A New Technique For Semi-Automatic Road Extraction Using High Resolution Satellite Images

Ms.Sudha C, Dr.S.Leninisha, Mr.Dhivagar G

Abstract: Recent days, object extraction such as roads, buildings, rivers etc from remote sensing images is an active research issue in the field of remote sensing. Road extraction system plays a crucial role in many Geographic Information System (GIS) applications mainly in urban planning, traffic management etc. Therefore, it makes use of different approaches with or without human interventions to extract complete road network. With the use of human assistance, semi–automatic road extraction approach provides more accurate results than the fully automatic approach which is not practical. As a result of recently launched satellites, high resolution images are highly available in which complexity increases much in urban areas due to rapid constructions like flyovers, bridges and change in the network often and there exists shadows due to trees, vehicles, buildings etc. Unfortunately, the available methods found difficult to produce an accurate and reliable result for urban areas with many occlusion and intersections. In urban areas, road extraction yet remains a challenging task. A novel approach for the road extraction process based on semi automatic method using high resolution satellite images is proposed. The performance of the proposed method is well efficient in extracting road regions.

Keywords: Semi-Automatic Method, Road Extraction, GIS applications, Remote Sensing Images

I.INTRODUCTION

Object extraction from remotely sensed images is a difficult task in the field of image processing. Especially, road extraction is a very hot research issue now days, as it is very helpful in numerous applications like geographic database maintenance, map generation. Of all GIS (Geographic Information System) data generation, map data generation is a very expensive as its process is time consuming and long term process. Also road detection system is very important for many GIS applications. Therefore many efforts have been put forward to have an efficient method to extract manmade objects like buildings, roads etc. Particularly, many people concentrated on the generation of producing well efficient road extraction system in order to have complete road network for map generation. In early days, roads are extracted manually by the human without any use of computer. Later on due to the technological development and efficient digital image analysis techniques, the process of road tracking is computerized. This computerized method of doing road tracking is of two categories: Semi automatic and automatic. Semi automatic road extraction system is used widely because of their performance where the system needs user's guidance to control the process. The information from the user may be providing the initialization points and any assistance when needed. In automatic method, there does not need any human intervention.

- *Ms. Sudha C is currently working as an Assistant Professor in Department of Computer Science & Engineering in CK College of Engineering & Technology, India, PH-9789611269. E-mail: cmsudhame@gmail.com*
- *Dr.S.Leninisha is currently working as an Associate Professor in Easwari Engineering College, India PH-9840546118. E-mail: sleninisha@gmail.com*
- *Mr.G.Dhivagar is currently pursuing Bachelor Degree in Department of Computer Science & Engineering in CK College of Engineering & Technology, India, PH-.9952316245 E-mail: dhivagar185@gmail.com*

The whole extraction process is done automatically without the help of user. In this approach even the initialization is done automatically by the system. Though automatic approach is less time consuming, it is not a practical one because of its accuracy in producing complete road which is not of full satisfactory. Hence semi automatic approach had attracted the attention of many researchers. As a result, many algorithms and methods have been proposed with variant results. The existing methods are able to detect the rural and sub-urban road network efficiently. This is because in rural and semi urban areas, the road network will not show complex structure as in urban areas. Therefore, till now no approach have been achieved the goal of providing an accurate and complete road network in urban areas. This is because of the fact that most of the urban areas show high complexity due to various urban developments' like large buildings, complex flyovers, bridges and also due to some occlusions like tree shadows, vehicles on the road. Another cause for the failure of the existing systems is that in urban areas the road structure differs from that of rural and urban areas In this paper, the section II describes the general road characteristics, the next section tells about the overview of the road extraction process. Then in section IV literature review of the work is done, the section V explains our proposed work for the semi automatic road extraction process.

II.GENERAL ROAD CHARACTERISTICS

Roads are generally extracted from digital remote sensing images based on road model generated using the knowledge of their characteristics which exhibits geometrical, topological, radiometric, functional and contextual properties (Gruen et al., 1995; Vosselman and de Knecht, 1995; Grun and Li, 1997; Zhou, 2006). Some of the road characteristics are: 1. In low resolution images, roads are considered as lines whereas in high resolution considered as parallel elongated regions 2. Roads vary slowly in their width 3.Road curvature appears slowly 4. Roads are usually homogeneous region 5. Roads build a network and connect cities 6. There appears a good contrast on the surface of the road from other adjacent areas 7. Higher roads like flyovers may cast shadow 8. Array of trees indicate road and make occlusions on road. For road extraction process in high resolution images, radiometric and

geometrical properties are highly focused. In high resolution remote sensing images, many characteristics of road details are highlighted. But it also has some drawbacks that it shows many variations in road details like road sides can change the contrast; cars of different sizes can be present; the road surface can change material and width and so forth. The complexity of the method increases if the road details are more. Hence selection of road details must be efficient. The roads are extracted based on some of the road characteristics highlighted in remote sensing images.

