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ROAD DETECTION FROM SATELLITE IMAGES

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Abstract — Road extraction from satellite images is challenging research area in information extraction from high-resolution remote sensing images such as IKONOS and QUICKBIRD. The road from satellite images can be identified based on its geometric, spectral, topological and contextual properties as well as on various illumination and geographical environment. The road network extraction results in map generation in short time. In this paper roads are extracted by semi-automatic method road network. Image Binarization is achieved by C means clustering algorithm followed by morphological operation which includes filtering and image thinning.
Keywords-component; Segmentation, Clustering, Road Detection, Morphological Filtering, Quality Measures.

I. INTRODUCTION

Roads play very important role in our daily lives; information related to the location of roads becomes essential. The information regarding not only allows human being to make decisions related to the environment, but also increases efficiency in route planning for transportation. At present, information regarding road locations and their characteristics are stored digitally in geographical databases such as Geographic Information Systems (GIS). Geographical Information System (shortly GIS) represents a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world. Road data enables GIS applications to facilitate a variety of services which include satellite navigation, route planning, transportation system modeling, land cover classification and even infrastructure management. The GIS application an also facilitate the traffic monitoring, routing and controlling. The Government agencies, civil defence organizations, relief agencies, and consumers depend heavily on maps to support their missions and activities [3]. Therefore road network extraction can be used for the generation of quick map of area interest.

The roads can be extracted by ground surveying which is time consuming process or by using satellite images. The roads extraction from remotely sensed imagery is categorized into semi-automated or fully automated process. In semi-automatic process requires some human interaction (selection of seed points) to guide a set of automated processes [2]. In other words, in semiautomatic road extraction, a road in the image is delineated using its geometric and photometric properties with the initial positions provided by an operator [5]. Automatic approaches pursue automatic location of a road in the image by recognizing the road and defining its positions accurately. Local photometric properties cannot classify a point or segment as a road point or segment reliably, since they depend on many factors, such as the season, time and weather condition of photography. The same object in different images may have different gray values, while different objects in one image may have similar intensity [5].

The high resolution satellite image such as IKONOS, QUICKBIRD contains more information's than low resolution and poses more challenges for road detection due to the complexities occurs due same gray level of non-road objects. First, a typical satellite sensor captures everything such as buildings, cars, roads, vegetation etc. Second, different objects are not seen as an isolated, but are mixed and interfere with each other, such as shadows of trees and buildings connected to the road, building top roofs whose grey value lies in same spectrum of road. Third, roads appear differently within the same image, due to their respective physical properties and these properties are affected by weather, illumination condition and resolution of satellite sensor. All these false indications and complexities pose difficulties in the process of road extraction. The traditional road extraction methods have some disadvantages such as some residual objects in the image which are not classified as roads and the inability to detect roads in all directions [6].

Therefore a good algorithm should be able to detect various objects and it is independent of illumination, weather and resolution of sensor. In low resolution images, roads are normally appear like single pixel line while in high-resolution images, contains more information regarding roads, vehicle as well as building roofs and their shadows.

The difficulties in road network extraction from remotely-sensed imagery lie in the fact that the appearance of road vary according to satellite sensor type, spectral and spatial resolution, ground and weather condition, etc. Even road appearance in the same image is also different due to different materials used for road construction such as cement road and highway road. Also spectral characteristic appears differently in different physical conditions such as roads in desert, vegetation field, hilly and valley, roads in village, in city, cycle tracks. The Pankaj and Garg [1] extract the road by automatic road extraction methods using adaptive thresholding method. The Hang Jin [2] extracts the roads by using homogeneity histogram followed by connected component analysis and pruning, while Talal [6] uses directional filtering followed by length filtering to obtain the results. Mena [4] gives a better classification of different types of road extraction methods.

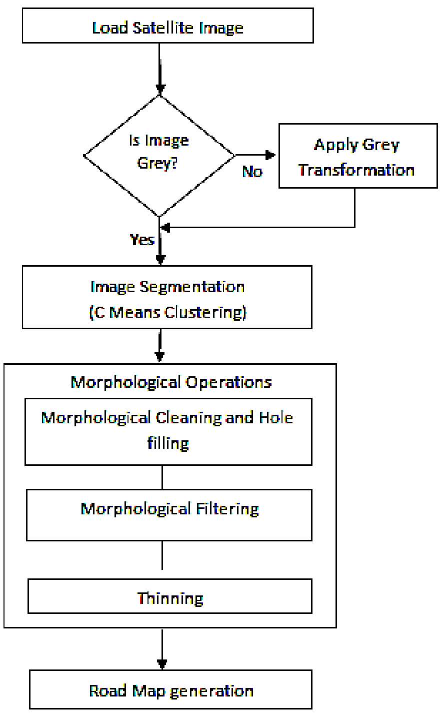

Figure 1- Flow chart of Road Detection algorithm

II. SEGMENTATIONOF ROAD REGIONS

The goal of image segmentation is to partition an image into a set of disjoint regions with uniform and homogeneous attributes such as intensity, color, tone or texture; etc [11] Road extraction from satellite images is a segmentation process that aims at locating roads in satellite images accurately while removing all other non road objects. The image segmentation is done by using c mean clustering algorithm. Clustering is a process for classifying objects or patterns in such a way that samples of the same group are more similar to one another than samples belonging to different groups.

