Road Extraction from Satellite Images

An Efficacious and Sturdy Technique

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***Abstract*— With the increasing population in the world, we need proper road map to reduce the efforts required in planning. Urban planning is an important part and its need is very high. Extracting road information is therefore is of great significance and thus can be very useful for urban planning. In this paper, an unmanned approach for road extraction is proposed which focuses on extracting roads and its component using a database from satellite images. Extracting roads can be very useful as the extracted roads can be used in various applications such as for delivery of goods using robots, urban planning, navigation systems, enhanced efficiency of map generation, etc. Also, the Geographical information system (GIS) database can be updated in which road information is an important part. In this method, the image is first pre-processed and then converted to scalar image for ease of implementation and the signal-to-noise ratio (SNR) is computed as one of the performance metric. The performance of algorithm is evaluated for satellite images. The experiment results proved that this method effectively reduces the noise from images and achieves accurate road extraction from the general images.**

Keywords—Median Filter; Average Filter; Morphological operations

I. INTRODUCTION

Roads are used mostly for transportation purposes and contribute a lot in the development of a country. The extracted roads can be used at various places such as for delivery of goods using robots, city planning, updating the Geographical Information System (GIS) database, etc. Therefore road infrastructure and design is the most needed requirement, however in order to successfully make use of roads, we need to update these road maps or designs regularly. Precise updation of the road networks is therefore achieved by using various road extraction techniques. Extracting the roads is done automatically and therefore satellite images with high resolution are used and processing techniques are implemented on them in order to easily extract the roads. Some of the methods are given in [1-4]. The satellites take images using sensors that pick up photons as they fly by. They take regular digital photos like a digital camera but it depends on which type of image is to be captured and the satellites capture images accordingly by detecting required wavelength and energy levels. The extraction of roads are thus of great importance and can be taken into account for many applications. The extracted roads are filtered out to remove any noise from the image and for a contrast enhancement a filter is applied on the filtered image.

