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Road Network Extraction Using Support Vector Machines

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Abstract— In this paper, a unique approach for road extraction using support vector machines (SVMs) is explained. Roads are probably the most important topographic object and it is necessary to have very short updating cycles for road networks. Hence for road network extraction satellite images are taken and from that images road network is extracted with the help of SVMs. Different types of satellite imagery like ALOS, IKONOS, QUICKBIRD, WORIDVIEW-1, SPOT-5 etc. can be used to extract particular road network. Here K means algorithm is used. Different types of ANNs and SVMs can be used for feature extraction. Here focus is on road network extraction using support vector machines.

Index Terms— K means, Roads, Satellite Imagery, SVMs etc.

1 Introduction

Road information plays a central role in the transportation application, as well as it is an important data layer in Geographical Information Systems (GIS). Automated road extraction can save time and labor in updating a road spatial database. Various approaches for road network extraction have been developed.

Road detection is an important requirement for the development and employment of intelligent vehicles. In the past decades, the research on vision-based road detection has been an important topic and various methods have been proposed to solve this problem [8, 13, 16, 18, 21]. In principle, vision-based road detection algorithms can be divided into three main classes: feature-based technique [13][18], model-based technique [21] and region-based technique [8, 16, 20].

Feature based technique is more accurate than any other technique. But it requires that the detected road having well-painted markings. Otherwise it can be easily interrupted by noise. Model-based technique is more robust than any other technique. However, most of the model-based approaches have some difficult and strict geometrical assumptions. Most effective approaches on region-based technique can be seen as a machine learning problem. The approaches which allow computer to change behaviour based on training set can become robust to noise.

It is very challenging task to analyse remotely sensed satellite imag considering the volume of data and combination of channels in which the image is acquired. The old classification techniques for analysing images on a pixel by pixel basis suffer from radiometric differences between adjacent pixels, and noise due to short observation times and large radiometric resolution when applied to high resolution images [12].

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J. Wang [8] trained the SVM classifier in initialization and a voting method is used by him to determine class of the block. But it required human supervised learning in each frame. Foedisch [7] selected the training data in each frame by dynamic windows but that method also showed some classification errors.

Here SVM is used to extract particular road network by extracting color features and texture features from satellite image. Color feature extraction is done by using statistical method and texture feature extraction is done by using Gabor filter method. Color features and texture features helps to analyse satellite image and to extract the road network with great accuracy as SVM is used.

2 Algorithm Outline

Here the whole algorithm is divided in to three parts 1) Selection of raw data 2) Feature extraction in which two types of features are extracted as a) Colour feature extraction b) Texture feature extraction 3) In third part of algorithm contains K means output , SVMs output and Final output. The algorithm outline is given in flow chart as shown in figure 1.

3 Basic Parts of Road Network Extraction Algorithm

3.1 Raw Data Selection

With the help of proposed algorithm raw data means original satellite image is selected on which SVMs can be applied to extract the road network. One of the original satellite images is as given below figure 2.

3.2 Feature Extraction

Feature Extraction is a form of dimension reduction method.
When the input data to an algorithm is too large to be processed and it is suspected to be redundant or reduced (much data, but not much information) then the input data will be transformed into a reduced form. Set of features is also called

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features vector. Transforming the input data into the set of features is called feature extraction [4]. Feature extraction is divided in to two parts a) Color feature extraction and b) Texture feature extraction.

