Robust and Efficient Method to Extract Roads from Satellite Images

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Abstract- In today's world of growing population, the need for urban planning is very high. In this paper, A robust and efficient method for extraction of roads from a given set of database is explained. Roads play a vital role and important role in urban planning and thus, its extraction can be of great help. The other applications of road extraction are: identification of isolated buildings that need to be detected and updating of GIS database according to the requirements of the human expertise. In this method, roads are extracted solely based on their color. The steps in the algorithm are easy to follow and implement. It is also less time consuming and an automatic method.

Keywords – Spectral angle, Median filtering, Morphological operations

I. INTRODUCTION

Road extraction plays one of the major roles in many applications regarding the betterment of present human lives. Thus, the need for road extraction using a robust and efficient method is also high. Currently, there are many ways to extract roads manually and automatically. Some of the methods are explained in [1-5].

The main disadvantage of the different above given methods is the difficulty to provide the best parameters for a particular given image. Road extraction explained in this paper depends only on the color of the road. The advantage of this method is that road images from any type of satellite can be used provided it has more than 0.5m resolution. Here, the images considered are multispectral images. Multispectral images are those images that consist of three or more spectral bands. Any type of roads can be extracted based on their color. The algorithm is implemented using MATLAB.

The remaining part of the paper is organized as follows. The proposed steps and extraction algorithms are explained in section II. Experimental results for the algorithm implemented are given in section III. Finally the conclusion for the algorithm implemented is given in section IV.

II. PROPOSED ALGORITHM

A. Proposed steps–

The first step in this method is the creation of a database. The database should contain multispectral road images whose road intensity values are within a particular range. By considering different intensity ranges, any type of roads can be extracted.

The basic steps involved in this method is given in Figure 1. The basic steps involved are: the conversion of a vector image to a scalar image using spectral angle, the scalar image is filtered using a median filter to remove noises that affects satellite images, filtered image is converted into a binary image, the binary image still contains unwanted objects and that is removed using morphological operations, edges of the extracted road is determined and finally the extracted road is overlaid onto the original image.

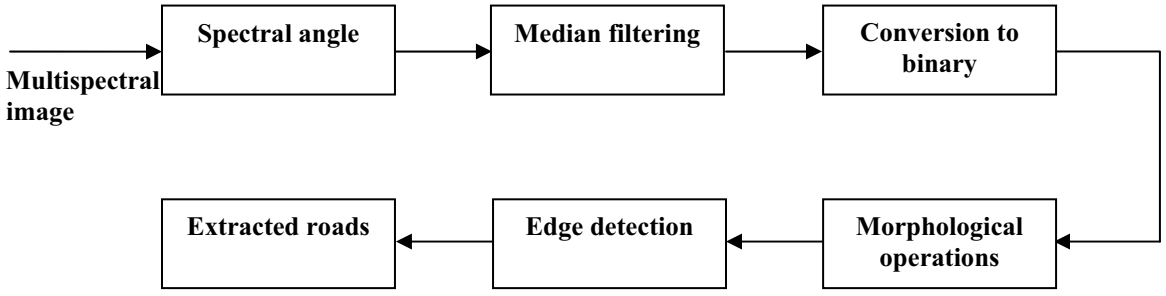


Figure 1. Basic steps involved

B. Road Extraction algorithm –

The various steps in the extraction algorithm is explained below

All multispectral images are considered as a vector since it contains three or more spectral bands. Processing of a image as a vector is quite difficult. Inorder to convert a multispectral image into a scalar there are many methods but here we use spectral angle to convert the multispectral image to scalar. The spectral angle of an image is given clearly in [6]. The spectral angle of an image can be determined using the equation

$$SA = \cos^{-1}\left(\sum_{b=1}^{n_b} r(b).p(b) \Big/ \sqrt{\sum_{b=1}^{n_b} r(b)^2 . \sum_{b=1}^{n_b} p(b)^2}\right) \quad (1)$$

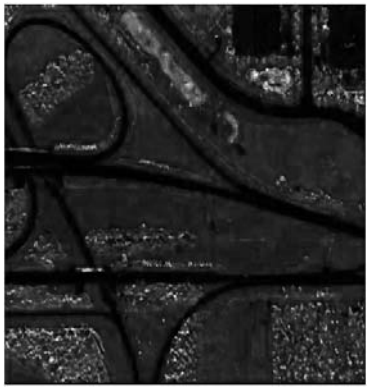
b is the spectral band, r is the reference pixel and p is the current pixel of a particular spectral band. Figure 2(b) shows the spectral angle image of an image from the database.

The two important advantages of using spectral angle for conversion are: (i) the algorithm depends only on the spectral angle and not on the number of spectral bands present in the image, thus this method can be applied to multispectral images with any number of spectral bands (ii) based on the reference pixel selected, any type of roads can be extracted. The roads to be extracted can be either tarred or dirt tracks. The output after calculating the spectral angle contains all roads in darker color.