III. FILTERING OF SEGMENTED IMAGE

Morphology is a method by which the structure of shapes within an image could be cleaned up and studied. It works simply by comparing each pixel in the image against its neighbors in various ways, so that it adds or remove, brighten or darken that pixel. It is applied over a whole image, perhaps repetitively; specific shapes can be found, filtered and can be modified.

Morphological operations are based on mathematical morphology, which can be used for removing isolated part of image with the help of algebraic non-linear operators. The segmented image is a binary image with road pixels labeled as 1's and non-road pixels as 0's. The morphological 'Clean' is used to remove isolated pixels such as binary 1's surrounded by 0's [10]. For small hole filling, we first invert the segmented image. We then delete the small regions and invert this image. This results in an image which has no small holes with road pixels as "1" and non-road pixels as "0". It is observed that the resulting image contains the non road parts which can be filtered by using morphological filtering such as combination of opening and closing.

After filtering there may be some discontinuity between the thinned detected roads due to noise. In order to connect broken segments' based on their relative orientation and distances morphological bridge is used to segment the unconnected pixels, that is, sets 0 valued pixels to 1 if they have two nonzero neighbors that are not connected

Thinning is similar to erosion, but it does not cause disappearance of the components of the object. It reduces objects to the thickness of one pixel, generating a minimally connected axis that is equidistant from the object's edges [9]. After applying the image thinning road network is extracted as shown in section 6.

The algorithm is applied on various images and resulting images are tabulated as shown. The resulting images are original, segmentation and thinned

IV. QAULITY MEASURES

For the evaluation of the road extraction results a number of quality measuresare defined. These measures are not meant to evaluate the extraction and the matching results in an absolute way. Rather, they are used to compare the results ofdifferent algorithms [29]. A common method for evaluating extracted roads is to usea reference road map (Ground Truth Images), which is assumed to be more accurateand more complete.The defined quality metrics comprises the following measurements:

True Positive (TP): The number of data correctly classified as belonging to thepositive class is called as true positives [6].

True Negative (TN): The number of data incorrectly classified as belonging tothe positive class is called as false positives [6].

False Positive (FP): The number of data incorrectly classified as belonging to thepositive class is called as false positives [6].

False Negative (FN): The number of data incorrectly classified as belonging tothe negative class is called as false negatives [6].

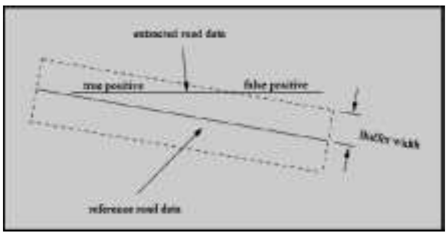

Figure-2: Matched extraction

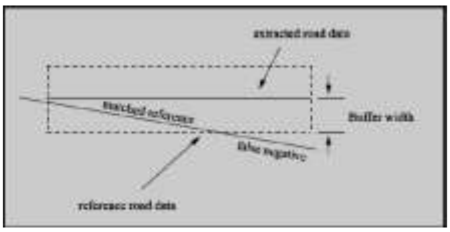

Figure-3: Matched reference

4.1 Completeness

Completeness is a measurement of the percentage of the reference road network that has been extracted. Thecompleteness is the ratio of the reference road data matched with the extracted road data to the total length of the reference road network. In true sense completeness represents \what is missing in the network I want" [29]. The completeness is calculated as

$$\text{Completeness} = \frac{\text{Length of Matched Reference}}{\text{Length of Reference}}$$

$$\text{Completeness} \approx \frac{\text{TP}}{\text{TP} + \text{FN}}$$

4.2 Correctness

Correctness serves as a measure of the precision of the extracted road network. In effect, the percentage of the extracted data which lie within the buffer around the reference data. The correctness metric is calculated as:

$$\text{Correctness} = \frac{\text{Length of Matched Extraction}}{\text{Length of Extraction}}$$

$$\text{Correctness} \approx \frac{\text{TP}}{\text{TP} + \text{FP}}$$

4.3 Quality

Quality is a measurement that combines completeness and correctness. The quality metric is calculated as:

$$\text{Quality} = \frac{\text{Length of Matched Extraction}}{\text{Length of Extracted Data} + \text{Length of Unmatched Reference}}$$

$$\text{Quality} \approx \frac{\text{TP}}{\text{TP} + \text{FP} + \text{FN}}$$

V. RESULTS AND DISCUSSION

The road detection from satellite image is segmentation process and post processing are required to filter out non road segments in order to extract road network. In case of gray images, gray level value difference between road and background in gray image plays an important role in feature extraction, if it is large, then false classification will be less. The performance parameters used for comparison are completeness, correctness and quality. The ideal value of completeness, correctness and quality is unity.

