A Study on Road Segmentation Techniques in Satellite Image Applications

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Abstract— Extraction of road regions from the satellite images performs a crucial role in case of automated mapping systems. It is specifically used in planning cities and also to update GIS (Graphical Information Systems). A methodology known as SAR sensing will works precisely on 24X7 throughout the year except in some abnormal conditions. There are also some manual techniques available for the same but yields the results which are faded out, cost effective and consume more time in extraction. It is necessary to automate the process of segmentation and classification of objects in SAR images for processing at greater levels. It is important to perform road region extraction from SAR images in a manner that it widely improves the ability to map generation which will helps in the vehicle navigation system. This leads to prolong the work and focusing on efficient methods to extract the required features of road region by giving a SAR image as an input. In this paper, our aim is to retrieve and automate the road region extraction from SAR images with the help of traditional neural networks. This paper primarily concentrates on recent related works in this domain and presenting some segmentation techniques. In order to attain precise results of ROI it requires some metrics for its evaluation. Some of such metrics are being discussed in this paper.

Keywords— *Segmentation, SAR images, road segmentation, evaluation measures.*

I. INTRODUCTION

One of the recent trends in image processing domain is Image Segmentation. It enables us to segment an image into some required regions so that one can analyze that image by themselves easily. One of the vast domains in segmentation is that Satellite Imagery. There are many approaches like K-means Clustering, Active Contours and Thresholding method in segmentation of satellite images. To evaluate the best method from those, we use some performance parameters such as Segmentation Accuracy, Correlation Ratio and so on [1]. In the past few years, road extraction from the satellite images becomes more popular in some research domains. It is especially applied at the time of planning a city, Cartography and can also be used to update recently identified roads in GIS (Geographic Information Systems). Few of the examples which provide higher resolution satellite images are The Google, Yahoo, Virtual Earth and other maps. To extract the road region from aerial view which is noisy and with less resolution is challenging task. To remove those noises we must apply the Gaussian filtering on image with greater frequencies. An algorithm known as Canny Edge detection [5] is used to make enhancements to an image. At the time of disasters such as strikes and other road disturbances it plays a key role in bringing into normal condition [6].

Human are having the ability to detect roads in remote sensing images with ease. But it is hard to automate by the computers. To find the road regions from the satellite images some veterans starts to search for gathering planar and also curvilinear featured and then applies their knowledge or experience to make sure that they are roads or any. In the perspective of human a method known as automatic hybrid road detection is proposed. It can also consider the benefits with the statistical (Gaussian Mixture Model method) and artificial neural network models. As the SAR images visually looks similar to rivers or railways it is complex to detect roads. Till date there is no approach developed for extracting the complete road regions from input SAR images but deep convolution neural networks were highly succeeded in object segmentation [2]. The block diagram of road extraction approaches is shown in Figure 1. An input depends upon the SAR image. Those yield by combining SAR images from various passes. Here we consider the images which are gathered at relatively similar concept and also grazing views. Our present work focuses on describing the road region extraction techniques from SAR images. For an instance we depicted the sample SAR image in Figure 2.

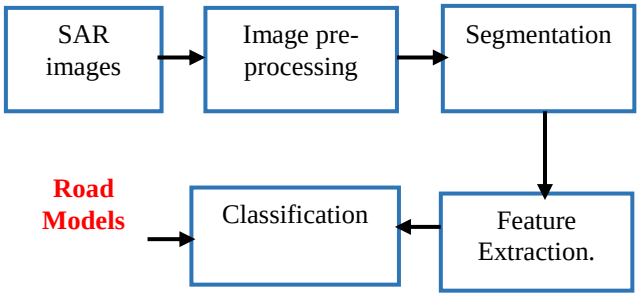

Figure 1: Block diagram of SAR road detection approach.