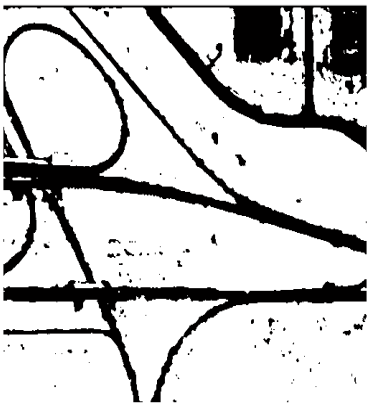
On the spectral angle image median filtering is done to remove the noise that affects the satellite image. When considering different types of filters, median filter is the most apt one to reduce noise in satellite image. This is clearly explained in [7]. Figure 2(c) shows the image after median filtering.

(a)

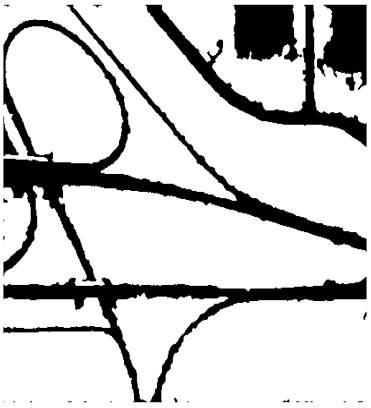
(b)



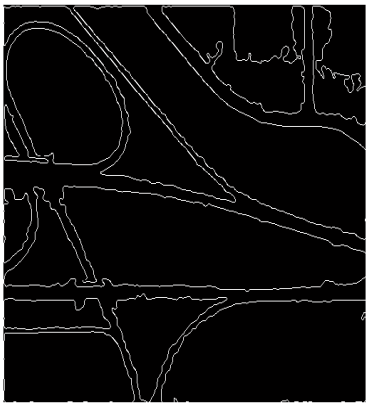
(c)



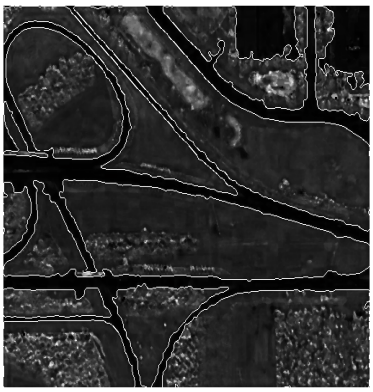
(d)



(e)



(f)



(g)

Figure 2. (a) Original image (b) Spectral angle image (c) Median filtered image (d) Binary image (e) Morphological image (f) Edge image (g) Final image

The filtered image is then converted into a binary image for easy and fast processing. The threshold for binary conversion is 0.07. The Figure 2(d) shows the image after converting it into a binary image.

The binary image still contains many unwanted pixels. One of easiest way to eliminate unwanted objects from an image is by applying morphological operations. Morphological operations are those operations used to remove undesired pixels based on the foreground and the background of an image. The importance of morphological operations can be more clearly understood by referring to [8]. Since the operations are done on the binary image, the MATLAB function used is 'bwmorph'. The image obtained after applying morphological operations is given in Figure 2(e).

After applying the morphological operations we get the clean roads but it is very important to obtain the edges of these roads for clear identification of the roads. Gradient filter is used for the edge detection and the type of operator used for the detection is 'sobel'. Sobel operator is used because the edges are extracted with greater accuracy. The edges of the roads is shown in Figure 2(f).

The final step is to overlay the extracted road onto the scalar image of the original image. Overlaying of the result helps to illustrate the accuracy of the road extraction. In the final image, the thin lines indicate the paths of roads in the image. The final image is given in Figure 2(g).

III. Experiment and Result

The database for road extraction can be created based on the color of the roads. The images can purchased from companies selling satellite images or the apt free images from internet can be downloaded. MATLAB 7.10 software platform is used to perform the road extraction. The size images used is 512* 512. From the Figure 2(g) it is clear that some of the objects other than roads are also detected. This is because those objects are also having the color within the particular range as that of roads. These objects could be small parts of barren land and parking lots. The outputs of various steps are given in Figure 2.

IV.CONCLUSION

The roads play a vital role in urban planning. The algorithm introduced is automatic one. It requires only very little interaction from the users. The algorithm was implemented to detect roadways from satellite images with resolution greater than 0.5m. The important and key parameter of this algorithm is the color of the roads in the database. Different types of roads can be extracted based on this algorithm. Since extraction is solely based on color, some of the barren lands and small areas of parking lots are also being extracted. This is because the locations also have the same pixel intensity values as that of roads. Different other techniques such as usage of Digital Elevation Models (DEM), active contours and artificial intelligence methods could be included to remove the unwanted objects that are being extracted. The algorithm implemented is fast, robust and easy to understand and implement.

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