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Building Extraction from very high resolution stereo satellite images using OBIA and topographic Information

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Abstract: The availability of very high resolution (VHR) satellite imagery (<1m) has opened new vistas in large scale mapping and information management in urban environments. Buildings are the most essential dynamic incremental factor in urban environment and hence their extraction is the most challenging activity. Extracting the urban features particularly buildings using traditional pixel based classification approaches as a function of spectral tonal value produces relatively less accurate results for these VHR Imageries. The present study demonstrates the building extraction using Pleiades panchromatic (PAN) and multispectral stereo satellite datasets of highly planned and dense urban areas in parts of Chandigarh, India. The stereo datasets were processed in photogrammetric environment to obtain the Digital elevation Model (DEM) and corresponding orthoimages. DEM's were generated at 0.5 m and 2.0 m from stereo PAN and multispectral datasets, respectively. The orthoimages thus generated were segmented using Object Based Image Analysis (OBIA) tools. The object primitives such as scale parameter, shape, textural parameters, and DEM derivatives were used for segmentation and subsequently to determine threshold values for building fuzzy rules for building extraction and classification. The rule based classification was carried out with defined decision rules based on object primitives and fuzzy rules. Two different methods were utilized for performance evaluation of the proposed automatic building approach. Overall accuracy, correctness and completeness were evaluated for extracted buildings. It was observed that overall accuracy was higher (> 93%) in areas having larger building and sparse built-up as compared to areas having smaller buildings and dense built-up.

Keywords: Object based Image Analysis; High Resolution Image processing; Building Extraction; Textures.

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1. Introduction

Rapid growth in the urbanization, demands monitoring features and a decision making system for planning and utility mapping. Feature extraction is an important aspect of remote sensing and is becoming more important than ever due to large number of datasets coming each day, which require extensive processing and automation. Subsequently, manual extraction and interpretation is time consuming. Automatic feature extraction has become a main objective to save time in updating data, and as a result of this, people are changing progressively to new procedures [1], specially focusing on extracting Roads [2] and Buildings [3,4]. Extraction of buildings on a common platform using high resolution (HR) satellite imagery is a complex & challenging task due to high variability in building features. A wide range of techniques and algorithms have been proposed for automatically constructing 2D or 3D building models from aerial imagery [5,6].

Quantitative information about building density can serve as a useful tool for the study of land use changes, illegal building development, urban expansion, etc., and, therefore, can contribute to the sound development of an area. Typical urban structures often have sizes smaller than the spatial resolution of the sensor when they are represented on a medium resolution image. In a high spatial resolution different texture values characterize them and can be used for identifying building and their densities. Rational polynomial coefficients (RPCs) have been a successful alternative to physical sensor model in relating the image space with the ground space [7, 8]. DEMs are an important requirement for the generation of high quality orthoimages and preparation of maps [9-12]. HR images whose spatial resolutions are about 1m were assessed for performance of the generated rational function model (RFM) generation process as well as the physical sensor model. The stereo pair's horizontal positioning accuracy of the physical and RPC models was found as 5.0 m in both cases with circular error 90 percent (CE90) [13].

Detecting building objects is a challenging topic even with high-quality remote sensing data. Rooftops have many forms and appearances regarding their color, shape, material, and optical issues such as illumination, reflection and perspective also bias the automatic identification. Although many studies have focused on feature extraction, they use spatial or structural features or both [14]. There are very few studies on incorporation of DEM in building extraction. An attempt is made here to utilize DEM, its derivatives, textures along with spectral and spatial information in an object based environment for building extraction.

2. Materials and Methods

VHR and HR satellite Pleiades-1A panchromatic (PAN) and multispectral stereo image datasets were used in this study. 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 Shivalik range of the Himalayas in northwest India. The overall methodology for photogrammetric processing and feature extraction carried out in this study is depicted in Figure 1.

The elevations played a significant role in high spatial resolution image photogrammetric processing and orthoimage generation The Pleiades stereo data, which was acquired was photogrammetrically processed for satellite triangulation using the RPCs. Thereafter, the DEM's were generated for the experimental site using PAN and multispectral stereo pairs at 0.5m and 2m posting interval respectively. The root mean square error (RMSE) achieved for Panchromatic (PAN) and Multi-spectral (MS) stereo datasets was 0.05 pixel and 0.03 pixel respectively Further the Digital elevation Model (DEM) and corresponding orthoimages were generated for both PAN and Multispectral stereo datasets.

The two orthoimages were then fused together using Principal components. An integrated dataset comprising of resulting Pan sharpened orthoimage, DEM layer, Suitable texture layers from DEM and orthoimage were then segmented using Multiresolution segmentation technique.. The object primitives such as scale parameter, shape, textural parameters, DEM derivatives and textures were used for segmentation and subsequently to determine threshold values for building fuzzy rules for building extraction and classification. The rule based classification was carried out with defined decision rules based on object primitives and fuzzy rules.