Figure 2: SAR Image

II. SEGMENTATION METHODS

The segmentation techniques are intended mainly to segment an image into required regions. To perform this there exist many segmentation techniques. In order to get segmented regions there applied many techniques, for instance SLIC super pixel methods on images [6]. Additionally there are various methods available [7, 8, 9], that treats region identification by global optimization by neglecting the noise. Those methods processes based on K-means approach using a Euclidean distance as a parameter to compute the similarities or distance [10]. In [11], the researchers explained that a Euclidean distance is almost same as to ratio-intensity. Under this section, we briefed the current approaches which are used for the computer automation of satellite images segmentation. There exist seven categories of segmentation techniques. Those are thresholding, region growing, classification based, cluster based, ANN based, PDE based method and Watershed algorithm [12]. However many methods processes based on considering either pixels discontinuities or its similarities [13]. We discussed only some segmentation methods and their overview is presented in this section and the broad classification is shown in Figure 3.

2.1 Thresholding

The thresholding process tries to demonstrate the intensity value known as Threshold. It will divide the classes based on our requirement.

The segmentation is done by grouping all pixels in to single class whenever the intensity is higher than a threshold and the remaining pixels in to other separate class. It is simple and effective in attaining image segmentation. The demerit with the thresholding is that there is the possibility of creating dual classes in it but in the case of multi-channel image applications it is impossible. In addition to this, the image's spatial characteristics are not taken into sight because those are noise sensitive. Therefore the deviations concerning classical thresholding were recommended that incorporates information based on the surrounding intensities and also connectivity [14].

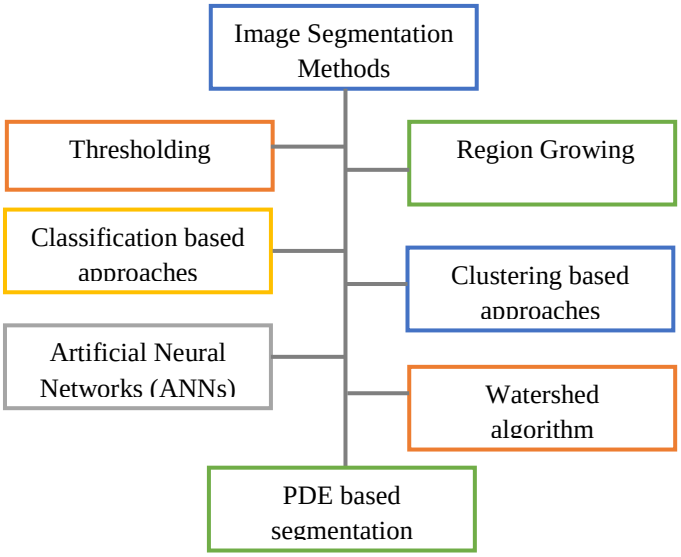

Figure 3: Image segmentation techniques

2.2. Region Growing

One of the techniques in extracting image portion is Region growing. It is connected based on some already defined criteria. This criterion depends upon the data's intensity and/or that image edges. This technique requires a seed pixel and will extracts all pixels which are connected with the initial seed with the same intensity value. The major disadvantage with this approach is it requires human interaction to attain a seed pixel. We can overcome this by the application of split and merge algorithms that do not need any seed points. The following are the basis steps for region growing and merging (reverse as shown in Figure 4). Assume 'S' be the actual image and 'k' be the specific predicate.

- Initially P_1=S
- Every region is partitioned into quadrants in which k(P_i)=False.
- If for each region, k(P_j)=True, then the merge of adjacent regions P_i and P_j such that k($P_i \cup P_j$) = True.
- Repeat the above step until the process of merging becomes impossible.

2.3. Classification-based Approaches

Classifier approaches are treated as pattern recognition method that always attempts to divide feature space derived from an image by data with the labels that are known. All the pixels which have similar characteristics are clustered into one class. These methods involve nearest-neighbor classifier, K-nearest-neighbor (k-NN) classifier, Parzen window classifier, Bayes classifier and so on. However it is not generally performs any spatial modeling. This is cleared by adding the intensity in identities and geometric information [16].

