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A Support Vector Machine Approach on Object Based Image Analysis for Feature Extraction from High Resolution Images

Minakshi Kumar , S.K.Srivastav and P.K.Garg
Indian Institute of Remote Sensing , Uttarakhand Technical University
minakshi@iirs.gov.in , sksrivastav@iirs.gov.in, pkgiitr@gmail.com

ABSTRACT

Key words: Support Vector Machine (SVM), Object Based Image Analysis (OBIA), Grey-Level Co-occurrence textures, Feature Extraction

Satellite images are the most important available data sources for generation and updating of available maps. They have highly improved in terms of spatial, spectral and temporal resolutions and by the sheer volume of collected images, the necessity of simplification of automation in feature extraction. Road data play a key role in urban planning, traffic management, military applications, and vehicle navigation as well as for decision making in numerous applications. The faster updation of road infrastructure is a need because the technology has brought map in the hands of people in the form of mobile phones and tablets. Road detection is one of the major issues of the road infrastructure extraction. Its accuracy depends on the type of methodology used. An attempt is made here to analyse the first order, the co-occurrence texture features and image transforms useful for discriminating roads from other features specially the buildings. The identified dataset forms high dimension feature space and the Support Vector Machine is a theoretically superior machine learning methodology with great results in classification of high dimensional datasets. In the past, SVMs have been tested and evaluated only as pixel-based image classifiers. Moving from pixel-based techniques towards object-based representation, the dimensions of remote sensing imagery feature space increases significantly. An SVM approach for classification was followed, based on primitive image objects produces by a multi-resolution segmentation algorithm. The SVM procedure produced the final object classification results which were compared to the Nearest Neighbor classifier results and were found to give better results in OBIA domain.

INTRODUCTION

With the recent developments of very high resolution (better than 1 meter in spatial resolution) space borne, airborne sensors and drones, the quality and details of the inherent information in the imagery has increased immensely. This poses challenges for our data processing capabilities and exposes inherent underlying limitations. Roads are one of the important man-made objects with great concern to be extracted semi-automatically. Object-oriented approach takes the form, texture and spectral information into account. Its classification phase starts with the crucial initial step of grouping neighboring pixels into meaningful areas, which can be handled in the later step of classification. Such segmentation and topology generation must be set according to the resolution and the scale of the expected objects. By this method, single pixels are not classified but homogenous image objects are extracted.

Many researches have tested the idea of using contextual information for improving segmentation process of road regions. Mena and Malpica (2005) have incorporated texture information in road extraction using the existing vector information and the high-resolution satellite or aerial images. Wang et al. (2008) performed sequential classification and subsequent reclassification using directional texture information. Jin and Davis (2005) used information fusion for updating road networks and for automatic road extraction. Mohammadzadeh et al. (2008) proposed a new fuzzy segmentation method for road detection in high resolution satellite images with only a few numbers of road samples. Then by using an advanced mathematical morphological operator, road centreline’s were extracted. A road detection strategy based on the neural network classifiers was introduced by Mokhtarzade and Valadan (2007) where a variety of input spectral parameters were tested on the functionality of the neural network for both road and background detection. The use of transforms, textures and segmentation have not been fully exploited for feature extraction. An attempt is made here to analyse the first order, the co-occurrence texture features and image transforms for man-made feature extraction. The aim is to aid in discriminating roads from other features specially the buildings.

STUDY AREA AND DATA USED

The area under study is taken is Dehradun city, capital of Uttarakhand. Two intermittent streams namely Rispana River and Bindal River, on the east and west respectively mark the physical limit of Dehradun municipality. The district is situated in the Northwest corner of the state. Dehradun, besides being seat for prestigious educational institutions and other technical institutions, is also famous for national level institutes such as Forest Research Institute, Wadia Institute of Himalayan Geology, Oil and Natural Gas corporation, Wild Life Institute, Indian Institute of Remote Sensing and many others.Dehradun is endowed with immense potentialities to be a place of tourist attraction besides being gateway to Mussoorie. The study was tested on Road network near Inter State Bus terminus, Dehradun. The major road network in the area are Saharanpur Road, Haridwar Bye Pass Road, GMS Road and Shimla Bye Road.

