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An Approach to Extract Road from Colour Image using Vectorization

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Abstract— Road extraction can be done by extracting the roads from image by accessing it through the features of road.The conversion from raster image of remote sensing image to vector image is an essential task for extraction and updating of linear cartographic matter in cartographic process. Many difficulties emerge in the automatic solving of this trouble. 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. Vectorization is performed using canny edge detection and CDT (Constrained Delaunay Triangulation) and then grouped resulting triangles into polygons to make up vector image. A sequence of pre-processing steps is applied to get better quality of image and to produce extended road network before vectorization. At the end, skeletonization is used to transform the components of digital image into original components.

Keywords— Vectorization, constrained Delaunay triangulation, canny edge detection, skeletonization

I. Introduction

The raster to vector conversion of the remote sensing image is an important task in 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 1 and 2. The approach applied on both the images individually to get the resultant road structure.

Figure1. Original Color image1

Figure2. Original Color image2

II. General Approach

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

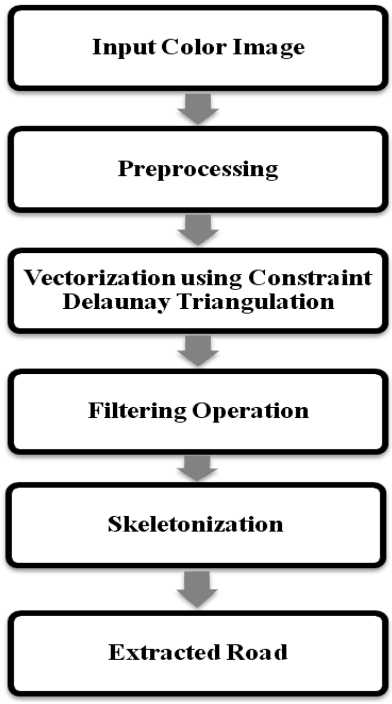

Figure3. General Approach

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.

III. PREPROCESSING

The input image is taken as an input to the working algorithm. The region of interest is developed which is subset of pixels in an input image. The pixels which are selected may either be an arbitrary region, or only a regular sub image of the input image, 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

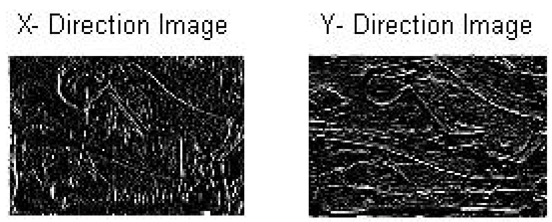

Figure4. Preprocessing on image (1)

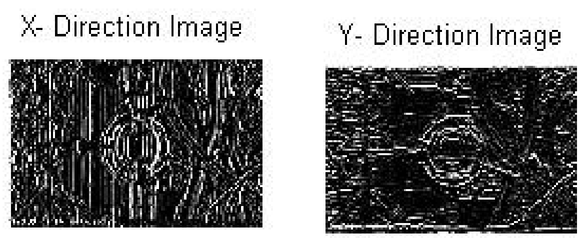

Figure5. Preprocessing on image (2)

IV. VECTORIZATION

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

A. 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. In order to implement the canny edge detector algorithm, a series of steps must be followed.

Step1: The first step is to filter out any noise in the original image before trying to locate and detect any edges. And because the Gaussian filter can be computed using a simple mask, it is used exclusively in the Canny algorithm. Once a suitable mask has been calculated, the Gaussian smoothing can be performed using standard convolution methods. A convolution mask is usually much smaller than the actual image. As a result, the mask is slid over the image, manipulating a square of pixels at a time. The larger the width of the Gaussian mask, the lower is the detector's sensitivity to noise. The localization error in the detected edges also increases slightly as the Gaussian width is increased.

Step 2: After smoothing the image and eliminating the noise, the next step is to find the edge strength by taking the gradient of the image. The Sobel operator performs a 2-D spatial gradient measurement on an image. Then, the approximate absolute gradient magnitude (edge strength) at each point can be found. The Sobel operator uses a pair of 3x3 convolution masks, one estimating the gradient in the x-direction (columns) and the other estimating the gradient in the y-direction (rows).

Step 3: The direction of the edge is computed using the gradient in the x and y directions.
Theta = invtan (Gy / Gx)

Step4: Once the edge direction is known, the next step is to relate the edge direction to a direction that can be traced in an image. So if the pixels of a 5x5 image are aligned as follows:

x	x	x	x	x
x	x	x	x	x
x	x	a	x	x
x	x	x	x	x

x x x x x

Then, it can be seen by looking at pixel "a", there are only four possible directions when describing the surrounding pixels - 0 degrees (in the horizontal direction), 45 degrees (along the positive diagonal), 90 degrees (in the vertical direction), or 135 degrees (along the negative diagonal). So now the edge orientation has to be resolved into one of these four directions depending on which direction it is closest to (e.g. if the orientation angle is found to be 3 degrees, make it zero degrees). Think of this as taking a semicircle and dividing it into 5 regions.