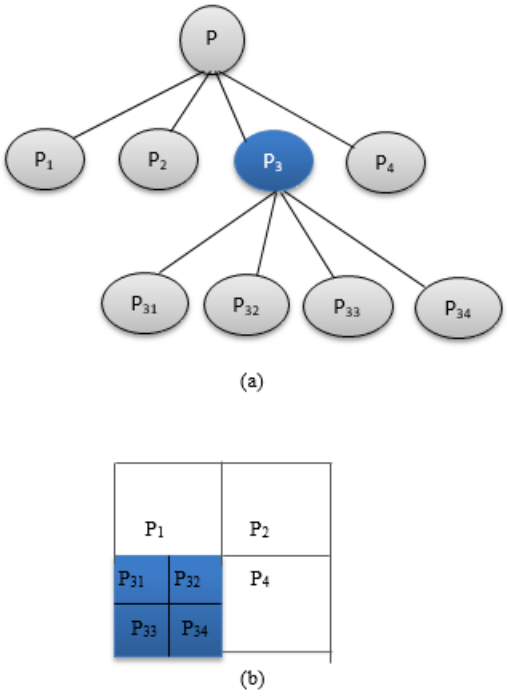

Figure 4: Division of regions based on quad tree.

The 'P' in the above figure is an input image which is classified into four quadrants namely P_1, P_2, P_3 and P_4.As our option one of those four quadrant is again classified into four sub parts. Those are highlighted in colored form and are shown in figure 4(b).

2.4. Clustering-based Approaches

The clustering procedures are intended to do same function like classifier approaches with the absence of training data and are called as unsupervised models. Typically we use 3 clustering procedures in general such as k- means, the fuzzy means paradigm and the expectation- maximization (EM) algorithm. Despite, the clustering paradigms do not require any training information but they requires an initial segmentation (or equivalently, initial parameters). It leads to produce key advantages for speedy computation [20].

2.5. Artificial Neural Networks

Artificial Neural Networks (ANNs) gives a paradigm concerning machine learning and also can be utilized in many ways in image segmentation. A classifier is extensively utilized and also can be applied on satellite imaging [18], where the weights depends on the usage of training data. Next an ANN is utilized to segment new information. Additionally, those ANNs are used in terms of unsupervised manner as a method of clustering, also for deformable models. Watershed Segmentation is considered as one of the most important intensity correction and ignores the noise with the use of edge-preserving directional anisotropic diffusion method. Finally an IDWT (Inverse DWT) is done to achieve the enhanced image.

2.6 Partial Differential Equation Based Segmentation Method

These are the fastest methods for segmentation .These is suitable in application of important situations. Basically there are two PDE approaches such as non-linear isotropic diffusion filter (used to enhance the edges) and convex non-quadratic variation restoration (used to remove noise). The outcomes of this PDE method has blurred edges along with boundaries which can be moved with close operators. In PDE approach the fourth order is used for reducing the noise from an image and whereas the PDE approach is 2nd order for identifying the edges and boundaries.

III. SATELLITE IMAGE CLASSIFICATION

A satellite is furnished with the SAR (Synthetic Aperture Radar) which has the ability to capture an area's topography. Moreover SAR sensors can operate without relying on weather condition, an important advantage during surveying a portion is influenced by some weather related disaster. Our present study focuses on extracting roads from satellite images. It is complex to recognize roads from SAR images.

3.1 Road segmentation

There is high demand for the instant acquisition and updating of road information. Despite of many research studies have

stated on partial and completely automated designs to extract roads. The notable risk here is that the resultant quality is insufficient for many applications. Some segments concerning road network are ignored and few are with error [22, 23].

3.2 Satellite Imaging Techniques

There prevail many methods and also techniques in the classification of satellite images. In its hierarchy [3] the major categories are Automated, Manual and Hybrid [17]. In 2010, Hui Kong et. Al [18] applied a method called as general road recognition from an image with the application of vanishing point detection approach. In this approach there was proposed that usage of 36 orientations Gabor Filters helps to retrieve the required data at each edge pixel.

J. Shabnam et al., [19] suggested a supervised method for the classification of satellite images with greater resolution into specific classis by applying fuzzy logic. This approach helps in classifying the satellite images majorly into five classes and those are barren land, road, vegetation, shadow and building. It is also used image segmentation including fuzzy models to classify satellite images. Fuzzy techniques are specifically utilized to enhance the accuracy rate in classifying the edge level objects.