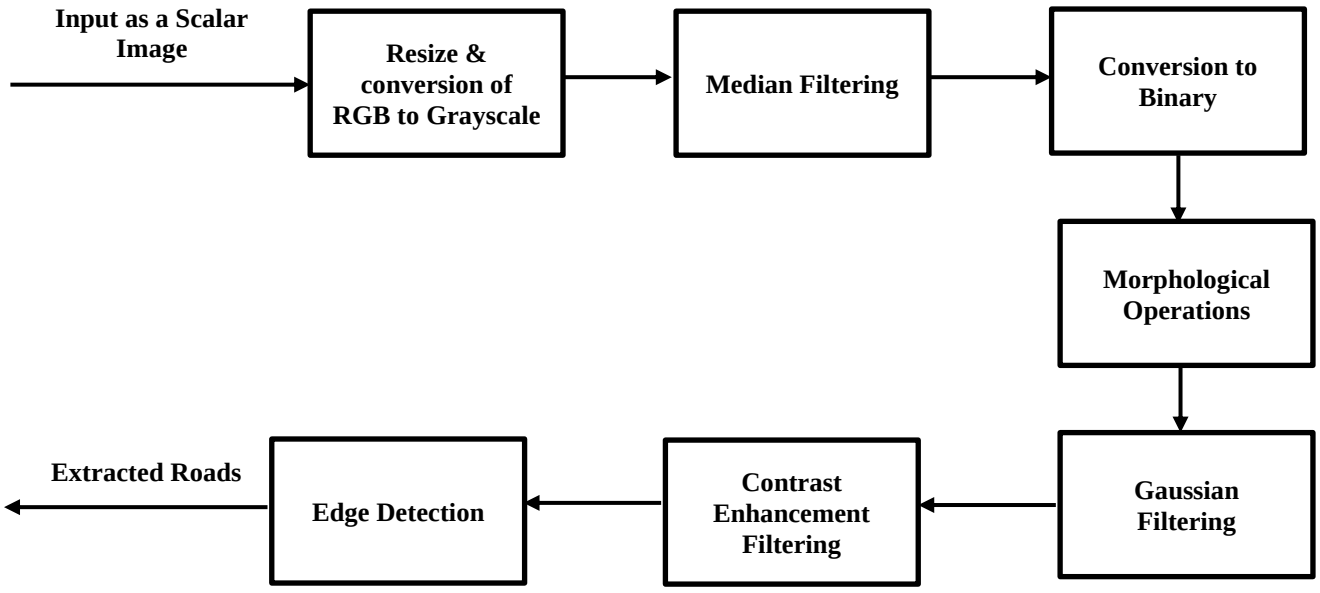

Figure 1. Block diagram for proposed algorithm

The SNR of the filtered and enhanced image is calculated and compared to check the efficacy of method. It is observed that the roads are exactly extracted and these extracted roads can be used according to their applications in various fields. This method is found to be very helpful in determining roads from satellite images which are of great importance and add credibility to the work in many fields.

II. ADDUCED ALGORITHM

A. Steps involved in Adduced Algorithm-

The assorted steps in the proposed extraction algorithm are explained below:

The database contains high resolution multispectral road images whose intensity is within a particular range. All the satellite images in the database are vector and are converted to scalar. The Block Diagram for different steps followed is shown in figure 1. : First the conversion of a vector image to a scalar image and then resizing it. Converting vector image to a scalar image is necessary to carry out further road extraction methods. After that image is converted from RGB to Gray scale and a median filter is used to remove any noise which is in the satellite image as shown in figure 2(c).

Median filter runs through the signal, and replaces each entry with median of neighboring entries. Also, the median filtering is the best type of filtering technique when it comes to removing noise from image. It can be clearly seen from [5]. The resulting median filtered image is converted to a binary image which can be easily processed and is shown in figure 2(d). The binary image still contains some unwanted objects in the foreground and background of image and morphological operations are applied on that binary image to remove the pixels which are not required in the extraction of roads. These operations include a function bwmorph, which is suitable for a binary image. It is followed by a function imerode which includes a structure element that is applied onto the binary image which results in output image of same size.

These operations remove some layer of pixels from outskirt of the roads and the pixels removed lie in the foreground and background of the image. The resulting image is shown in figure 2(e). Morphological operations are necessary and explained in [6-7]. Any noise still present can thus be removed by using a Gaussian filter as it is a low pass filter so it reduces the effect of other high frequency components present in the image and is shown in figure 2(f), followed by a contrast enhancement filter as shown in figure 2(g). Finally, to extract roads we need to detect the edges of the roads and can be seen in [8]. Edges are detected by using a filter in MATLAB which uses an operator 'sobel' and resulting image is shown in figure 2(h).

This operator efficiently extracts road as compared to other operators and it is followed by overlaying the extracted roads onto the input scalar image as shown in figure 2(i).

The performance metric SNR is a measure of the type of noise that is present in the image to be analyzed. It is useful in random and uniformly distributed noise (like Gaussian).

$$SNR = \frac{\sum_{a=0}^{M-1}\sum_{b=0}^{N-1}\hat{f}n(a,b)^2}{\sum_{a=0}^{M-1}\sum_{b=0}^{N-1}\left[fn(a,b)-\hat{f}n(a,b)\right]^2} \qquad (1)$$

Equation (1) represents the SNR. In (1), $\hat{f}n$ is the noisy image and fn is the original image.

III. RESULTS AND DISCUSSION

The final results are better, the SNR (Signal-to-Noise Ratio) is improved and it's calculation can be seen in [9]. All the results are completely shown in figure 2. The figure 2(a) is the original image, figure 2(b) is the converted gray-scale image followed by figure 2(c) which is the median filtered image and the figure 2(d) still contains some objects detected along with the roads because of the same intensity value as that of the roads. To remove the unwanted pixels in the image still left in the image, morphological operations are used. The objects other than roads can be any unused land, plot, parking space, etc.

The images can easily be taken from the internet for use and can be processed in order to obtain extracted roads to evaluate the algorithm. Figure 2(e) is the image which shows the results after removing the components which are not required in the final resulting image. All the images are processed in MATLAB and output after every step is clearly shown in figure (2).

IV. CONCLUSION

As the method used is a sturdy one, therefore the roads can be extracted efficiently and with less noise in the image. The method used is sturdy and gives results which are better and can be used easily to extract roads from satellite Images. All the images shown are obtained using the method proposed and depict the better result. The algorithm used is efficient, sturdy and gives results with less noise in the extracted roads image. Thus, the extracted roads obtained in the final resulting image can be used for applications which use roads such as maps and navigation systems. The final result is better noise immune and thus the roads are efficiently extracted.