Step 5: After the edge directions are known, non-maximum suppression now has to be applied. Non-maximum suppression is used to trace along the edge in the edge direction and suppress any pixel value (sets it equal to 0) that is not considered to be an edge. This will give a thin line in the output image.

Step 6: Finally, hysteresis is used as a means of eliminating streaking. Streaking is the breaking up of an edge contour caused by the operator output fluctuating above and below the threshold. If a single threshold, T1 is applied to an image, and an edge has an average strength equal to T1, then due to noise, there will be instances where the edge dips below the threshold. Equally it will also extend above the threshold making an edge look like a dashed line. To avoid this, hysteresis uses 2 thresholds, a high and a low. Any pixel in the image that has a value greater than T1 is presumed to be an edge pixel, and is marked as such immediately. Then, any pixels that are connected to this edge pixel and that have a value greater than T2 are also selected as edge pixels. If you think of following an edge, you need a gradient of T2 to start but you don't stop till you hit a gradient below T1.

Figure6. Canny Edge Detection of Image1

Figure7. Canny Edge Detection of Image2

B. **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.

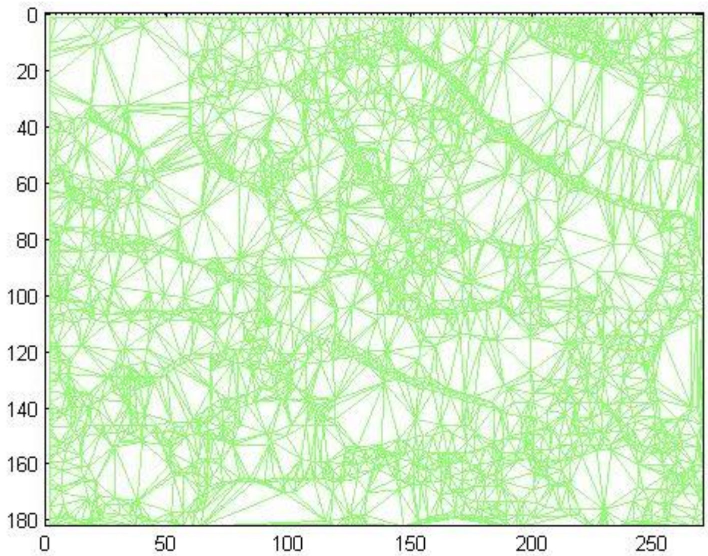

Figure8. Constraint Delaunay Triangulation of Image1

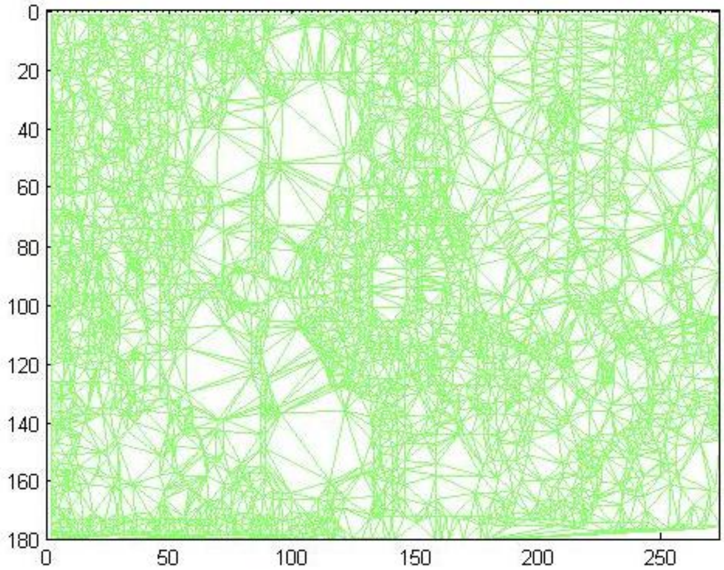

Figure9. Constraint Delaunay Triangulation of Image2

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.