DibyaJyoti Bora et al. (2014) [20], was presented in her paper work regarding image segmentation. It is considered as an extensive concept in research domain and a choice of many researchers by author. The advantage with the clustering models of image segmentation is it is wide field and can be applied in various domains in engineering. In this paper work she developed a novel approach for image segmentation by clustering as a basis for it. A Sobel filter is used for filtering and obtaining the outcomes and we used Watershed algorithm as a marker.

Muhammad Waseem Khan et al. in 2014 [21], was stated in his paper work as image segmentation is an essential part in an image processing. It is not harder to find the objects count in that image after being performed the segmentation. He was also developed a novel approach to segment an image by using innovative trends. In this paper, our objective is to identify the region of a road from an input image. The task varies by an input image and also the captured image varies in some cases. For instance, an input image belonging to sub-urban area developed urban area, emerging sub-urban area or emerging urban area and some of those images are shown in Figure 5. The overview of extracting road regions from SAR images are shown in Figure 6. The results are evaluated by taking some parameters into sight and are presented in the following sections.

IV. EVALUATION METRICS

There is having some parameters to do comparison between Segmentation techniques. Different quantitative measures will help to evaluate the quantitative performance of the recommended algorithm for road segmentation. Such measures are achieved by doing the comparison of different segmented road inputs and actual base road images. The different quantitative measures utilized for evaluation are: Mean, Variance, Standard Deviation, SNR (Signal to noise ratio), Recall, Precision, Accuracy and F-Measure. Finally,

$$\text{Recall} = \frac{TP}{TP+FN} \quad (1)$$

$$\text{Precision} = \frac{TP}{TP+FP} \quad (2)$$

$$\text{Accuracy} = \frac{TP+TN}{TP+FP+TN+FN} * 100 \quad (3)$$

$$\text{F-Measure} = \frac{2*precision*recall}{precision+recall} \quad (4)$$

Here, the terms TP: True Positives FP: False Positives TN: True Negatives FN: False Negatives respectively

a b c d

Figure 5: Numerous Satellite Images a. Developed sub-urban, b. Developed urban-area, c. emerging sub-urban, d. Emerging urban-area.

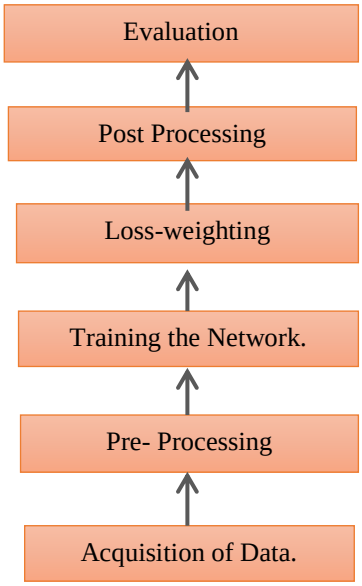

Figure 6: Training Process with evaluation

V. CONCLUSION

Road extraction from the satellite images performs a crucial role regarding automated mapping schemes. There is the availability of various methods to perform segmentation and every method is application dependent. We discussed various types of segmentation techniques and related works to SAR imaging procedure. Even though there are different methods for ROI extraction but there required efficient methods for entire automation of extracting roads. Besides to this, we recommended a notion to automate this process by training with the related traditional networks. Even so, in this paper our work implementation levels is limited we concentrated on the literature work in this research domain. To the best of our awareness, there is availability of minimum measures to evaluate the tasks regarding segmentation and there is also good scope for research.

REFERENCES

[1] Jose M. Alvarez, Theo Gevers, Yann LeCun, and Antonio M. Lopez. Road scene segmentation from a single image. In Proceedings of the 12th European Conference on Computer Vision - Volume Part VII, ECCV'12, pages 376–389, Berlin, Heidelberg, 2012.

[2] P. Lu, K. Du, W. Yu, R. Wang, Y. Deng, and T. Balz, "A new region growing-based method for road network extraction and its application on different resolution SAR images," IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 7, no. 12, pp. 47724783, 2014.

[3] H. Yu, X. Zhang, S. Wang, and B. Hou, "Context-Based Hierarchical Unequal Merging for SAR Image Segmentation," IEEE Trans. Geosci. & Rem. Sens. 51(2), 995-1009 (2013).