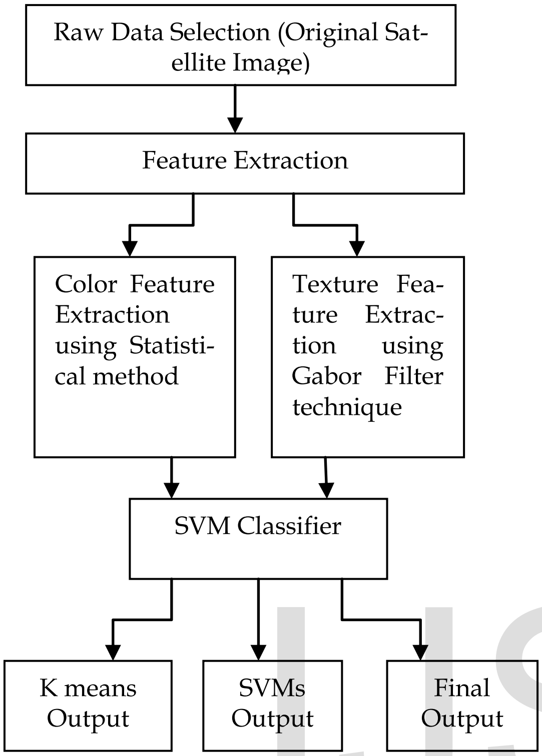

Fig1. Flowchart of Algorithm

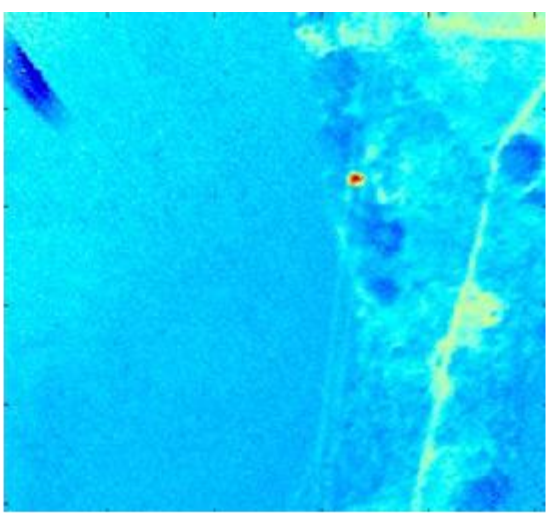

Fig2. Original Satellite Image [22]

a) Color Feature Extraction

It is possible to recognise an image by human's eye only because of Color feature. Color is used to tell the difference between objects, places, and the time of the day.Color features are extracted with the help of statistical method. Usually colors are described in three dimensional color spaces; these are either be RGB (Red, Green, and Blue), HSV (Hue, Saturation, and Value) or HSB (Hue, Saturation, and Brightness). For extracting the color features the most common technique is based on color histograms of images [20]. Color feature extraction technique shows following figures. It contains original RGB image, hue Image, saturation image, value image and histogram which is shown in figure 3, 4, 5, 6, 7 sequentially.

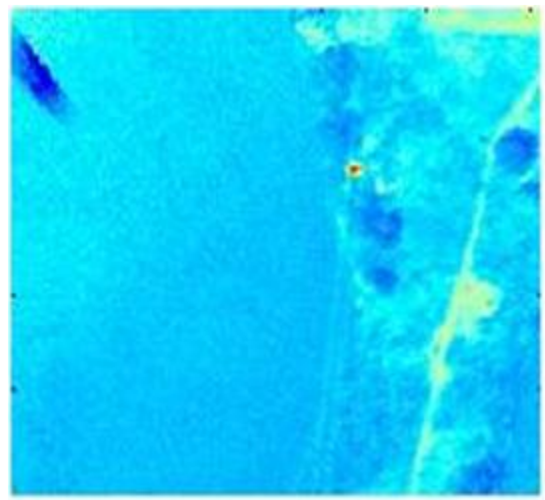

Fig3. RGB Image of Satellite

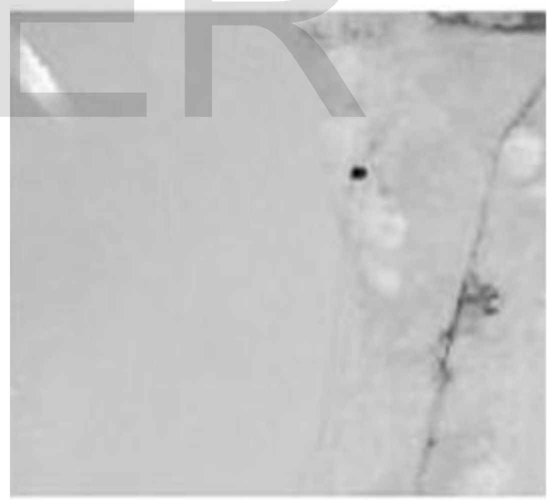

Fig4. Hue Image of Satellite Image

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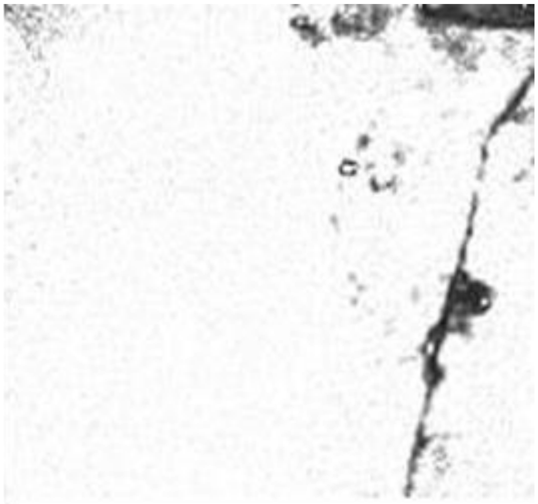