Figure-2: test image-1

Figure-3: test image-2

Figure-4: test image-3

Figure5: test image-4

Image	Completeness	Correctness	Quality
test image-1	0.6887	0.7085	0.5366
test image-2	0.6698	0.7227	0.5329
test image-3	0.2492	0.6371	0.2182
test image-4	0.5387	0.9122	0.5122

Table-1:Performance Comparison

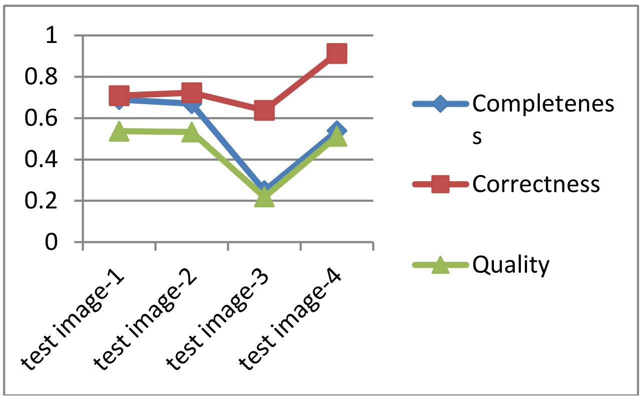

Figure7:Comparison Graph

IV. CONCLUSION

The semi automatic method of road network extraction using C means clustering improves the accuracy of road extraction. Through the experimentation it is found that segmentation by C means algorithm is not sufficient to detect all the roads; the resulting image contains the non road objects whose grey level spectrum is same as roads grey value such as building top roof and tree shadow etc. These non road objects can be removed by means of filtering. After filtering non road objects are connected by means of morphological operation which again smooth's the detected road. If the road in the same remotely sensed imagery has different grey level signature, it is observed that single seed point selection will not extract the road accurately. Therefore it requires multiple seed point selection for improving the accuracy of road detection.

REFERENCES

1. Pankaj Pratap Singh & R. D. Garg, "Automatic Road Extraction from High Resolution Satellite Image using Adaptive Global Thresholding and Morphological Operations" Journal of Indian Society of Remote Sensing, pp 631-640, Sept 2013.
2. Hang Jin, Yanming Feng, Bofeng Li "Road Network Extraction with New Vectorization and Pruning from High-resolution RS Images" 23rd International Conferenceon Image and Vision Computing IEEE, Nov 2008
3. Cem Unsalan, Kim L. Boyer. "A system to detect houses and residential street networks in multispectral satellite images", Computer Vision and Image Understanding" Vol 98, Issue 3, pp 423-461 June 2005;
4. J.B. Mena "State of the art on automatic road extraction for GIS update: a novel classification" Pattern Recognition Letter, Volume 24, Issue 16, , Pages 3037-3058, December 2003.
5. John C. Trinder and Yandong Wang "Automatic Road Extraction from Aerial Images" ,Geospatial Technology for Earth Observation,pp 289-327, August 2009
6. T. M. Talal, M. I. Dessouky, A. El-Sayed, M. Hebaishy and F. E. Abd El-Samie. "Road Extraction from High Resolution Satellite Images by Morphological Direction Filtering and Length Filtering" Sensing and Imaging: An International Journal, Volume 14, Issue 1, pp 29-55, June 2013.
7. Frank Y Shih. "Image Processing and Mathematical Morphology Fundamentals and applications" CRC Press..
8. Rafael C. Gonzalez, Richard Eugene Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Pearson Education.
9. for satellite image data base: www.cse.iitm.ac.in~sdasvplabsatellite.html
10. Subhagata Chattopadhyay, Dilip Kumar Pratihar, Sanjib Chandra De Sarkar "A Comparative Study Of Fuzzy C-Means Algorithm And Entropy-Based Fuzzy clustering Algorithms", Computing and Informatics, Vol 30, No 4, 2011.
11. A.H.Souri "An Approach to Automatic Road Detection on High Resolution Remotely Sensed Imagery", Remote Sensing 56C 13374-13379, 2013.