III.OVERVIEW OF ROAD EXTRACTION PROCESS

Generally road extraction process involves some basic operations like preprocessing of an input image, identification of the road points, road tracking process and post processing the extracted road segments. Preprocessing is an essential one for panchromatic SPOT images as they have high contrast globally. In this step, edges of interested regions are sharpened and noises are removed. After that road positions are to be found either with the help of user or automatically using some methods. It follows road detection process where road regions are either extracted or traced out. The result of the road detection have some problems like missing some road branches, added some non road linear regions as road segments. For that post processing is done after the extraction of the region of interest (road) to get an accurate and complete road. Road extraction methods proposed by many researchers for this process are based on knowledge, model, region, testing, dynamic programming, graph searching, snakes, classification, segmentation, edge detection, mathematical morphology etc. the available methods are used either for road centerline extraction or for entire road region extraction.

IV.LITERATURE REVIEW

In this section, the works related to semi automatic road extraction are illustrated. Firstly profile matching method is used popularly for road detection by many researchers. In 1978, Quam proposed a road tracking and anomaly detection system in which he used maximum cross correlation technique for matching two profiles [18]. In this tracker, only road centerlines were extracted for the aerial images and there may exist some false alarms in anomaly detection. Least square matching is more advantageous than cross correlation in profile matching as it predicts the shift between two profiles and used for updating parameters. Therefore, in paper [21], Vosselman and Knecht introduced a new road system different from Quam with the use of least square profile matching and Kalman filter. In their system, the Kalman filter was used to update the parameters. This predictive nature of Kalman filter is used to continue the road tracking process if the profile matching fails temporarily when there is any interruption due to obstacles like shadows of trees etc. In 1996, Jedynak and German used a different approach for this process. Their approach is based on active testing model where few tests are performed to get the required true hypothesis. Gruen and Li, 1997 [6], proposed a new approach using dynamic programming [7] [Gruen and Li, 1995] and LSB snakes. In their work, they developed LSB snakes (Least Square B Spline snakes) for estimating energy minimization function. In 2001, Park and Kim introduced template matching for road extraction process instead using “snakes”. In their work, road centerline of any orientation is extracted with moderate curvature successfully. But it fails if roads with shadow [17]. Shukla et al introduced a new algorithm for road extraction from high resolution images using path following approach [20]. Hence to have more accurate results, Dal poz et al proposed a modified approach for medium and high resolution satellite images where they modified the cost (merit) function of by constraint function embedding edge properties. In 2004, Kim et al used least square template matching. To extract road network from classified SAR images, in 2004, Xiao et al developed an approach using Genetic algorithm based on road pixels [23]. In this paper classification was done by fuzzy C means algorithm. To search optimization roads, Genetic algorithm was used. Road tracking can be done more effectively in aerial images by the use of Zhou et al system [26]. They developed the tracking system based on human-computer interaction and Bayesian filtering. Zhang et al improved the existing road tracker using the cooperation of angular texture signature and template matching. Auto tuning Kalman filter is combined with profile matching for road detection process by Wang and Zhang [19]. In 2008, a new road tracer was introduced based on T shaped template matching to extract ribbon roads of more than three lanes and strip of vegetation from high resolution satellite images of urban areas. This method is actually an integration and improvement of profile matching and rectangular template matching. Least square matching is used to search the precise the road centerline position. In their system, human involvement guarantees correctness, completeness and accuracy of road tracking process [13]. Anil and Natarajan introduced a semi-automatic approach using active contour model for high resolution satellite images as the method described in paper [2] was efficient for aerial images. This also faces the problem of road cast by shadow.Circular template window matching was introduced for the tracking process by J. Cheng et al [11]. Because of the use of template window which is circular reduces the computational time in finding the road center point. As the people, over many years of experience found it difficult to implement the extended Kalman filter, unscented particle filter was proposed by Jenita Subash in 2011 for high resolution satellite images. Wang et al proposed a new approach for semi automatic road extraction method for high resolution satellite images [16]. Their approach is based on the combination of multi profile analysis and extended snakes. Three dimensional road extractions in rural areas using stereoscopic aerial images were introduced by Dal Poz in 2012. Radiometric properties of stereoscopic images are integrated into its associated energy function using the mathematical relationships connecting road points in image space and in object space. Using this, the road centerlines are extracted directly in the object space of the image. Monoscopic based extraction procedure is more stable because of the use of DTM (Digital Terrain Model) highly. But this procedure does not require the use of DTM [1]. Recently, Chaudhuri et al [3] developed a method using customized operators for accurately derive the road segments using semi automated road detection approach from high resolution panchromatic satellite images. The operators include directional morphological enhancement, directional segmentation and thinning.