WorldView-2 is Digital Globe's 8-Band Multispectral Satellite was launched on 8 October 2009. It is a satellite with high spatial and high spectral resolution. It captures 46 cm (resampled to 50 cm) panchromatic imagery, and 1.84 m resolution (resampled to 2.0 m), 8-band multispectral imagery. The high spatial resolution enables the discrimination of fine details, like vehicles, shallow reefs and even individual trees in an orchard, and the high spectral resolution provides detailed information on such diverse areas as the quality of the road surfaces. (www.digitalglobe.com). An ortho rectified image of Dehradun, Uttarakhand, India acquired by World View −2 on 26th April 2010 was used to explore the potential for road network and types from high resolution imagery. The location map and False colour composite (FCC) of study area is presented in Figure 1.

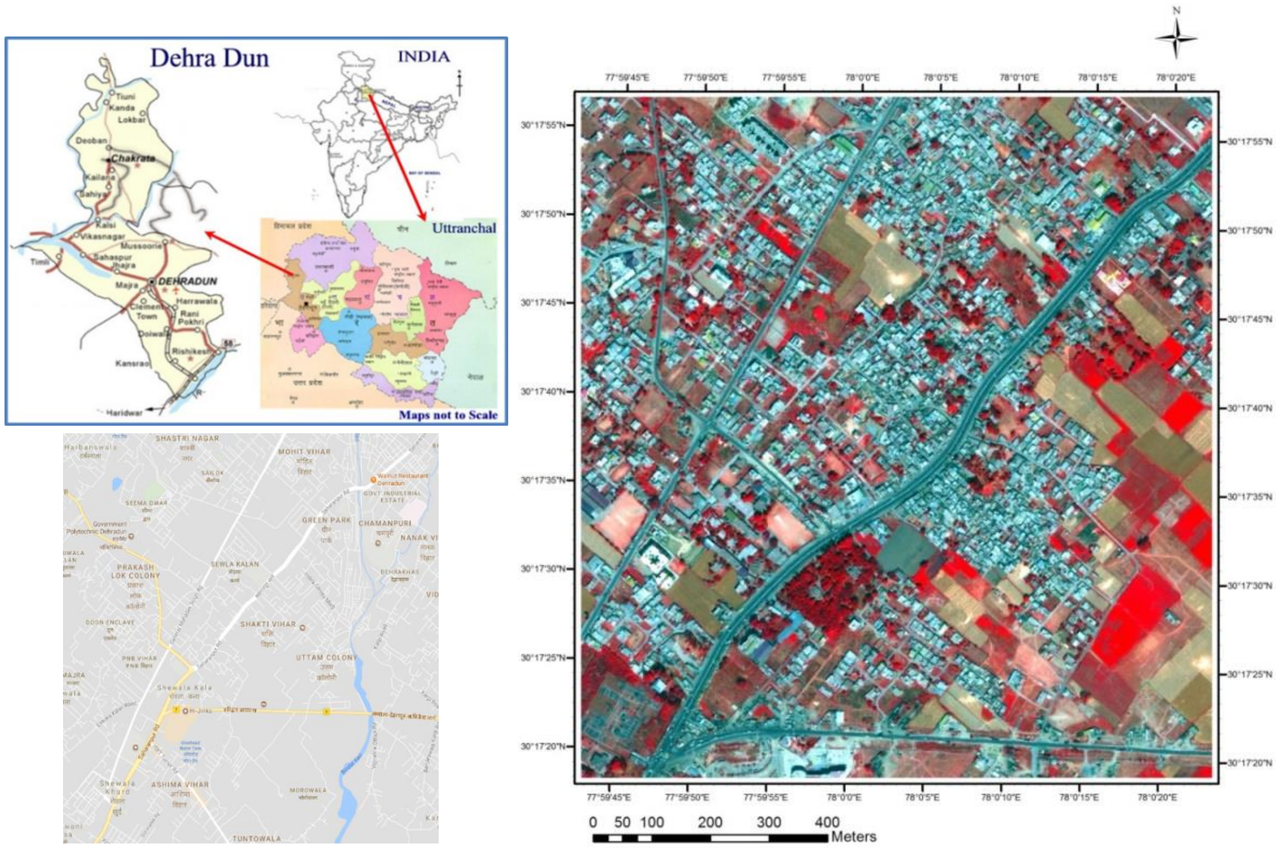


Figure 1: Location Map and False colour composite of the study Area

METHODOLOGY

For analyzing data in multispectral domain, it is common practice to convert multispectral data into reflectance before performing the analysis. It is important when the goal is to produce accurate spectral signatures and deriving bio physical parameters. Therefore, the image was processed to convert the digital numbers (DN) to the top-of-atmosphere (TOA) reflectance. The shape of the top-of-atmosphere spectral radiance curves, as a function of wavelength, is dominated by the shape of the solar curve. The conversion method is adapted from Updike and Comp (2010).The multispectral TOA reflectance image (2.0 m) was fused with TOA reflectance panchromatic image (0.5 m) using Gram Schmidt (GS) orthogonalization technique to obtain an 8 band multispectral band at 0.5 m spatial resolution. The GS technique was preferred over others owing to the property that all the 8 bands are used as compared to three bands in other cases.

The fused image is processed for second order texture images, which are the average of all directional textures i.e., horizontal, vertical and two diagonal directions, defined by a window and at particular Greyscale quantization level. In the next step Image transforms particularly Principal component Analysis (PCA) and Independent Component Analysis (ICA) were computed on 8 band data.

The integrated data set formed was segmented using multiresolution segmentation and classified using support vector machine classifier. The extracted roads were then refined using morphological operations. The roads were then categorized based on the width. The evaluation of the extracted road was carried out by comparing automatically extracted road with manually plotted road axes used as reference data. The evaluation is processed in two steps: Matching of extracted road primitives to the reference network and calculation of quality measures. The overall methodology is illustrated in the Figure 2.

