

# Linear Feature Extraction from Microwave Images Using CGVF Snake Model

V.RAMACHANDRAN

Department of information science and technology, Anna university, Chennai, India,  
ramcndrn@gmail.com.

K.VANI

Department of information science and technology, Anna university, Chennai, India,  
vani@annauniv.edu

**Abstract**— Linear Feature Extraction from Microwave Images (SAR) using CGVF Snake Model is proposed in this paper. Microwave images are independent of climate and having more noise. Noise is removed in this work. After the edges are detected, GVF field is produced followed by Snake is initialized and then two external constraint forces are developed in this model. The first one will points on the snake and determine the basic shape of a snake. The second one generating the curves is smooth and grows in a correct direction. For each iteration, the snake is deformed in edges and removes the discontinuities for extracting the linear features. The results of feature extraction from microwave images using CGVF Snake model to increase the correctness and quality of satellite Mapping.

**Keywords**— gradient vector flow (GVF), synthetic aperture radar (SAR), controllable gradient vector flow (CGVF), linear feature extraction.

## I. INTRODUCTION

Microwave images(SAR) are capable of operating under weather conditions and have more noise(i.e. Salt and pepper noise or speckle noise) .These images are suitable options for most of the real time application such as road extraction, ridge extraction etc. Due to noisy nature, SAR image is not a suitable option for real time application, so proper pre-processing is mandatory option for SAR image. Road extraction application expects some pre-processing steps they are, Noise reduction, Edge detection etc.

Removing noise in the image needs the filter technique such as Median filter [7]. Median filter helps to reduce the conflict occurs due to presence of salt and pepper noise. Because of curve Nature, Most of the edge detection technique will not suitable for extracting the edges of the road.

After removing the noise, edges are detected. Normally the Edge in an image may be defined as a rapid photometric change in the registered intensity values. From a pixel level perspective, edge can be viewed as the regions of an image where the image values undergo a sharp variation. In discrete 2-D image edge is detected as linear combination of the point's singularities between pixels. The edge detection is discussed in [9], [11], [12], [16], [17] and [20].In proposed work canny edge detection is applied to detect the edges and then feature are extracted.

Microwave images contain many linear features (i.e. road and ridge networks). Extracting those linear features is a fundamental task in many image processing and computer

vision applications. Traditionally the snakes are developed to detect features. In [1], M. Kass, A. Witkin, and D. Terzopoulos presents Snake or active contour is a curve defined within an image domain that can move under the influence of internal forces coming from the curves themselves and external forces computed from the image data. In [2] and [13], Xu et al. present

a class of external force named gradient vector flow (GVF) that largely solves the problems such as initialization and poor convergence to boundary concavities of traditional snakes. In particular, they may be not pulled to the target feature correctly. Aiming at improving the performance of traditional GVF snakes, the improved CGVF snakes are employed in this work to close gaps in linear feature extraction which is important step involved. Since they can fixes the connection points during the deformation and provide smooth linking curves rather than straight lines.

The rest of the paper is organized as follows Section II contains the system description. It describes the overall system contains noise removal, edge detection and linear Feature Extraction. III discusses experimental results and finally Conclusion is given in Section VI.

## II. SYSTEM DESCRIPTION

The System Architecture for linear feature extraction from microwave images using CGVF Snake Model is illustrated in figure1.

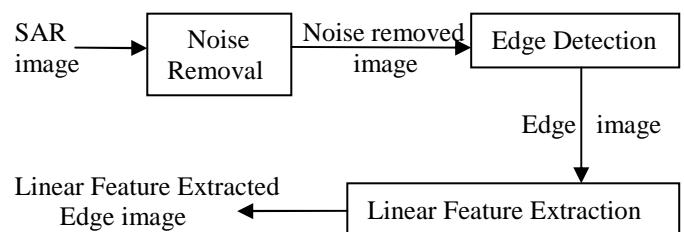


Fig. 1 System Architecture

This System includes three processes such as noise removal, Edge detection and linear Feature extraction is described below.