V.PROPOSED WORK

The proposed work on road extraction combines morphological filtering and length filtering. In our proposed

work the steps involved are broadly classified as 1.Image enhancement 2.Road Extraction 3.Post processing which is represented in the Figure 2 and 3. The following sections clearly describe the steps involved in our work.

A. Image Enhancement The remote sensing images are first introduced to morphological filtering in order to enhance the objects in the images. In this step, the road contrast is adjusted. The morphological filters are non-linear filters utilize the geometric features of the images rather than the analytic feature and was introduced by Serra. The basic morphological operations are dilation, erosion, opening and closing. Opening includes erosion followed by dilation and the closing operation includes dilation followed by erosion. The algorithm for image enhancement employs morphological close-open and close-open operations using the same structuring element. The opening of a set A is defined by,

$$A \bullet B = (A \Theta B) \oplus B$$

Similarly the closing of a set A is defined by,

$$A \bullet B = (A \oplus B) \Theta B$$

where B is the structuring element.

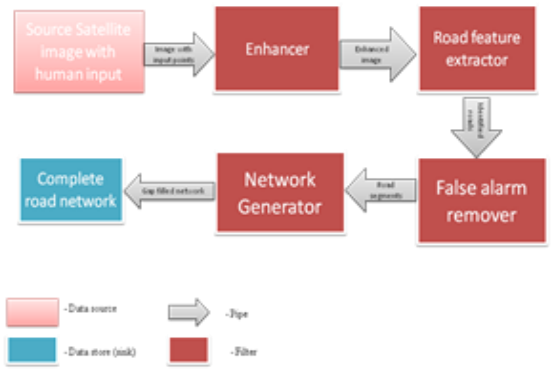


Figure 1. *Architecture of the Road Extraction Method*

B. Road Extraction Roads are often represented by various shape properties. In our approach we have taken the parameters-color, width and the direction of the road for extracting the road regions. After getting single seed point from the user, our system automatically finds the width of the road for tracking process to continue. Road pixels are grown on eight directions to find out the length of the road on each direction. With the help of calculated lengths, the minimum road width is identified. Based on the road width and color threshold, it starts capturing roads in both directions (left and right). It will go until it finds the edge of the straight road.

C. Post Processing After the road extraction process, the resultant may sometimes show some non-road regions extracted. Those non road regions are using post processing steps like thinning. The result of the proposed work is shown in the Figure 3 and the result obtained is then tested for accuracy, correctness and completeness.

$$Completeness = \frac{Length\ of\ matched\ road\ reference}{Length\ of\ \ road\ reference}$$

$$Correctness = \frac{Length\ of\ matched\ extraction}{Length\ of\ extraction}$$

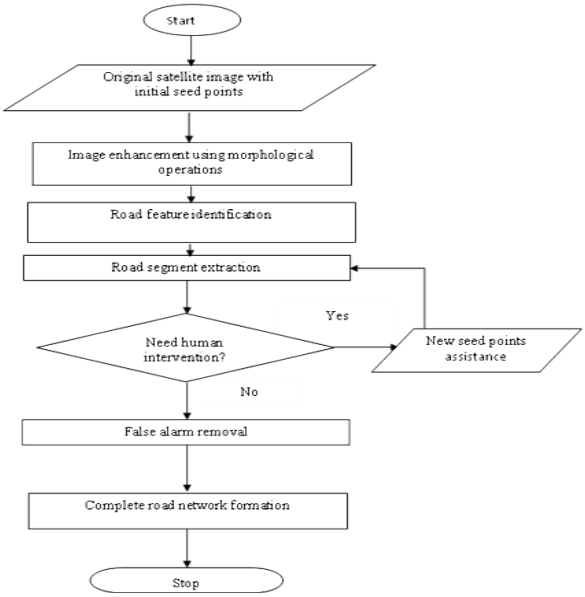
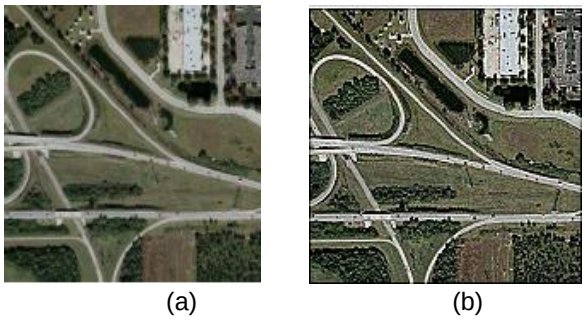
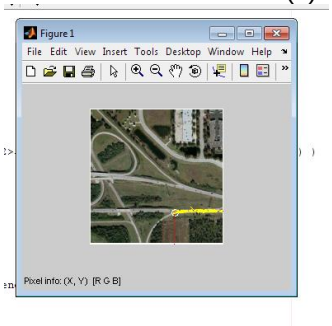


