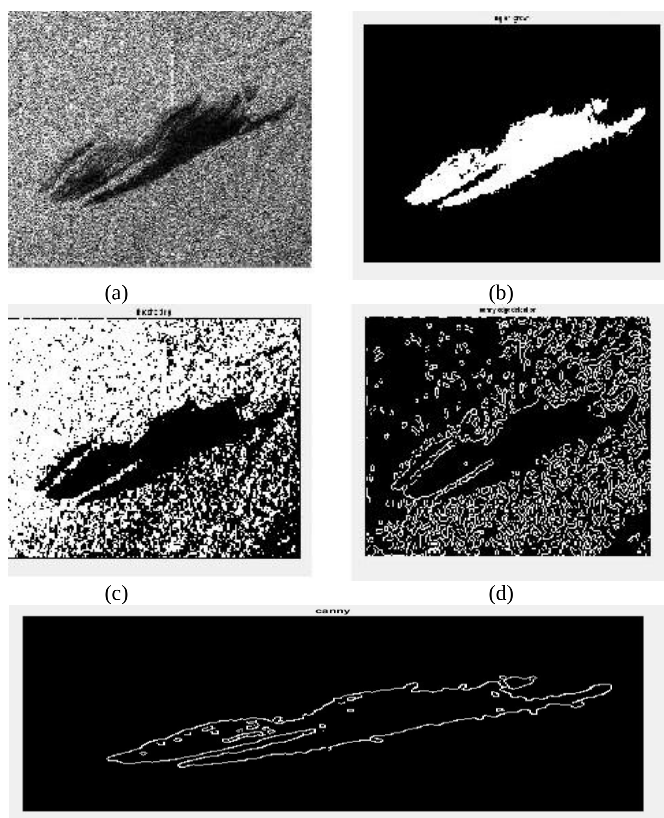
III. EXPERIMENTAL RESULTS

The purpose of this study is focused on extracting the edges of oil spill information in SAR images more clearly. Figure 5 shows the rough edges of oil spill detected by edge detection without thresholding and Figure 6 shows the rough region of oil spill detected by edge detection after threshold segmentation. Edge detection after threshold segmentation results to more accurate information than simple edge detection method. But the drawback of this method is that it leads to many small hot spots which are misclassified between the oil spills and other objects like water or land, possibly due to the wind, wave, and other influencing factors. Thus, the paper proposes another method called region growing technique which is applied after thresholding and then edge detection is included to get more accurate information. The oil films extracted by thresholding, region growing combined with edge detection are shown in Figure 9 (b) and (c) respectively. The new algorithm addresses non-closed boundary issues that mean, the image would be accurate if the oil spill should be closed and consistent. This method greatly improves the accuracy of the edge extraction of the oil spill. The edge of the oil spill extracted from image shown in Figure 9 (b) is well closed and consistent with the original image. Another SAR image of an oil spill in the Mediterranean Sea is shown in Figure 10. The comparison of different methods applied to extract oil film extracted from SAR image are shown in Figure 10 (b), (c), (d) and (e) respectively.



(a) (b) (c)

Figure 9. Oil spill extracted using edge detection after thresholding and region growing method (a) Original SAR image, (b) Region grown method applied after thresholding, (c) Edge detection after thresholding and region growing method.



(a) (b) (c) (d) (e)

Figure 10. Comparison of different methods applied to extract oil spill from SAR image (a) Original image, (b) Region grow method applied in original image after filtering, (c) Oil spill extracted through threshold segmentation without region growing method, (d) Oil spill extracted through thresholding followed by edge detection without region grow , (e) Oil spill extracted through thresholding followed by region growing method and then edge detection method is applied.

From Figure 10(b) and Figure 10 (e) it proved that the accuracy has a significant improvement using the region growing method after thresholding as compared to edge detection or thresholding without region growing techniques (shown in Figure 10(c) and Figure 10(d)).

IV. Conclusion and Future Scope

The exact location of oil spills is essential and meaningful for simulating the trajectory for automation monitoring. The method presented in this paper is based on edge detection after threshold segmentation and region growing method. To avoid the heterogeneity in SAR image and to bring the oil image structure clearer and accurate in water, the new combination of methods is applied which consist of threshold segmentation followed by region growing method and finally, the edge of the image is detected by the Canny algorithm. But this method is applied in the gray level image rather than spectral images. To overcome this limitation, future research is based on the combinations of thresholding and region growing method with edge detection in hyperspectral remote sensing images, to get clearer images in presence of any kind of ocean noise.

REFERENCES

[1]. F. Yu, W. Sun, J. Li, Y. Zhao, Y. Zhang, G. Chen*," An improved Otsu method for oil spill detection from SAR images"*, Oceanologia, Vol. 59, Issue.3, pp.311-317, 2017.

