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Comparison of color road extraction using vectorization method with the existing methods

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Abstract: The extraction of road from high resolution satellite images is very complex, and difficult task. Most of the researchers had shown their results on a few selected set of images. Maximum work in the road extraction area was based on greyscale images. Our approach is design to extract the road from color image using pre-processing and vectorization. Vectorization process is performed using canny edge detection and Constrained Delaunay Triangulation. Results obtained from CDT are in the form of triangles, these resulting triangles are grouped into polygons to build up vector image. Skeletonization process is used to transform the components of digital image into original components. At the end, our final resultant image is skeletonised color image.

Keywords: Pre-processing, Vectorization, Canny Edge Detection, CDT, Skeletonization.

I. INTRODUCTION

The raster-vector conversion of remote sensing image is a very important task in the extraction and updating of linear objects in cartographic processes. For the purpose of converting the remote sensing image the various techniques have been developed and applied for the extraction of the information from the images. The original images on which proposed approach apply is given in figure 2(a). The approach applied on both the images individually to get the resultant road structure. Our approach reduces various kinds of distortions, compared with other methods. Other important method focused on skeleton extraction. However the main focus of these approaches is to vectorize the raster image without further exploitation of the obtained polygonal format. A chain of pre-processing is applied to improve quality of image and to generate extended road network for further processing. Firstly, the image is pre-processed to get better tolerance by resisting the noises, and then roads are extracted. In contour vectorization is applied to convert the binary image of drawings from raster form to vector form. The image vectorization starts with canny edge detection followed by a constrained Delaunay triangulation (CDT) where the lines resulting from the pre-processing stage are used as constraints for Delaunay triangulation.

II. REVIEW OF PREVIOUS WORK

In the last years, many approaches have been developed to deal with the detection of roads from satellite images.

Knowledge-Based Methods: These methods include radiometric and geometric properties of the roads. The hypotheses for roads are generated using rules, and a top down process is applied to verify road hypotheses. The limitations of these methods are that the algorithm may not work on a road occlusion in complex scenes and cast by much shadow.

Mathematical Morphology: these methods are used for detecting road networks from high-resolution images using mathematical morphological operations. In aerial and high resolution images, the estimated road centerline network is at last extracted. But road gaps may possibly still exist, if the road surfaces are totally broken and no other information supporting the connection.

Snakes: these are model and strategy based on the multi-scale recognition of roads in combination with the geometry constrained boundary extraction using snakes is presented in [1].

Classification: Most of existing road extraction techniques for multispectral images based on reliable and automated classification of the road surfaces. The limitation of this method is that accuracy of the roads is far from acceptable.

Region Competition: this is combined approach includes region growing and region competition for road extraction of centerlines and the sides. The initial seeds are provided to begin manually, and hence, this is a semiautomatic process.

Perceptual Grouping: An adaptive filtering procedure captures the predominant directions of roads and enhances the extraction results.

III. General Approach

The main objective of our approach is to pass satellite image to a vector representation that facilitates the extraction of road structures from an input image. Figure1 shows block diagram of general approach.

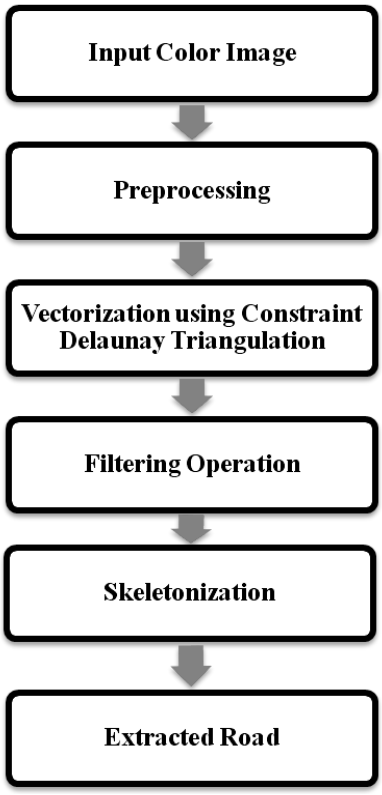

Figure1. General Approach

The main algorithm is preceded by a treatment that provides points that are judged to belong to lines and will be introduced to constraints to the Delauny triangulation.

A. Preprocessing

The input image is taken as an input to the working algorithm. The region of interest is developed which is a subset of the pixels in an input image. The selected pixels may either be a fairly arbitrary region, or only a regular sub image of the input image, and then after followed by the pre-processing where the correlation is calculated. Correlation is a statistical measure of the association between variables. It summarizes the direction and closeness of linear relations between two variables.

Correlation coefficients can range from -1 to +1. The value of -1 represents a perfect negative correlation while a value of +1 represents a perfect positive correlation. A value of 0 represents a lack of correlation. The correlation coefficient is defined as

$$Corr(p,r)=\frac{\sum(r_i-\bar{r})\times(p_i-\bar{p})}{\sqrt{\sum(r_i-\bar{r})^2}\times\sqrt{\sum(p_i-\bar{p})^2}}$$

Where p=current pixel

r= reference pixel

B. Vectorization

The vectorization phase includes the Canny Edge detection and Constrained Delaunay triangulation (CDT).