Figure 2. *Flow Chart of Road extraction Process*





(e)

Figure 3. *Results for Road Extraction (a) Original Image, (b) Enhanced result (c) and (d) Extracted road by the proposed method and (e) Screenshot*

VI.CONCLUSION

Data from remote sensing images are used in wide range of applications. In this paper, we clearly explained the overall road extraction process from remote sensing images and illustrated various methods proposed in semi - automatic road extraction approaches. Then the proposed method for extracting road regions from high resolution satellite images is presented. Image enhancement is done using morphological filtering to shape the boundaries of the objects and to adjust the contrast of the regions. Roads are then extracted using the length calculation. The proposed method is succeeded in extracting straight lines with slight curves resulting in values on the order of 40% completeness. Now work is being done to refine the extraction process.

ACKNOWLEDGEMENT

The authors would like to thank all the reviewers of this paper for their useful review comments and ideas to have a quality paper. They are also very much grateful to Dr. Vani, Associate Professor in the department of IST, CEG Campus, Anna University, Chennai, India for her guidance in this research work.

AUTHORS BIOGRAPHY

Ms.Sudha C received the B.E. degree in Information Technology from Annamalai University, Chidambaram, India in 2008 and Master of Engineering in the field of Software Engineering from SRM Easwari Engineering College, Chennai, India in the year 2013. Currently Pursuing Ph.D. in Annamalai University, India. She has around three years teaching experience. Her fields of interests are image processing, pattern recognition, remote sensing, data mining, big data analytics and Internet of Things.

Dr. S.Leninisha received the B.E. degree in Computer Science and Engineering from Madurai Kamaraj University, Tamil Nadu, Chennai, in 2000, M.E. degree in Computer Science and Engineering from Anna University, Tamil Nadu, Chennai, in 2006 and received her Ph.D. degree in Anna University, Chennai in the Faculty of Information and Communication Engineering, in 2017. She has around 15 years of teaching experience. Now she is working as an Associate Professor in Easwari Engineering College affiliated to Anna University, Chennai, Tamil Nadu. Also, she is a Member of IEEE professional body. Her main research interests are feature extraction in remotely sensed images, pattern recognition, and invariants for object recognition. She published many papers in international conference and journals in various research areas.

Mr.G.Dhivagar is currently pursuing Bachelor Degree in the Department of Computer Science & Engineering in CK College of Engineering & Technology, TamilNadu, India. His area of interest are data mining and image processing.

REFERENCES

[1] Aluir P. Dal Poz, Rodrigo A. B. Gallis, João F. C. da Silva, and Érico F. O. Martins, “Object-Space Road Extraction in Rural Areas Using Stereoscopic Aerial Images”, IEEE GEOSCIENCE AND REMOTE SENSING LETTERS, VOL. 9, NO. 4, JULY 2012

[2] Anil. P. N, Natarajan. S, “A Novel Approach Using Active Contour Model for Semi-Automatic Road Extraction from High Resolution Satellite Imagery”, IEEE Second International Conference on Machine Learning and Computing, 978-0-7695-3977-5/10, 2010

[3] Chaudhuri.D, N. K. Kushwaha, and A. Samal, “Semi-Automated Road Detection from High Resolution Satellite Images by Directional Morphological Enhancement and Segmentation Techniques”, IEEE Journal Of Selected Topics In Applied Earth Observations And Remote Sensing. This article has been accepted for inclusion in a future issue of this journal. Content is final as presented, with the exception of pagination

[4] Dal Poz P, Gallis R. B. A, and Silva J. F. C, “Three-dimensional semiautomatic road extraction from a high-resolution aerial image by dynamic-programming optimization in the object space,” IEEE Geosci Remote Sens. Lett., vol. 7, no. 4, pp. 796–800, Oct. 2010

[5] Geman D and B Jedynak, An active testing model for tracking roads in satellite images, IEEE Trans. PAMI, vol.18, no.1, pp.1-14, January, 1996

[6] Gruen A and Li, H.H., "Semi-automatic linear feature extraction by dynamic programming and LSB-Snakes", Photogrammetic Engineering and Remote Sensing, Vol 63(8), pp. 985-995, 1997

[7] Gruen, A and Li, H.H., "Road extraction from aerial and satellite images by dynamic programming", ISPRS Journal of Photogrammetry and Remote Sensing, 50(4), 11-20 (1995).