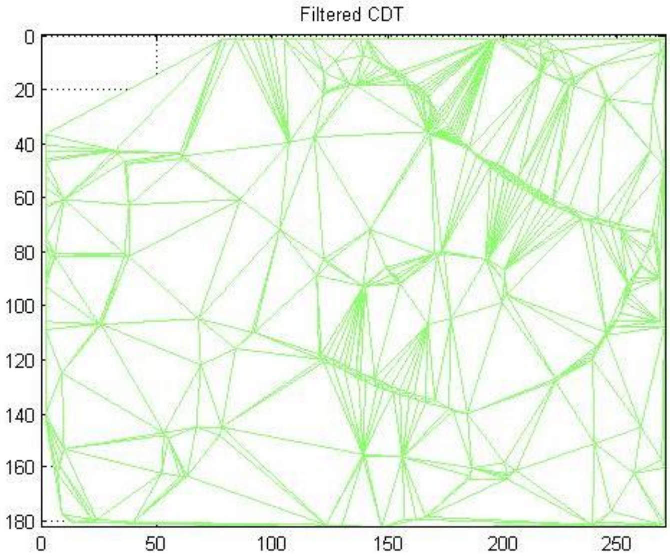

Figure10. Filtered Constraint Delaunay Triangulation of Image1

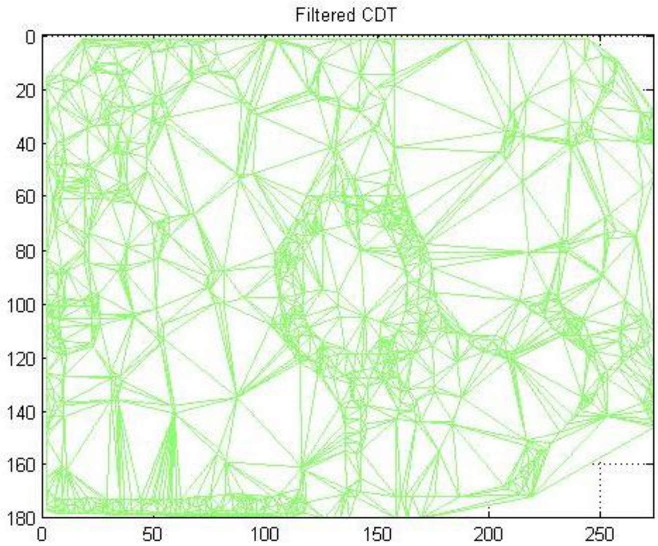

Figure11. Filtered Constraint Delaunay Triangulation of Image 2

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.

V. SKELETONIZATION

Finally the skeletonization is done to the color images for obtaining the final results. Skeletonization is a transformation of a component of a digital image into a subset of the original component. It is global space domain technique for the shape representation that has been studied extensively since skeletons have attractive properties which make them suitable for structural pattern recognition. The skeleton typically emphasizes the geometric properties and topological shape, such as connectivity, topology, length, direction, and width. There are two recognized paradigms for skeletonization methods: The one is iterative thinning of an original image until no pixel can be removed without altering the topological and morphological properties of the shape. The other definition used for a skeleton is that of the ridge lines formed by the centers of all maximal disks included in the original shape, connected to preserve connectivity. This leads directly to the use of distance transforms or similar measures which can be computed in only two passes on the image. The final step in our algorithm is to extract the skeleton of the obtained polygons.

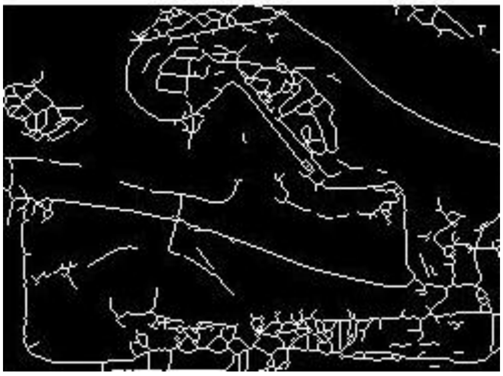

Figure12. Skeletonised result of Image1

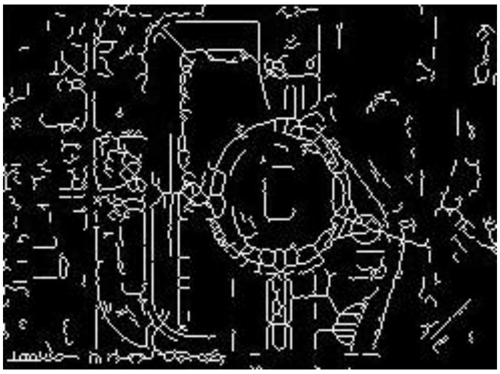

Figure13. Skeletonised result of Image1

VI. RESULTS

The resultant skeletonised color images are given in figure14 and figure15. Both input and output are in color form. The previous approach [7] gives the output in greyscale format and does not map the result to show the path on original image.

Figure14. Road Extracted resultant image from Original image1

Figure15. Road Extracted resultant image from Original image 2

VII. CONCLUSIONS

Our approach gives automatic extraction of road from the color image and improved visibility Factor in the resultant image. It is easy to take a decision and provide better recognition of roads. The signs and other details on the road merged in the previous approach. Our approach does not merge the information and give detail as it is original image. 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. But still further improvement required. The accuracy of the resultant first image and second image is approximately 84% and 99%. The improvement is required for type of images as in figure1.

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