Fig5. Saturation Image of Satellite Image

Fig6. Value Image of Satellite Image

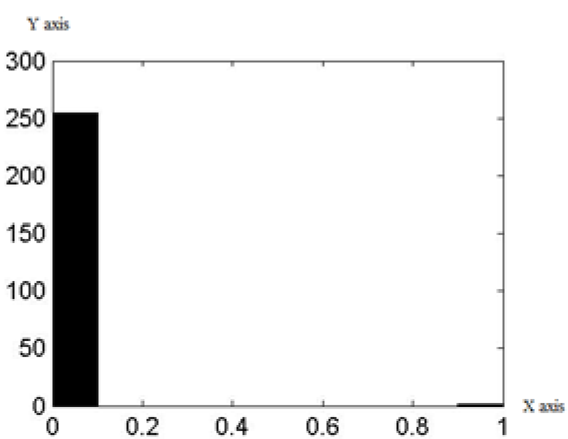

Fig7. Histogram

There is RGB to HSV conversion. HSV image is as shown in Figure 8.

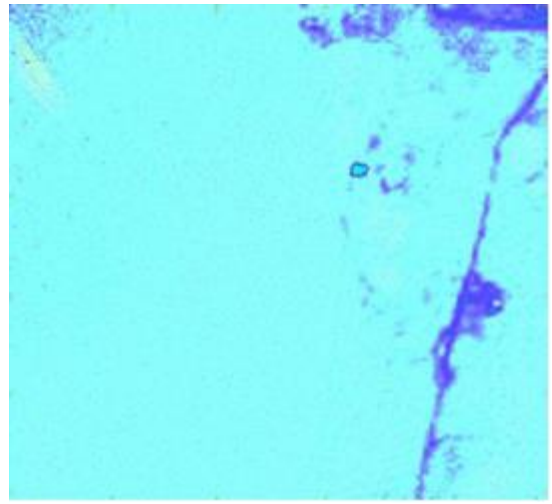

Fig8. HSV Image of Satellite Image

Variance of image is as shown below figure 9.

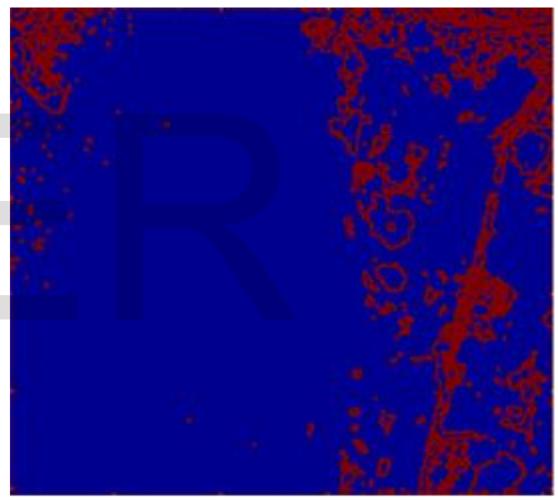

Fig9. Variance of Image of Satellite Image

b) Texture Feature Extraction

Texture feature extraction deals with the process of computing characteristic of an image which numerically describes texture properties of an image [1] as well as some other measurements that can be used to classify the image texture. Texture feature extraction is done by using Gabor filter method.

Several studies on Gabor filter found this method provides means for good spatial localization [1] and highly non-orthogonal. The results are significant in correlation between texture features. This method is linearly independent [6] [10]. Gabor filters have been successfully used not only in segmentation but also in classification of textured images [14]. The advantages of Gabor filter are it is not only able to capture the texture features at different orientations and frequencies but also it can achieve the optimal localization in spatial and frequency domain. Besides, Gabor filter can significantly extracts

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texture features and has been shown to perform better than other methods [6]. It is very efficient as compared to others [5]. The texture feature extraction using Gabor Filter method is as shown in figure 10.