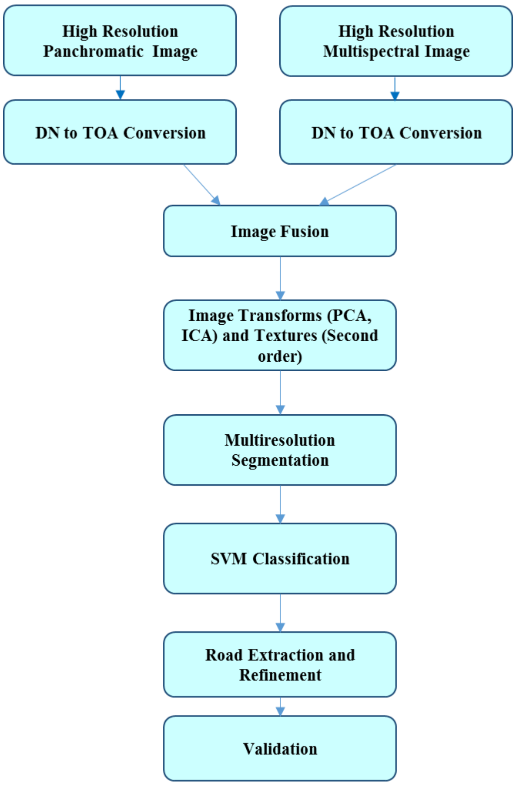


Figure 2 Methodology Flow

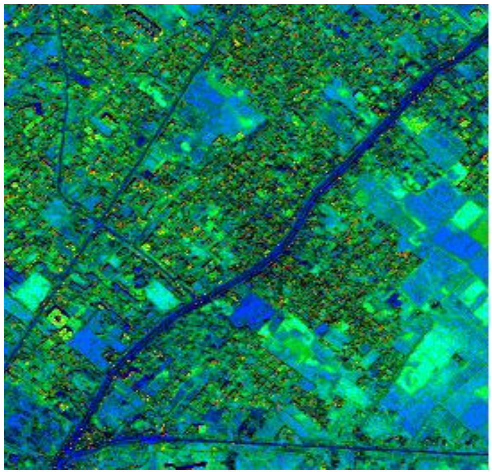
RESULTS AND DISCUSSION

Texture is one of the most important features when identifying objects from a raster image. There are five first order texture parameters (data range, mean, variance, entropy, and skewness) and Eight Grey Level Co-occurrence (mean, variance, homogeneity, contrast, dissimilarity, entropy, second moment, and correlation) parameters. Computing first and second order textures on 8 band dataset resulted in 104 different features. The texture images Mean, Variance, Homogeneity, Contrast, and Second Angular Momentum (Energy), were found useful for discriminating roads from other classes. The identified dataset forms high dimension feature space and the Support Vector Machine is a theoretically superior machine learning methodology with great results in classification of high dimensional datasets. Both PCA and ICA were found useful as both uses higher order statistics. Both remove correlations, ICA in addition removes higher order dependence and all components are equally important. The useful textures adnd transforms are presented in Figure 3. Figure 4 illustrates the classified results and extracted roads. Accuracy of the extracted road network was evaluated by using buffer method. Accuracy evaluation needs reference road data. The visually interpreted road centerline from WorldView 2 image was digitized and used as a reference. The quality measures were computed which address the problem of completeness and correctness of the extracted road network. In the present study the results attained are completeness 91.57% , correctness of 90.94% with the overall quality being 89.99%.

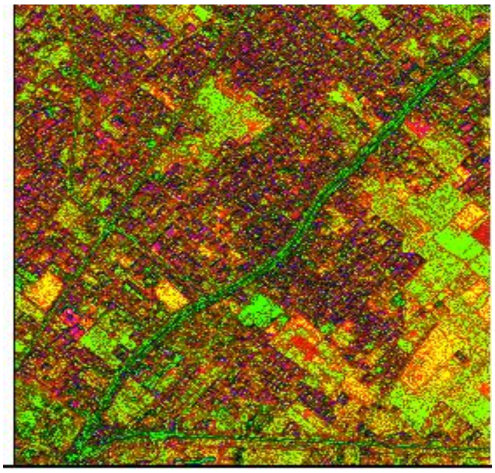
CONCLUSIONS

In this paper, an approach to detect road from high resolution image using was carried out using a high dimension dataset. The method described above worked well in those area also which contained structures like trees and vehicles. The obstacles on road which make the road boundary difficult are the tree line bounding the road segments, shadows of high buildings fall on the road and the tone of the road spectrally mixing up to with building rooftops. Another problem encountered was different structures that form main road. Some road segments are made up of a combination of metalled road and concrete road , where as some segments of main road composed of metalled and nonmetalled roads and other areas have 'tracks' along the road side. Higher dimension dataset (texture and transforms) were found useful in most of the problems encountered. The OBIA has simplified the categorization of major and minor roads. The method find high applicability n current scenario of high resolution datasets.

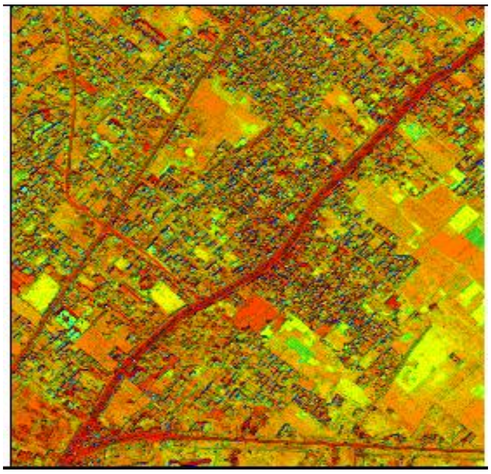
a) Texture GLCM Mean NIR 2, NIR 1 , RedEdge



