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Research Article

A Spectral Structural Approach for Building Extraction from Satellite Imageries

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Abstract Automatic feature extraction from high resolution satellite imagery remains an open research area in the field of remote sensing, computer vision and machine learning. While many algorithms have been proposed for automatic building extraction, none of them solve the problem completely. This paper proposes a system for increasing the degree of automation in extraction of building features from high resolution multispectral satellite images. Image segmentation is a prerequisite for processing of very high spatial resolution imageries. Most image segmentation methods use spectral information of an image alone for generating image objects. A novel image segmentation method for very high spatial resolution multispectral images using combined spectral and structural information is proposed in this paper. The method involves computation of textural parameters from high resolution multispectral imagery and is combined with the spectral bands for extracting spectral-structural characteristics. Hence in addition to the spectral information, the tone, texture and shape information is evaluated for an object-oriented analysis. The support vector machines classification rules are applied on the generated object primitives. The proposed image segmentation method is well applicable to the segmentation of imagery over urban and suburban areas for large scale building extraction.
Keywords *Image segmentation; Multi-resolution segmentation; Support vector machines; Textural analysis*

1. Introduction

Image segmentation involves the partitioning of a given image into a number of homogeneous regions according to a given criterion. Image segmentation is a key and prerequisite step for processing of very high-resolution imagery. The quality of image segmentation directly affects the quality of subsequent object-based image analysis and applications. While the traditional pixel-based approach for remote sensing image classification is based on the statistical analysis of multispectral features of the pixels in an image, object-based image analysis (OBIA) allows the use of a wide range of additional information (Aguilar et al., 2012, Blaschke et al., 2014). The OBIA approach involves two steps: segmentation and classification. After segmentation, a very large number of features can be calculated for the resulting objects. The main advantages of OBIA, compared with pixel-based approaches, is the larger number of available features and the fact that the features convey more information when they are calculated on real objects than when sampled on a square grid (Baltsavias 2004; Barrile et al., 2008; Su et al., 2008) having a very large number of features poses two problems. First, the larger the number of features used in classification, the longer the computing time needed.

Second, using a very large number of explanatory features, especially when some of them are redundant, noisy or information less, might result in a less accurate classification. This is the so-called curse of dimensionality or the Hughes effect, which is an important issue in optimization and machine learning. Previous work done using the above methods mainly compared the accuracy improvement on pixel based classification by object based classification (Kumar M, 2013; Kumar M et al., 2009a). Because of the diverse composition of features in an urban environment, extracting urban features from high resolution imagery is a difficult task. In urban area, previous work focused on extracting on extracting either buildings (Kumar M, 2009 a, b; Ettarid, 2008; Xiaoying, 2005) or roads (Kumar M, 2014) where high resolution image was segmented and classified to obtain requisite buildings.

Most existing image segmentation methods use spectral information of an image alone and the exploration of new and sophisticated image segmentation methods has been a focus of image processing and analysis. A novel image segmentation method for very high spatial resolution multispectral images using combined spectral and structural information is proposed in this paper. The main objective of this study is to evaluate different object primitives which have homogeneous colour, similar texture, and constrained shape which when combine with spectral information results in accurate image segments then using spectral data alone. This paper proposes a system for increasing the degree of automation in extraction of building features from high resolution multispectral satellite images by identification of a suitable classification method for the above object primitives.

1.1. Study Area and Data Used

Chandigarh is a city and a union territory of India that serves as the capital of the Indian states of Punjab and Haryana. Chandigarh is bordered by the state of Punjab to the north, west and south, and to the state of Haryana to the east. Chandigarh was one of the early planned cities in the post-independence India and is internationally known for its architecture and urban design. The master plan of the city was prepared by Swiss-French architect Le Corbusier. It is located near the foothills of the Sivalik range of the Himalayas in northwest India. It covers an area of approximately 114 km^2. It has an average elevation of 321 metres (1053 ft).