### A. Noise removal

V.Ramachandran, K.Vani

Presence of noise in an image is the major drawback for SAR image. It shows false edges in the Edge mapped image. So keeping Noise Removal process prior to all is an effective idea is illustrated in figure 2.

Initially Noisy (SAR) image is converted to gray scale image is followed by Histogram equalization to enhance the contrast and median filter helps to remove the salt and pepper noise and finally produces the noise removed image.

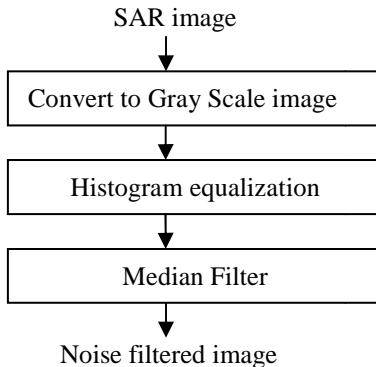


Fig. 2 Noise Removal

1) *Convert to Gray Scale image*: It converts RGB to Gray scale by replacing the RGB values.

$$Y=wR\mathbf{R}+wG\mathbf{G}+wB\mathbf{B} \quad (1)$$

Where **R**, **G**, **B** and **Y** are Red, Green, Blue and Gray pixel .  
wR, wG, wB are Weight Parameters their values are wR=0.2125, wG =0.7154, wB= 0.072

2) *Histogram equalization*: It is equalize the Histogram to enhance the contrast of the image. It has following steps.

- Form the cumulative Histogram.(Cum)
- Normalize the value by dividing it by Total number of pixels. (Cum/Total)
- Multiply these values by the maximum gray level(L) value and round off the value.(cum/total)\*(L-1)
- Map the original value to the result of step a one-to-one correspondence.

3) *Median Filter*: It is used to remove the Salt and pepper Noise. It has following steps.

- Read the pixel values.
- Sort the pixel values.
- Find Median value.
- Substitute median value to central values for each mask.

The above mentioned processes are help to remove the noise from SAR images efficiently and produce the noise filtered SAR image as a output.

#### B. Edge Detection

Canny Edge detection is used in this process. Initially noise filtered images was smoothed followed by compute the edge map gradient and then Finding edge Magnitude for Sharp edges.

Apply the Non-maximum suppression to compare the

edge strength of the current pixel with the edge strength of the pixel in the positive and negative gradient direction. If the edge strength of the current pixel is largest; preserve the value of the edge strength. If not, remove the value. Double thresholding helps to extract the strong and weak edges. Edge tracked by hysteresis is used to eliminate the weak edges and finally produces the edge image. These processes are illustrated in the following figure 3.

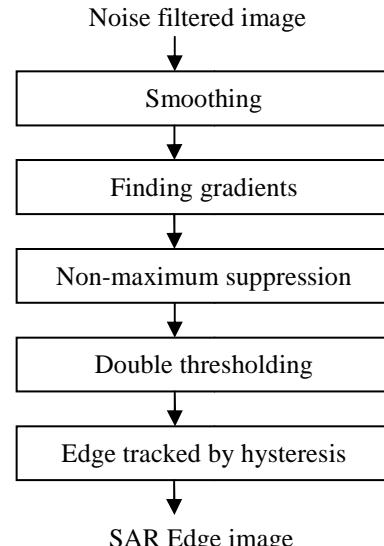


Fig. 3 Edge Detection

1) *Smoothing*: The image is smoothed by following equation.

$$g(m,n) = G_\sigma(m,n) * f(m,n) \quad (2)$$

$G_\sigma = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left[-\frac{m^2+n^2}{2\sigma^2}\right]$ , where  $\sigma$ =Standard deviation. Defaultly  $\sigma=1.4$ ,  $f(m,n)$  is noise filtered image.

2) *Finding gradients*: Gradient magnitude can be determined by the following formula.

$$M(m,n) = \sqrt{g_m^2(m,n) + g_n^2(m,n)} \quad (3)$$

Here  $g_m$ ,  $g_n$  are gradient in x and y direction. To find the direction of the edges by using the Formula.

$$\theta(m,n) = \tan^{-1}[g_n(m,n)/g_m(m,n)] \quad (4)$$

3) *Non-maximum suppression*: It is used to convert the gradient magnitudes to "sharp" edges. It has the following process.