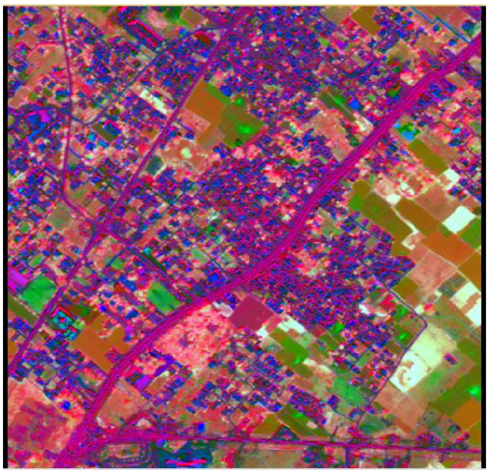
b) FCC GLCM Variance, Mean ASM, NIR 1



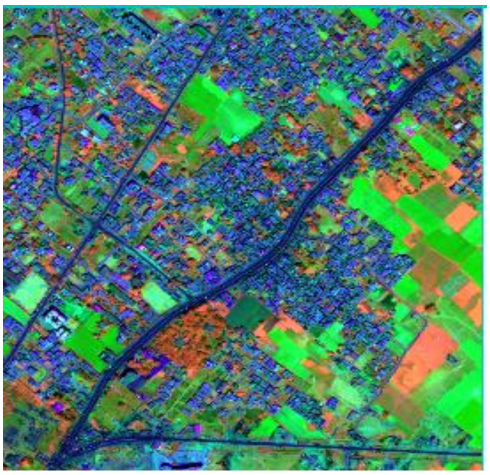
c) FCC GLCM Mean, ASM , Variance NIR 2



d)FCC GLCM Homo. Mean and Contrast NIR 2

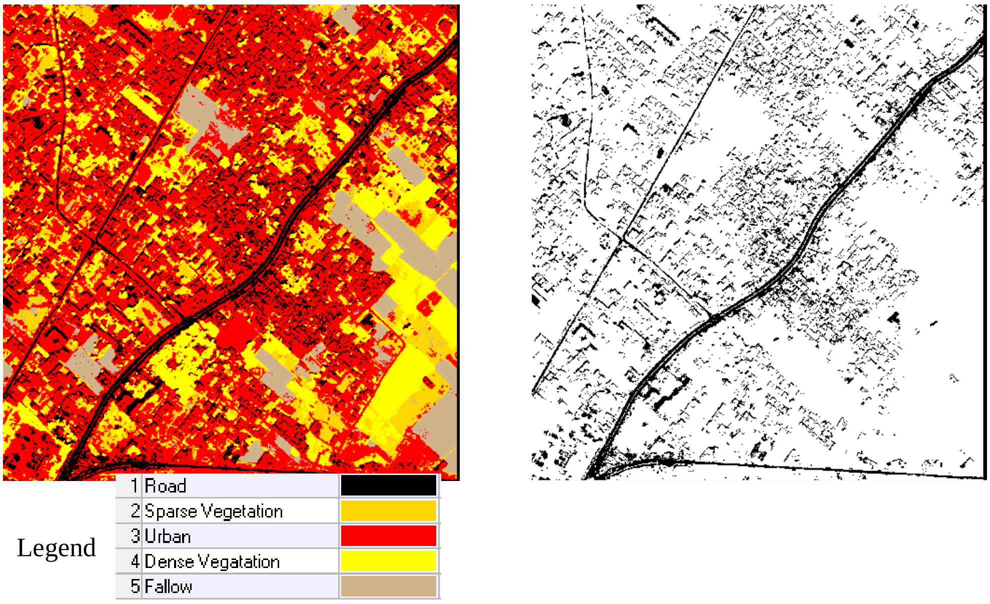


e) PCA 1,2,3

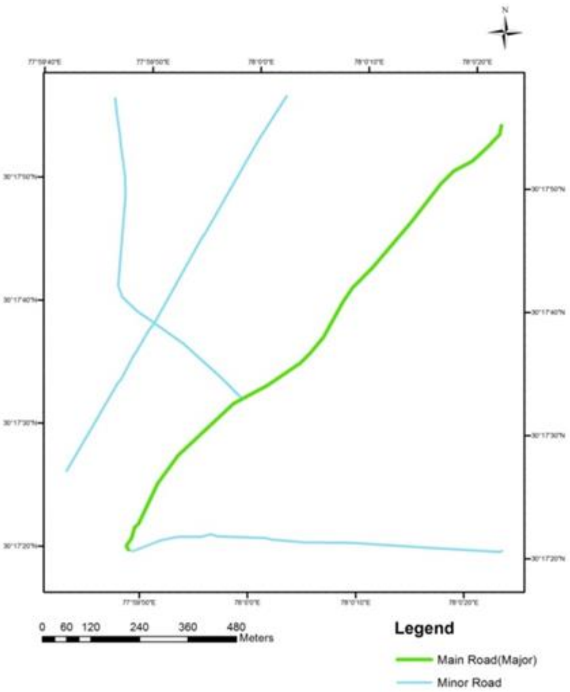


f) ICA

Figure 3 Textures and Transforms



a) Classified results b) Extracted roads



c) Roads after refinement and categorization

Figure 4: Results

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