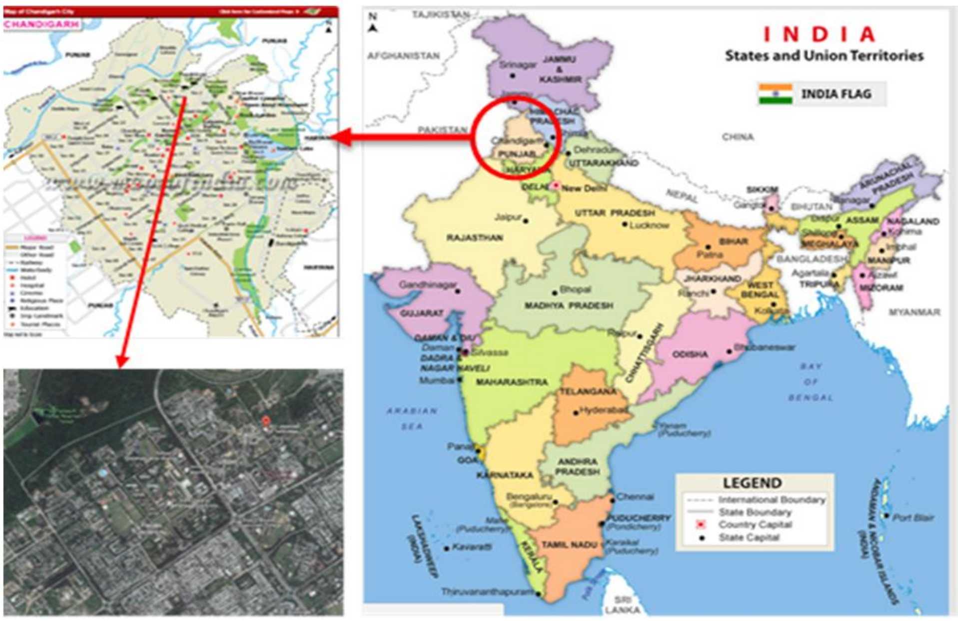

Figure 1: *Location map of study area*

Chandigarh has a humid subtropical climate characterized by a seasonal rhythm: very hot summers, mild winters, unreliable rainfall and great variation in temperature (−1 °C to 46 °C OR 30.2 °F to 114 °F). The average annual rainfall is 1110.7 mm. The city also receives occasional winter rains from the Western Disturbance originating over the Mediterranean Sea. As of 2011 India census, Chandigarh had a population of 1,055,450, [1] making for a density of about 9,252 (7,900 in 2001) persons per square kilometer. There are numerous educational institutions in Chandigarh like Panjab University, Post Graduate Institute of Medical Education and Research (PGIMER), Government Medical College & Hospital, PEC (Punjab Engineering College) University of Technology and many other private and public institutions (https://en.wikipedia.org/wiki/Chandigarh). The test area is a part of Chandigarh covering major institutions. The location map of Study area is presented in Figure 1. The satellite data used is a part of Chandigarh captured by World View 2 Satellite on May 11, 2015. The specifications of satellite data are tabulated in Table 1.

Table 1: *Satellite data specifications*

Satellite Data Used : Worldview2	
Resolution	Panchromatic: 0.46 meters GSD at nadir*, 0.5 meters GSD at 20° off-nadir
	Multispectral: 1.84 meters GSD at nadir*, 2.0 meters GSD at 20° off-nadir
Wave length Range Panchromatic Band	450 - 800 nm
	8 Bands
Multispectral Bands Wave length Range	Coastal: 400 - 450 nm
	Blue: 450 - 510 nm
	Green: 510 - 580 nm
	Yellow: 585 - 625 nm
	Red: 630 - 690 nm
	Red Edge: 705 - 745 nm
	Near-IR1: 770 - 895 nm
	Near-IR2: 860 - 1040 nm

2. Materials and Methods

The method involves computation of textural parameters from an original high resolution multispectral image and combined with the spectral bands for quantification of spectral-structural characteristics of a pixel. The multi-resolution image segmentation is then applied on this combined spectral-structural image, resulting in the formation of the different level of polygon primitives at different space scale. Hence in addition to the spectral information, the tone, texture and shape information is evaluated for an object-oriented analysis. Object primitives which have homogeneous colour, similar texture, and constrained shape are generated providing us different view of the scene at different resolution. The segmentation guided classification rules were applied on the previously generated object primitives. The methodology flow is presented in Figure 2.