[8] Geman and Jedynak, "Detection of roads in SPOT satellite images," Proc. IGARSS '91, Helsinski, Finland, June 1991.

[9] Hu.X, Zhang. Z, Zhang.J, " An approach of semi-automated road extraction form aerial images based on template matching andNeural Network", International Achieves of Photogrammetry and Remote Sensing, Amsterdam, Netherlands, Vol. XXXIII,Part B3, pp. 994-999, 2000
[10] Jenita Subash, "Unscented Particle Filter in Road Extraction from High resoltuion Satellite Images", ICRTIT, 2012
[11] Jianghua Cheng, Yongfeng Guan, Xishu Ku, Jixiang Sun , "Semi-automatic Road Centerline Extraction in High-Resolution SAR Images Based on Circular Template Matching", IEEE 978-1-4244-8039-5/11, 2011
[12] Kim T., Park S-R, Kim M-G, et al., "Tracking road centerlines from high resolution remote sensing images by least squares corelation matching", Photogrammetric Engineering and Remote Sensing, Vol 70(12):1417-1422, 2004
[13] Lin Xiangguo, Ji-Xian Zhang, Li Haitao, Yang Jinghui, "Semi-automatic Extraction of Ribbon Road from High Resolution Remotely Sensed Imagery by a T-shaped Template Matching", Geomatics and Information Science of Wuhan University.34(3),293-296, 2009
[14] Lin X. G. , Zhang J. X, Liu Z. J , Shen J, " Semi-automatic extraction of ribbon roads form high resolution remotely sensed imagery by cooperation between angular texture signature and template matching", The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVII. Part B3b, Beijing, 2008
[15] Mckeown, D., Denlinger, J., "Cooperative methods for road tracing in aerial imagery", Proceedings of the IEEE Conference in Computer Vision and Pattern Recognition, 662–672, 1988
[16] Min Wang & Siqi Zhang, "Road extraction from high-spatial-resolution remotely sensed imagery by combining multi-profile analysis and extended Snakes model", International Journal of Remote Sensing, 32:21, 6349-6365, 2011
[17] Park S.R., T.Kim, "Semi-automatic road extraction algorithm from IKONOS images using template matching, Proc. 22nd Asian Conference on Remote Sensing", pp.1209-1213, 2001
[18] Quam, L.H., "Road Tracking and Anomaly Detection in Aerial Imagery", Proceedings of DARPA Image Understanding Workshop, pp. 51-55, 1978
[19] Ruisheng Wang, Yun Zhang, "Semi-Automated Road Extraction from QuickBird Imagery", ISPRS, 2003
[20] Shukla., Chandrakant. R.and Ramachandran. R., "Semi-automatic road extraction Algorithm for high resolution images using path following approach", In ICVGIP'02, Ahmadabad, vol. 6, pp. 231–236, 2002
[21] Vosselman, G., Knecht, J.D. , " Road Tracing by Profile Matching and Kalman Filtering", Automatic Extraction of Man-made Objects from Aerial and Space Images, Birkhäuser Verlag, Basel, pp. 255-264, 1995
[22] Xiangguo Lin, Jixian Zhang, Zhengjun Liu, Jing Shen, "Semi-automatic road tracking by template matching and distance transform", IEEE Urban Remote Sensing Joint Event, 2009
[23] Xiao Zhi-Zhang, BAO Guang shu, JIANG Xiao que, "Road network extraction in classified SAR images using genetic algorithm", Article ID: 1005 - 9784(2004)02 - 0180 – 05 Vol. 11 No. 2, 2004
[24] Xiaofeng Sun, Yingcheng Li, Xiangguo Lin, "Semi-automatic Extraction of Ribbon Roads from VHR Remotely Sensed SAR Imagery", IEEE 978-1-4244-7210-9/10, 2010
[25] Zhang. R, Zhang. J, Li. H, " Semi-automatic extracting of strip road based on the angular texture signature and profile matching from high-resolution remote sensing image", Remote Sensing, Vol 12 (2) :42-50, 2008.
[26] Zhou J, Bischof W.F and Caelli T, "Road tracking in aerial images based on human computer interaction and Bayesianfiltering",ISPRSJ. Photogram.Remotesens.,vol.61,no.2,pp.108-124,2006