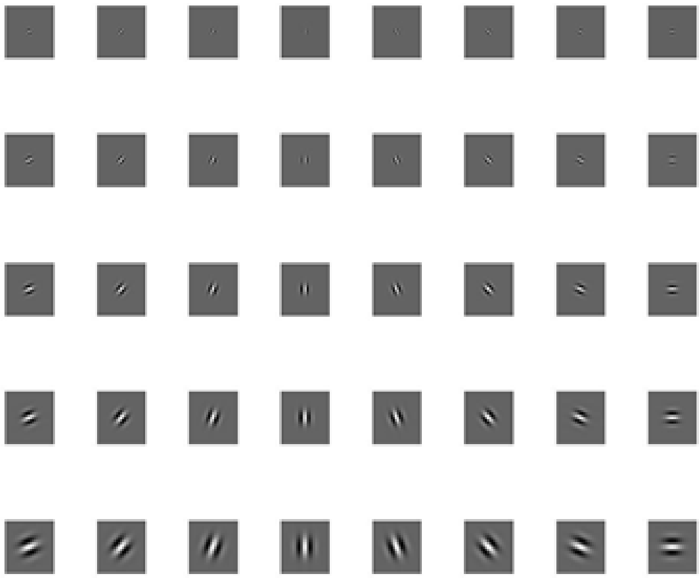

Fig10. Texture Feature Extraction using Gabor Filter method

Gabor filter is one of the most established textures expresser introduced by Gabor in 1946 [3]. Texture features extraction is done by using Gabor filter method by doing analysis of an image in terms of frequency domain [9]. Gabor filter is basically a Gaussian function which is modulated by complex sinusoidal of frequency and orientation. It can perform in both spatial and frequency domain [11] and also can perform in any number of dimensions. These filters are more desirable as they provide the finer distinctions of the different textures [11]. The Gabor filter is analysed by taking the Fourier transform of an image and multiplying it with the Gaussian function which is centred at various frequencies and it takes the IFFT of the results. It is important to ensure all the frequencies of an image are covered by the choice of central frequency [11]. This research applied the 2-D Gabor filter as the data set collected is two-dimensional images. The Gabor filter is utilized to extract the texture features by doing analysis of frequency domain of an image using different and orientations and frequencies. Final texture feature extraction is as shown in figure 11.

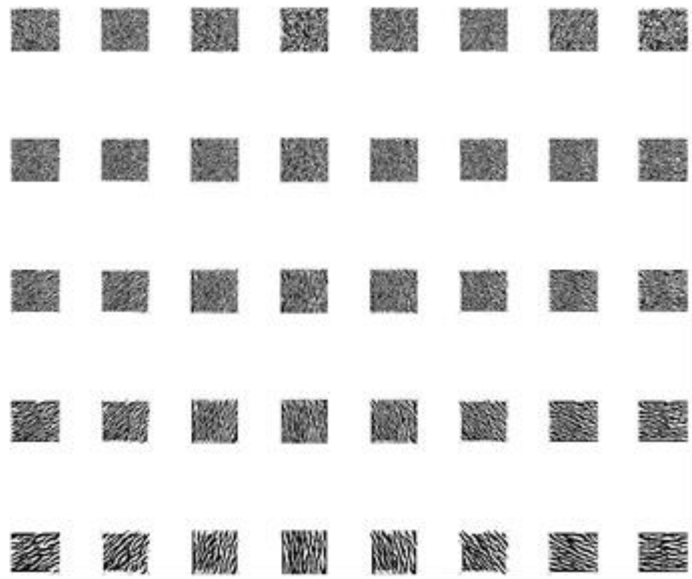

Fig11.Final Texture Feature Extraction Image

3.3 SVMs Classifier

The feature vector on each pixel of the input image is extracted by using SVMs classifier. Then, each vector is classified by the trained classifier. SVM classifier component is in charge of training and classification. To train the SVM classifier the training data and classifier parameters are taken and the trained SVM classifier is used to classify image into road/non-road classes. Road detection classifier classification Outline is shown in below figure 12.

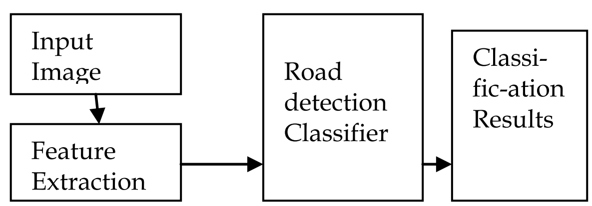

Fig12. Road detection classifier classification Outline

3.4 Final Output

a) K means Output

To extract the road network from satellite images K means algorithm is used. K Means algorithm is a clustering algorithm that classifies the input data set into number of clusters based on their distance from each other [17]. Clustering is method to group similar kind of objects into one cluster. K-means clustering [2] finds clusters such that objects within every cluster are as close as possible, and as far from objects in other clusters as possible. K-means clustering requires to mention the number of clusters to be partitioned and a distance metric to specify

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how close two objects are to each other. K means clustering shows output as shown in figure 13.