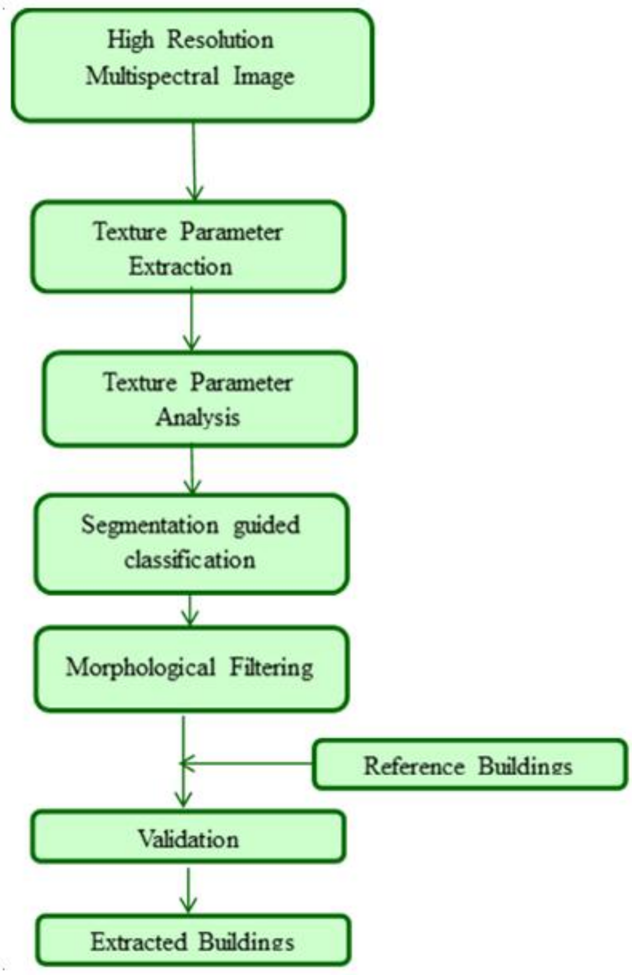

Figure 2: *Methodology flowchart*

3. Results and Discussion

The Grey level co-occurrence matrix (GLCM) was computed and second order textures parameters were computed on the eight bands of World view 2 Imagery. The GLCM based measures can be

grouped into Contrast Group which uses weights related to distance from GLCM diagonal. This group has Contrast, Dissimilarity and Homogeneity textures. The Orderliness group defines the orderliness of a window and uses weighted average of GLCM elements. This group has Angular Second Moment, Energy and Entropy parameters. The third group consists of GLCM mean, GLCM variance and GLCM Correlation is statistics which can be computed. It was observed that Contrast, Dissimilarity behaved similarly as GLCM variance and GLCM Entropy behaved similar to GLCM Entropy. GLCM mean and Correlation are more independent.

In the present case study GLCM data range, dissimilarity aided in boundary detection. GLCM Entropy was useful in discriminating Vegetation areas and the colour composite of GLCM Mean, Variance and Correlation segregated the shadows. The layers were used for segmentation using Multiresolution approach with scale parameter varying between 25- 40 for different shape and sized buildings. A higher scale parameter was used for larger buildings and a smaller one for large urban areas with small houses. The image was then classified using segmentation guided classification. Accuracy assessment was done for building classification using test samples. Accuracy achieved for buildings extracted was 87% after combination of Textural information as compared to 76% without structural information.