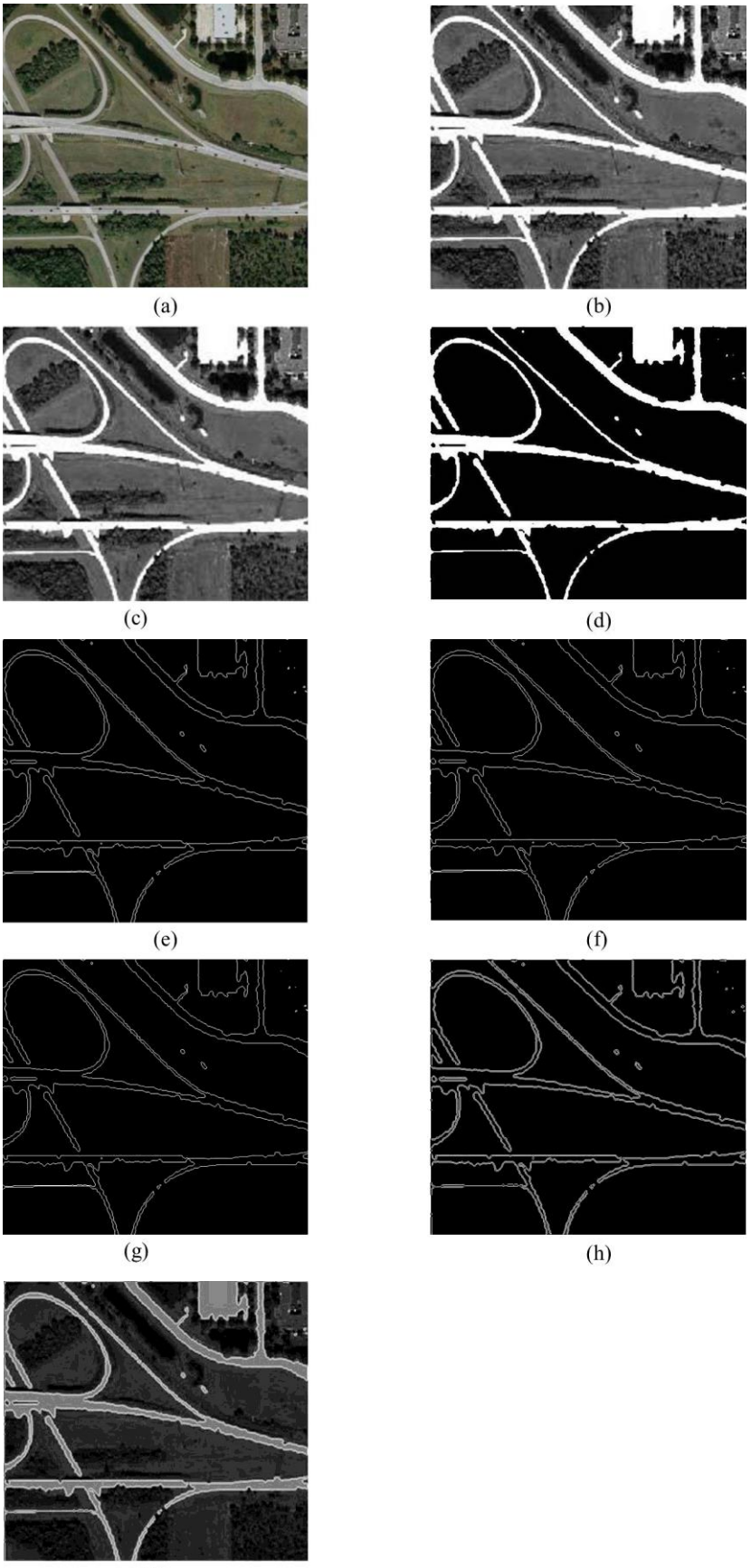

Figure 2. (a) Original Image (b) Gray-scale Image (c) Median Filtered Image (d) Binary Image (e) Morphological Image (f) Gaussian Filtered Image (g) Contrast Enhanced Image (h) Edge detected Image (i) Final Image

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