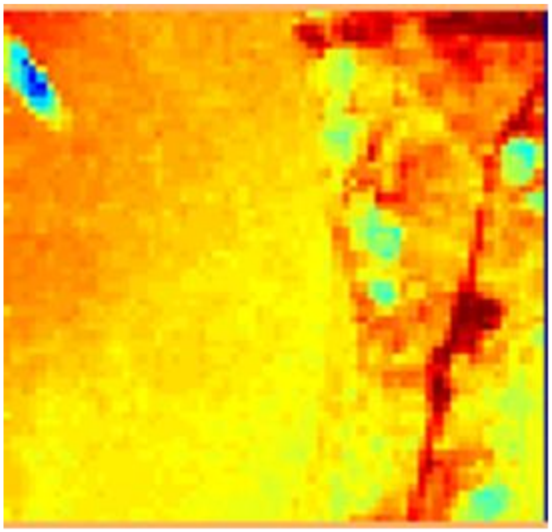

Fig13. K means Output

b) SVM Output

SVM uses hyperplane surface to separate the classes so as to increase the margin among them is the main idea of SVM. SVM is used to implement to minimize Structural Risk that reduces the generalization error of a decision function [19]. SVM shows output as shown in below figure 14.

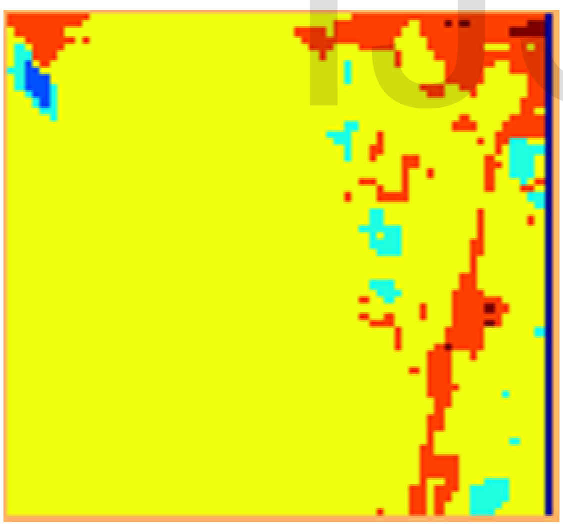

Fig14. SVM Output

Finally road network extraction using SVMs gives output as shown in figure 15. Here road is shown with red color.

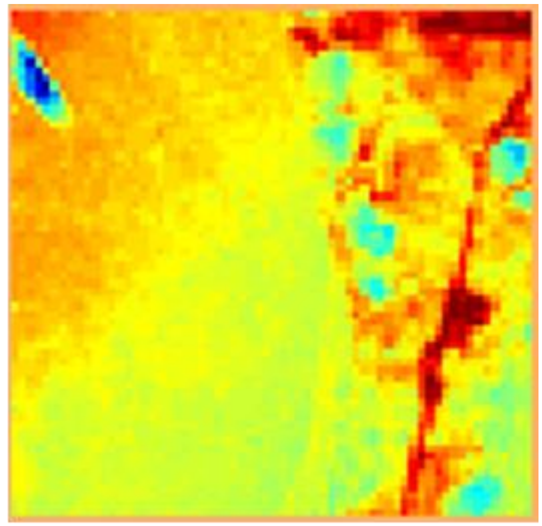

Fig15. Final Output

There is comparison of SVMs accuracies and Kappa coefficients as shown in table 1.

Table1.Comparisons of SVMs Accuracies and Kappa Coefficients

	Krishna Mohan Buddhiraju and Imdad Ali Rizvi [12]	Authors Results
Accuracy (%)	89.62	**99.0044**
Kappa Coefficient (%)	87.35	**99.3357**

4 Conclusion

In this paper introduced algorithm used for road network extraction using SVMs is showing up to 99% accuracy, which is better than neural networks. This research can help to find out road network of different areas from different types of satellite images.

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