- Compare the edge strength of the current pixel with the edge strength of the pixel in the positive and negative gradient direction
- If the edge strength of the current pixel is largest; preserve the value of the edge strength. If not remove the value

4) *Double thresholding*: It is used for finding Strong and Weak edges. It has the following steps.

- Edge pixels stronger than the high threshold are marked as strong.  
 $M(x,y) = M(x,y) > T_1 \rightarrow \text{Strong edge.}$

Here  $T_1$  is high threshold value .

b) Edge pixels weaker than the low threshold are suppressed.  
 $M(x,y)=M(x,y)>T2 \rightarrow$  removed edge.  
 Here  $T2$  is low threshold value.

c) Edge pixels between the two thresholds are marked as weak.  
 $M(x,y)=T1 < M(x,y) > T2 \rightarrow$  Weak edge.

5) *Edge tracked by hysteresis*: It is used to eliminate weak edges and ensure the strong edges. It has the following steps.

a) The edge pixels are divided into 8-connected Neighbourhood.

b) It's containing at least one strong edge pixel are then preserved, while other are suppressed.

The above processes are helps to produce an edge image as an output. These edge images also contain some unwanted features. So to extract those linear features (i.e. roads, ridges) CGVF Snake model is proposed in this paper.

### C. Linear Feature Extraction Using CGVF Snake Model

To extract the linear feature is difficult process in many existing algorithm such as Snakes [1] and GVF Snake [12],[13] algorithm . So the CGVF Snake model is proposed to improve existing algorithms to extracting those features and remove the discontinuities efficiently.

Initially GVF field is produced (i.e. internal and external forces of an image) followed by the Snake is created and then CGVF Snake is employed to close the gap (i.e. remove the discontinuities) and finally produces the linear features extracted image. These processes are illustrated in Figure 4.

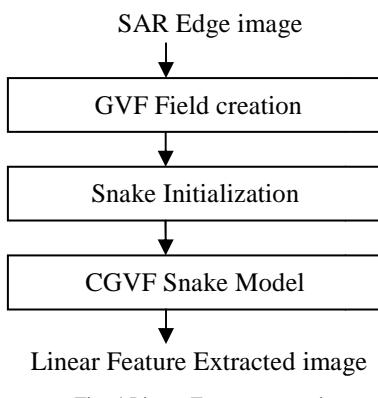


Fig. 4 Linear Feature extraction

6) *GVF Field creation*: It is defined as the vector field  $V=(u,v)$ . This vector field is created by the following equation.

$$\begin{aligned} \mu \Delta^2 u - (u \cdot f_x)(f_x^2 + f_y^2) &= 0 \\ \mu \Delta^2 v - (v \cdot f_x)(f_x^2 + f_y^2) &= 0 \end{aligned} \quad (5)$$

Where  $f_x$  and  $f_y$  are partial derivative of edge image.  $\Delta^2$  is Laplacian operator.  $\mu$  is used to find the smooth of force field .

7) *Snake Initialization*: snakes are computer-generated curves that move within images to find object boundaries.

$$c(s) = (x(s), y(s)), s[0,1] . \quad (6)$$

Its energy functional can be written as

$$E_{\text{snake}} = \int_0^1 [E_{\text{int}}(c(s)) + E_{\text{image}}(c(s)) + E_{\text{con}}(c(s))] ds \quad (7)$$

Here  $E_{\text{int}}$  - internal energy of the snake,  $E_{\text{image}}$  - image forces,  $E_{\text{con}}$  -external constraint forces.

After initial Snake created then it is moved in image through internal energy, external energy and image force.