[4] A. R. Weeks "Fundamentals of Electronic Image Processing" SPIE/IEEE Press, 1996, ISBN 0-8194-2149-9

[5] V. Amberg, M. Coulon, P. Marthon, and M. Spigai, "Improvement of road extraction in high resolution SAR data by a context-based approach," in Proceedings of the IEEE International Geoscience and Remote Sensing Symposium (IGARSS '05), pp. 490–493, Seoul, Korea, July 2005.

[6] A. Levinshtein, A. Stere, K. N. Kutulakos, D. Fleet, S. J. Dickinson, and K. Siddiqui, "Turbopixels: Fast superpixels using geometric flows," IEEE Trans. Patt. Anal and Mach. Intel. 31(12), 2290-2297 (2009).

[7] K. Hedman and S. Hinz, "The application and potential of Bayesian network fusion for automatic cartographic mapping," in Proceedings of the IEEE International Geoscience and Remote Sensing Symposium (IGARSS '12), pp. 6848–6851, Munich, Germany, July 2012.

[8] C. He, Z. Liao, F. Yang, X. Deng, and M. Liao, "Road extraction from SAR imagery based on multiscale geometric analysis of detector responses," IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 5, no. 5, pp. 1373-1382, 2012.

[9] P. Lu, K. Du, W. Yu, R. Wang, Y. Deng, and T. Balz, "A new region growing-based method for road network extraction and its application on different resolution SAR images," IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 7, no. 12, pp. 47724783, 2014.

[10] R. O. Duda, P. E. Hart, and D. G. Stork, Pattern classification, John Wiley & Sons, New York, NY (2012).

[11] D. Xiang, T. Tao, Z. Lingjun, and S. Yi,, "Superpixel generating algorithm based on pixel intensity and location similarity for SAR image classification," IEEE Geosci. and Rem. Sens. Lett. 10(6), 1414-1418 (2013).

[12] A. R. J. Katz, "Image Analysis and Supervised Learning in the Automated Differentiation of White Blood Cells from Microscopic Images", Master's thesis, Department of Computer Science, RMIT, Feb. 2000.

[13] Haralick, R.M. and Shapiro, L.G. (2005) Image segmentation techniques, Comput. Vis. Graph. Im. Proc., 29, 100–132.

[14] Lee S. and Crawford, M.M. (2005) Unsupervised Multistage Image Classification Using Hierarchical Clustering with a Bayesian Similarity Measure, IEEE Trans. on Image Processing Vol. 14, No.3, Pp. 312-320.

[15] Ghosh M, Das D, Chakraborty C, Ray AK. Automated leukocyte recognition using fuzzy divergence. Micron. 2010; 41(7):840- 6.

[16] Fabio Scotti, "Robust Segmentation and Measurement Techniques of White Cells in Blood Microscopic Images", Instrumentation and Measurement Technology Conference, Sorrento, Italy, 24- 27 April 2006.
[17] Horning, N. 2004. "Land cover classification methods", Version 1.0. American Museum of Natural History, Center for Biodiversity and Conservation. Available at http://biodiversityinformatics.amnh.org
[18] H. Kong, J.Y. Audibert and J. Ponce, "General road detection from a single image." IEEE Trans. On Image Processing, Vol. 19(8), pp. 2211– 2220, 2010.
[19] Shabnam Jabari and Yun Zhang, 2013. " Very High Resolution Satellite Image Classification Using Fuzzy Rule-Based Systems", Algorithms, vol.6, no.4, pp. 762-781.
[20] DibyaJyoti Bora (September, 2014) "A Novel Approach Towards Clustering Based Image Segmentation", IJESE, Volume-2 Issue-11, pp 6-10
[21] Muhammad Waseem Khan et al, "A Survey: Image Segmentation Techniques", International Journal of Future Computer and Communication, Vol. 3, No. 2, April 2014, pp 89 -93
[22] H. Badino, U. Franke, and R. Mester. Free space computation using stochastic occupancy grids and dynamic programming in *ICCV workshop*, 2007. 3
[23] A. Wedel, H. Badino, C. Rabe, H. Loose, U. Franke, and D. Cremers. B-spline modeling of road surfaces with an application to free-space estimation. *IEEE Trans. ITS*, 2009.

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