1. Canny Edge Detection

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions.

2. CDT

The Delaunay triangulation is performed on the image obtained after the Canny Edge detection. The Delaunay triangulation has the property that the circumcircle of any triangle in the triangulation contains no point of V in its interior. The Delaunay triangulation is constructed from a set of circum-circles. These circum-circles are chosen so that there are at least three of the points in the set to triangulation on the circumference of the circum-circle. None of the points in the set of points falls within any of the circum-circles.

C. Filtering

The generated triangle edges are then filtered. The constraints are kept while the other edges are filtered out according to a pre-specified set of rules. We use a well-known set of criteria for perceptual organization employed in human vision such as proximity, closure and contour completion. The elements tend to be perceived as aggregated into groups if they are near each other. Thus, edges are removed using a threshold filtering. The closure principle: elements tend to be grouped together if they are parts of a closed figure. In this case, the edges bounded by the same constraints are deleted. The contour completion rule states that between different contour edges, only the shortest edges are kept. The result is a segmented image that is represented as a set of spectrally attributed polygonal patches: a vector image.

D. Skeletonization

Finally the skeletonization is done to the color images for obtaining the final results as given in figure. Skeletonization is a transformation of a component of a digital image into a subset of the original component. The skeleton typically emphasizes the geometric properties and topological shape, such as connectivity, topology, length, direction, and width.

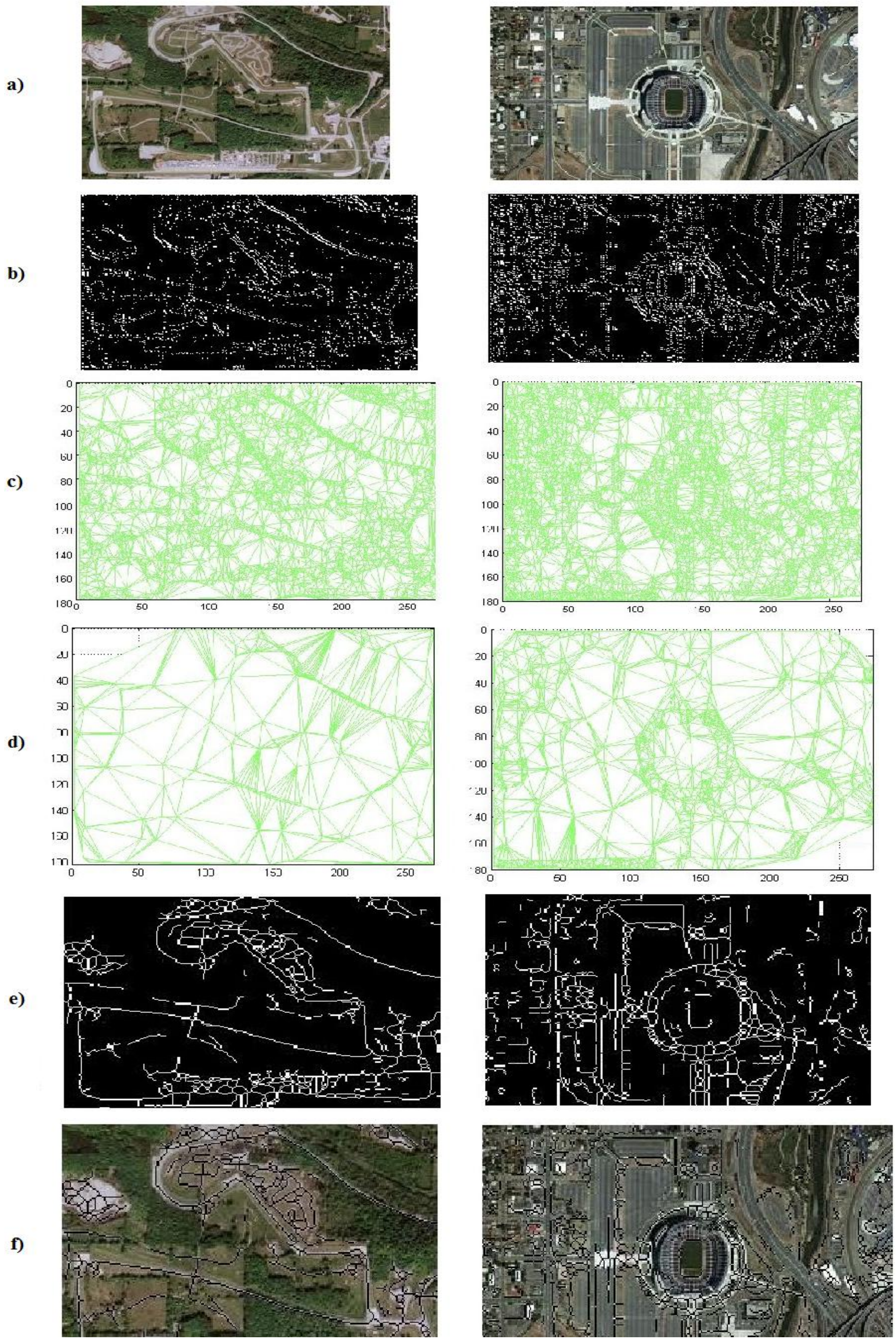

Figure2 (a) Input color images for road extraction process. (b) Result obtained from Canny Edge Detection. (c) Processed using CDT. (d) Triangles obtained from CDT grouped into polygons using filtering. (e) Skeletonization process output. (f) Final resultant skeletonized color image.