8) *CGVF Snake Model*: It is an improved GVF snake model. It is developed from GVF Snake [2]. In GVF snake, snakes are moved in undesired path in edges. It's also generating ears. So the CGVF Snakes are employed to remove the ears and passed through edges in correct direction. It is developed by the following external constrains forces created in this paper.

a) *Point pin energy*: It is fixes specified points  $P$  on the Snake. Collection of these connected points to form a basic shape of the Snake. it's energy function can be written as

$$E_{\text{pin}} = \kappa \sum_{p \in P} \prod_{c_i \in c} H(\|c_i - p\| - \delta) \quad (8)$$

Here  $\kappa$ -weight parameter,  $\delta$ -is the tolerance determining whether two points are the same or not and  $c_i$  - Snake points and  $H$  -Heaviside function is determined by.

$$H(z) = \begin{cases} 1, & \text{if } z \geq 0 \\ 0, & \text{else} \end{cases} \quad (9)$$

b) *Ear avoiding energy*: it makes the curve smoother and grows in the correct direction. it's energy function can be written as

$$E_{\text{ear}} = \rho [1 - \prod_{c_i, c_j \in c, i \neq j} H(\|c_i - c_j\| - \delta)] \quad (10)$$

Here  $\rho$ - Weighted Parameter.

External forces are formed by

$$E_{\text{con}} = E_{\text{pin}} + E_{\text{ear}} \quad (11)$$

These  $E_{\text{con}}$  pixels values are substituted in equation (7) for snake deformation.

These above mentioned processes are used for extract the linear features. For each iteration the snake is grow in edges correct direction and close the gap(i.e. remove the discontinuities) to extract the linear features efficiently.

### III. EXPERIMENTAL RESULTS

The proposed algorithm has been implemented and the performance results are presented.Figure(4) shows an TRA\_SAR\_image1 represents the road network and Figure(5) shows an TRA\_SAR\_image2 represents the mountain area.These images are taken from china with high resolution and high frequency.



Fig. 5 TRA\_SAR\_IMAGE(Road Network)

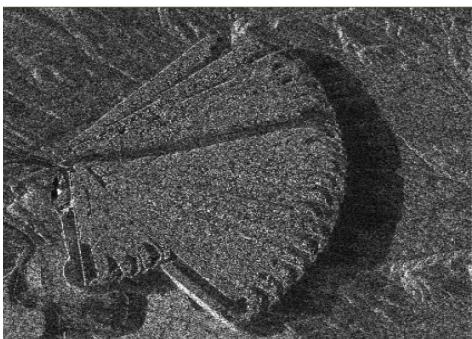


Fig. 6 TRA\_SAR\_IMAGE(Mountain Area)

During the Noise Removal process, Noise removed image is produced. Figure(5) and Figure(6) shows an noise removed image1&2 for TRA\_SAR\_IMAGE1 and TRA\_SAR\_IMAGE2.

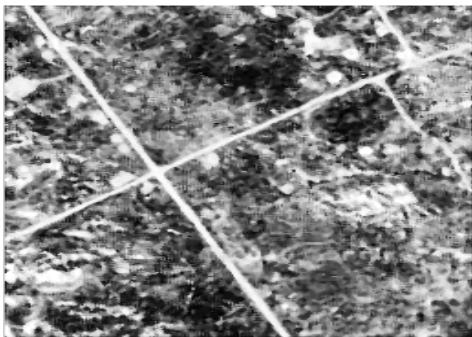


Fig. 7 Noise removed image1

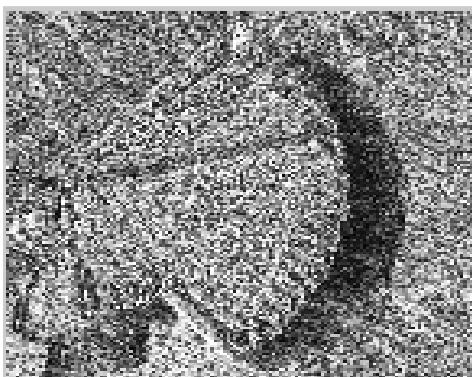


Fig. 8 Noise removed image2

During the edge detection process, edge image is produced. Figure(7) and (8) shows an Edge image1&2.