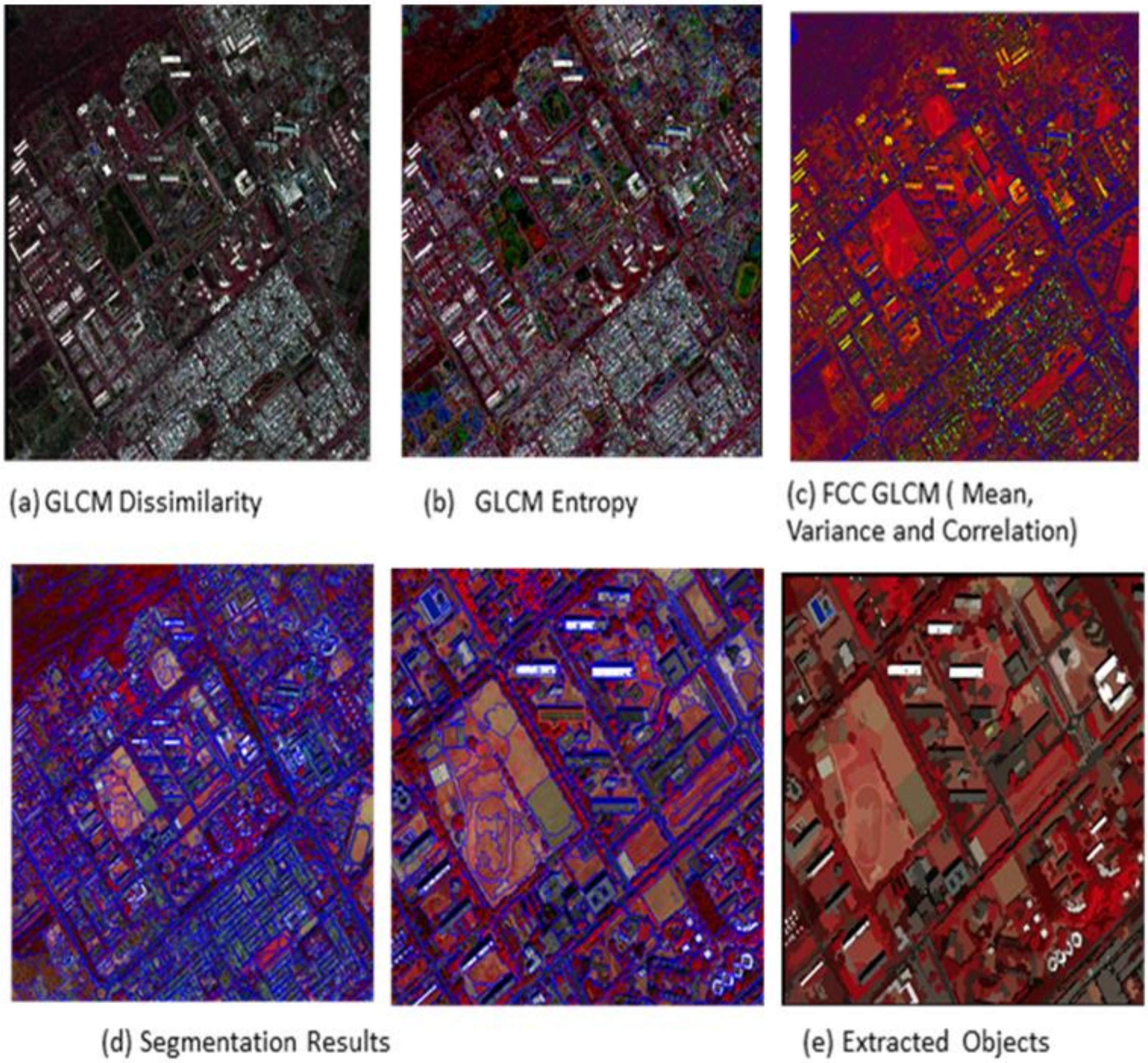

Figure 3: *Results*

4. Conclusion

The accuracy of segmentation results depend upon the use appropriate parameter values in image segmentation. Most studies have proposed trial and error methods of determining segmentation parameters yet there is no standard or widely accepted method. The determination of segmentation parameters is dependent on the analyst’s experience. Segmentation evaluation is an essential dispensable processing step. In this study visual inspection and reference based discrepancy method was employed to fully evaluate the effectiveness of the proposed method.

Visual inspection is still one of the most commonly used methods. It considers the geometrical position as well as the membership of one object class to a single region. For quantitative evaluation of segmentation, the discrepancy based method was adopted, where the segmentation result is quantitatively compared with reference data. The reference data were acquired by manually

delineating polygons from different land cover classes. Accuracy achieved for buildings extracted was 87% after combination of Textural information as compared to 76% without structural information. The development of new and sophisticated image segmentation methods is crucially important for object-based analysis. High Resolution images usually have high spatial information; the combination of spectral and spatial information in image segmentation may produce more accurate results. This study proposed a new image segmentation method using spectral and textural information. Experimental results demonstrate that the joint use of spectral and structural information outperformed the use of either information alone. The proposed image segmentation method is well applicable to the segmentation of imagery over urban and suburban areas for large scale building and road extraction.

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