IV. Results and Comparisons

To evaluate accuracy assessment, the extracted roads obtained from our methodology are compared with the referenced roads. Therefore, there are two measures used to calculate accuracy of road extraction: (a) completeness and (b) correctness. The completeness represents the number of pixels of reference roads whereas correctness indicates the correctly extracted roads.

$$Completeness = \frac{lenght\ of\ matched\ refernce}{length\ of\ refrence}$$

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

In figure, the completeness and correctness of Image in figure 2(a) is 3929 and 3296 respectively for first image, the completeness and correctness is 4803 and 4786 respectively for second image. Therefore, the accuracy represents the percentage of data that are correctly classified using our approach.

In the Figure3, results of existing approaches and our proposed approach is given. It can be observed that the results of our proposed method, given in Figs. 3(g), are significantly better than those of other approaches and are quite close to the ground truth, as given in Figs. 3(b)-3(f). It is observed from the results shown in Figure 3 and Tables I that the performance measure for our proposed algorithm is superior to those of the other methods. The results obtained using the proposed methodologies are much superior to the methods presented in [2], [3] and [4]. The correctness and completeness value of Image 3 in our proposed approach are 4952 and 4644 respectively. These values are used to calculate the accuracy of the Image.

Table I. Accuracy Comparison of Proposed and previous approach

Methods	Accuracy
FeatureObjeX [4]	91.8%
Tuncer[2]	86.7%
Mokhtarzade et. al[3]	88.2%
Proposed Method	93.7%

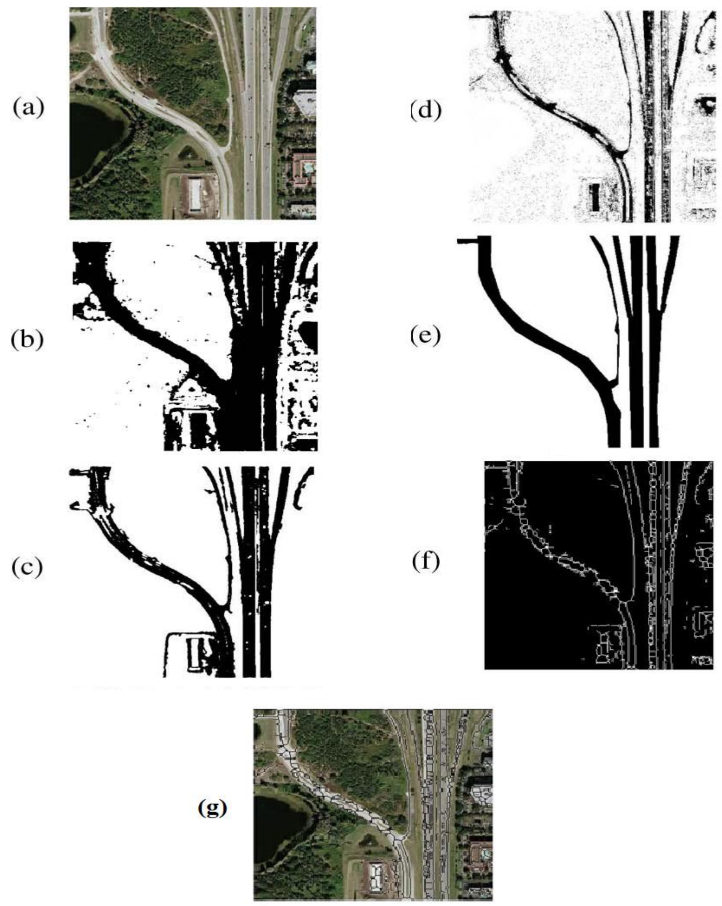

Figure3. (a) Four satellite images of size (512 × 512) from a suburban area of a developed region. (b) Results from FeatureObjeX [4]. (c) Results of the method proposed in [2]. (d) Results of the method proposed in [3]. (e) Hand-drawn (manual) road map (f) Results of method proposed in [5]. (g). Result of our proposed approach.

V. CONCLUSION

Our approach gives an automatic extraction of road from the input color image and improves the visibility factor in the resultant color image. It is easy to take decision and provide the better recognition of the roads. The signs or symbols and other details on the road merged in the previous approach. Our approach does not merge the information and give detail as it is in the original image. The visibility of our resultant image is much better than the previous existing approaches resultant image as shown in Figure3. We implement various vectorization techniques like triangulation canny edge detection etc followed by the Skeletonization to provide the better results and correct path of the roads. All of the existing approach works on greyscale image and gives result in black and white. But our approach gives color output. But still our approach provides better accuracy than the previous approaches. Further improvements can be done to provide more accuracy and visibility of the road.

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