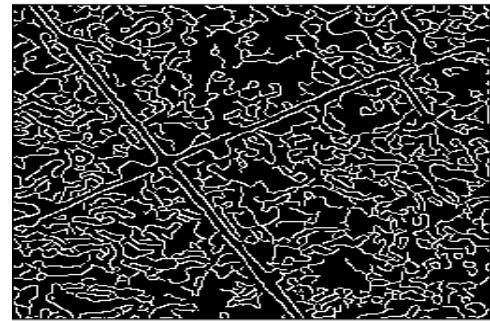


Fig. 7 Edge image1

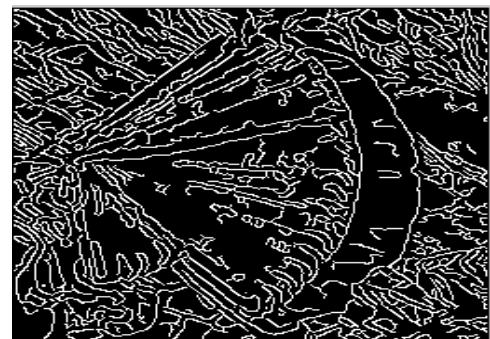


Fig. 8 Edge image2

During linear feature extractoion process, linear feature extracted image is produced. Figure(9) and (10) shows an Linear Feature Extracted image1&2.

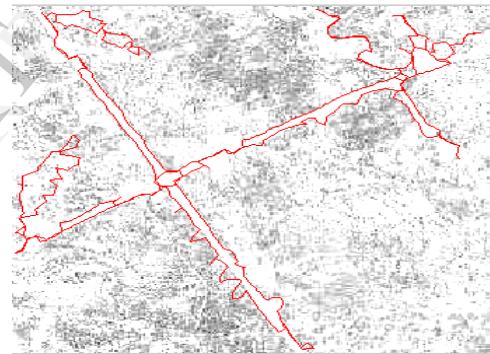


Fig. 9 Linear Feature Extracted image1

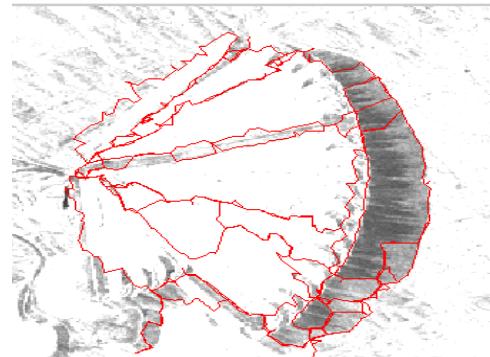


Fig. 10 Linear Feature Extracted image2

#### IV. CONCLUSIONS

Linear Feature is an important characteristic in Microwave images. These images are affected by noise. So the noise is removed in this work by using an median filter method and the edges are detected by canny edge detection algorithm. After the GVF field was produced then Snake was initialized. The

V.Ramachandran, K.Vani

Snake was deformed in edges by applying an external constrain forces of CGVF Snake model. Finally the linear features are extracted and discontinuities are removed in this work. The experimental results show an extraction of linear features efficiently and increase quality of satellite Mapping. In future work, the new algorithm has to be implemented to improving an extraction of linear feature from microwave images to overcome the problems of missing edges in this work.