[2]. J. Chen, B. Guan, H. Wang, X. Zhang, Y. Tang, W. Hu, *"Image thresholding segmentation based on two dimensional histogram using gray level and local entropy information",* IEEE Access, Vol. 6, pp.5269-5275, 2017.

[3]. E. Niharika1, H. Adeeba, A.S.R Krishna, P.Yugander, *"K means based Noisy SAR Image Segmentation using Median Filtering and Otsu Method"* ,IEEE, 2017 International Conference on IoT and Application, India, 2017.

[4]. A.S. Banu, P. Vasuki, S.M.M. Roomi, A.Y. Khan, *"SAR Image Classification by Wavelet Transform and Euclidean Distance with Shanon Index Measurement"*, IJSRNSC, Vol. 6, Issue.3, pp. 13-17, 2018.

[5]. S. Pahadiya, R. Khatri, *"Compare Modify Canny Edge Detection Method with Existing Edge Detection Methods"*, IJCSE, Vol.6, Issue. 2, pp. 337-340, 2018.

[6]. N. Ikonomakis, K.N. Plataniotis, M. Zervakis, A.N. Venetsanopoulos, *"Region growing and region merging image segmentation"*, IEEE, Proceedings of 13^{th} International Conference on Digital Signal Processing, Greece, pp.299-302, 2002.

[7]. R.C. Gonzalez, R.E. Woods, S.L. Eddins, *"Digital Image Processing Using Matlab"*, Pearson Publisher, U.S, pp.299-302, 2010.

[8]. J. Canny, *"A computational approach to edge detection"*, IEEE Transaction on Pattern Analysis And Machine Intelligence, VOL. 8, Issue. 6, 1987.

[9]. C. Deng, G. Wang, X. Yang, *"Image Edge Detection Algorithm Based on Improved Canny Operator "*, Proceedings of the 2013 International Conference on Wavelet Analysis and Pattern Recognition, China, pp. 168-172, 2013.

[10]. C.H. He, X.F. Zhang, Y.C. Hu, *"A Study on the Improved Algorithm for Sobel on Image Edge Detection",* Optical Technique, Vol. 38, Issue. 3, pp. 323-327, 2012.

[11]. W.B. Wei, "*Study on Edge Detection Method. Computer Engineering & Applications",* Vol. 42, Issue. 30, pp. 88-91, 2006.

[12]. G. Hu, X. Xiao, *"Edge Detection of Oil Spill Using SAR Image"*, IEEE, 2013 Cross Strait Quad-Regional Radio Science and Wireless Technology Conference, China, pp.466-469, 2013.

[13]. N. Otsu, "*Threshold Selection Method from Gray-Level Histograms",* IEEE Trans. on System, Man, and Cybernetics. Vol.9, Issue.1, pp.62- 66, 1979.

[14]. W. Li, M. He, S. Zhang, "*A New Canny-Based Edge Detector for SAR Image"*, IEEE, 2008 Congress on Image and Signal Processing, China, pp.211-215, 2008.

[15]. B. Wang, S. Fan, *"An improved CANNY edge detection algorithm "*, IEEE, 2009 Second International Workshop on Computer Science and Engineering, China, pp.497-500, 2010.

[16]. X. Yu, J. Yla-Jaaski, *"A new algorithm for image segmentation based on region growing and edge detection"*, IEEE International Sympoisum on Circuits and Systems, Singapore, pp.516-519, 2002.

[17]. B.D. Setiawan, A.N. Rusydi, K. Pradityo, *"Lake edge detection using Canny algorithm and Otsu thresholding"*, IEEE, 2017 International Symposium on Geoinformatics (Icy), Indonesia, pp.72-76, 2017.

[18]. E. Schwinger, A.Z. Munthe-Kaas , *"Comparative analysis of various thresholding techniques on TerraSAR-X images in the presence of speckle noise"*, IEEE, 2013 8th International Sympoisum on Image and Signal Processing and Analysis (ISPA), Italy, pp.36-42, 2013.

Authors Profile

Dhrisya Krishna pursued Bachelor of Technology from University of Calicut in 2017. She is currently pursuing Master of Technology in Department of Electronics and Communication from APJ Abdul Kalam Technological University, since 2017. She has published research papers based on Manifold error detection and correction in reputed international journal. Her main research work focuses on inventing innovative technologies on Radar, Sonar images of ocean to detect objects in ocean from satellite with high resolution.

Keerthi Krishnan K pursued Bachelor of Technology from University of Calicut in 2005 and Master of Technology from IIT Delhi, Delhi in 2015. She is currently working as Assistant Professor in Department of Electronics and Communication at NSS College of Engineering, Palakkad since 2007.
She is a life member of ISTE since 2007. She has published many research papers in reputed international journals and conferences including IEEE. Her main research work focuses on Signal Processing. She has 11 years of teaching experience.