## REFERENCES

- [1] M. Kass, A. Witkin, and D. Terzopoulos, "Snakes: active contour models", International Journal of Computer Vision, vol. 1, pp. 321-331, 1987.
- [2] C. Xu and J. L. Price, "Snakes, shapes, and gradient vector flow," IEEE transactions on Image Processing, vol. 7, pp. 359-369, 1998.
- [3] C. Wiedemann and H. Ebner. "Automatic completion and evaluation of road networks", Int. Arch. Photogram. Remote Sens., IEEE transactions on Image Processing vol3. 33, pp. 976-986, 2002.
- [4] R. Touzi, A. Lopes, and P. Bousquet, "A statistical and geometrical edge detector for SAR images," IEEE transactions on geoscience and remote sensing letters, vol. 26, pp. 764-773, Nov. 2006.
- [5] Y. B. Hou, and Y. Xiao, "Active snake algorithm on the edge detection for gallstone ultrasound images," IEEE 9th International Conference on Signal Processing, vol.16, pp. 474-477, 2008.
- [6] Siwaporn S., Suebskul P. Crack Detection on Asphalt Surface Image Using Enhanced Grid Cell Analysis Proceedings of the 4th IEEE International Symposium on Electronic Design, Test and Applications, vol.31, No.6, pp.38-40, 2006.
- [7] P. Gamba, F. Dell' Acqua, and G. Lisini, "Improving urban road extraction in high-resolution images exploiting directional filtering, perceptual grouping, and simple topological concepts", IEEE transactions on geo science and remote sensing letters, vol. 3(3), pp. 387-391, Jul. 2006.
- [8] Peggy Subirats, J. Dumoulin, V. Legeay, Dominique Barba, "Automation of pavement surface crack detection using the continuous wavelet transform", IEEE International Conference on Image Processing (ICIP 2006), vol.7, pp.3037-3040.
- [9] Wang Min And Zhang Yanning, "Gray-scale Image Edge Detection Based on directional Beamlet Transform", IEEE transactions on Image Processing .vol.7, pp.1120-1124, 2008.
- [10] Na WEI , XiangMo ZHAO , XiaoYu DOU HongXun SONG "Beamlet Transform Based Pavement Image Crack detection", IEEE International Conference on Intelligent Computation Technology and Automation, vol.13, pp.881-883, 2010.
- [11] CHEN Weirong WANG Chao ZHANG Hong, "Road Network Extraction in High Resolution SAR Images". IEEE transactions on Image Processing , vol.23, pp.1120-1124, 2009.
- [12] Florence Tupin, Henri Maître, Jean-François Mangin, Jean-Marie Nicolas, and Eugène Pechersky, Detection of Linear Features in SAR Images: Application to Road Network Extraction, IEEE transactions on geosciences and remote sensing, vol. 36, no. 2, march 1998.
- [13] Chenyang Xu and Jerry L. Prince, Gradient Vector Flow: A New External Force for Snakes, IEEE Proc. Conf. on Comp. Vis. Patt. Recog. (CVPR'97), vol.30, pp.67-71, 2003.
- [14] Gianni Lisini, Céline Tison, Florence Tupin, and Paolo Gamba, "Feature Fusion to Improve Road Network Extraction in High-Resolution SAR Images", IEEE transactions on geoscience and remote sensing letters, VOL. 3, pp.217-221, 2006.
- [15] X. Bresson, S. Esedo\_glu, P. Vandergheynst, J.P. Thiran, and S. Oshery, "Global Minimisers of The Active Contour/Snake Model", EPFL on Dept of mathematics, vol.19, page 1-27, 2005.
- [16] Byoung-Ki Jeon, Jeong-Hun Jang, and Ki-Sang Hong, "Road Detection in Space borne SAR Images Based on Ridge Extraction", IEEE transactions on geoscience and remote sensing letters, vol.32, pp.735-739, 1999.
- [17] Li Su-yuan1, Yang Wen2, Yang Hang, Sun Hong, "Road Extraction from High Resolution Dual-Polarization SAR Images over Urban Areas", Proc. of SPIE Vol.8, pp. 7285-7285, 2008.
- [18] Sun Zhaoyun1, Wang Chaofan2, Sha Aimin2, "Study of Image-Based Pavement Cracking Measurement techniques", IEEE Ninth International Conference on Electronic Measurement & Instruments, vol.12, pp.140-143, 2009.
- [19] He Youquan, Qiu Hanxing, Wang Jian, Zhang Wei, Xie Jianfang, "Studying of Road Crack Image Detection Method Based on the Mathematical Morphology", IEEE 4th International Congress on Image and Signal Processing, vol.9, pp.967-969, 2011.
- [20] LUO Lei1,2, WANG Xin-yuan1, JI Wei3, LI Chao1,2, "Automated Detection of Lunar Craters Based on Chang'E-1 CCD Data", IEEE 4th International Congress on Image and Signal Processing, vol.37, pp.883-887, 2012.

**V.Ramachandran** is pursuing his Master of Technology in Information Technology from College of Engineering, Anna University, Chennai, India.

**Dr.K.Vani** is currently a Associate Professor in Department of InformatioScience and Technology, College of Engineering, Anna