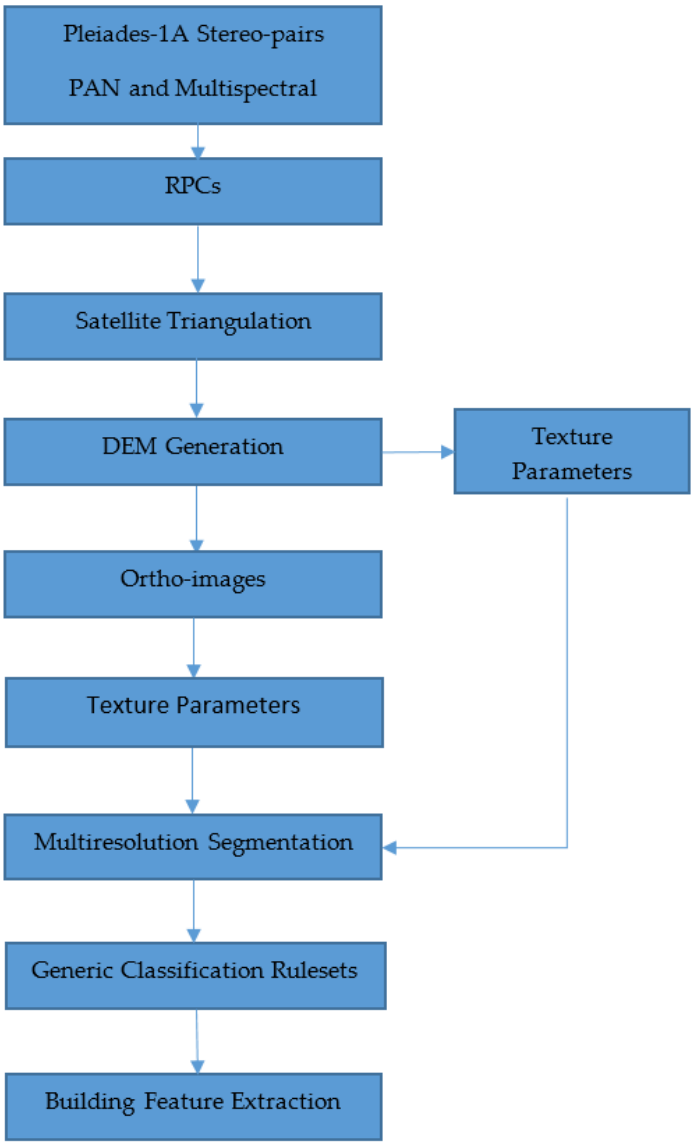
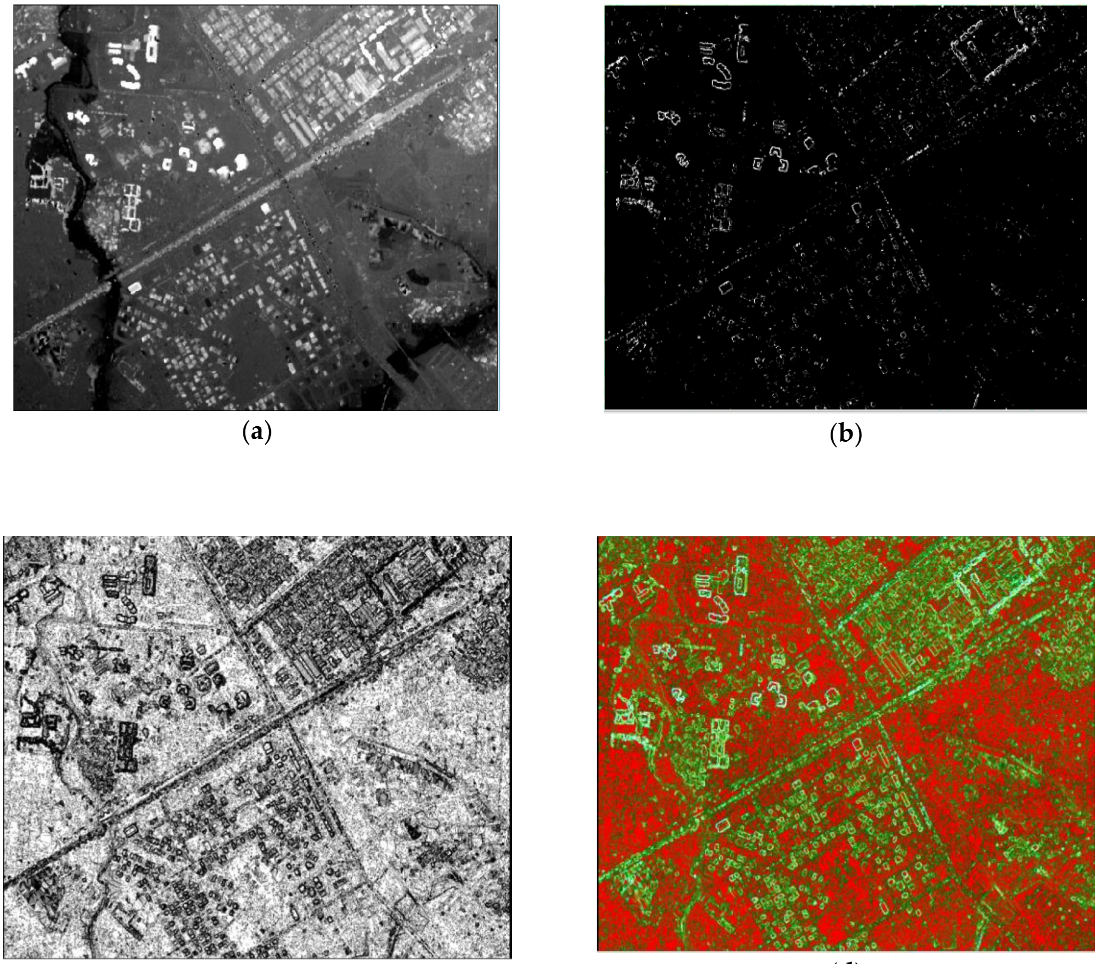


Figure 1. Methodology for photogrammetric processing and feature extraction

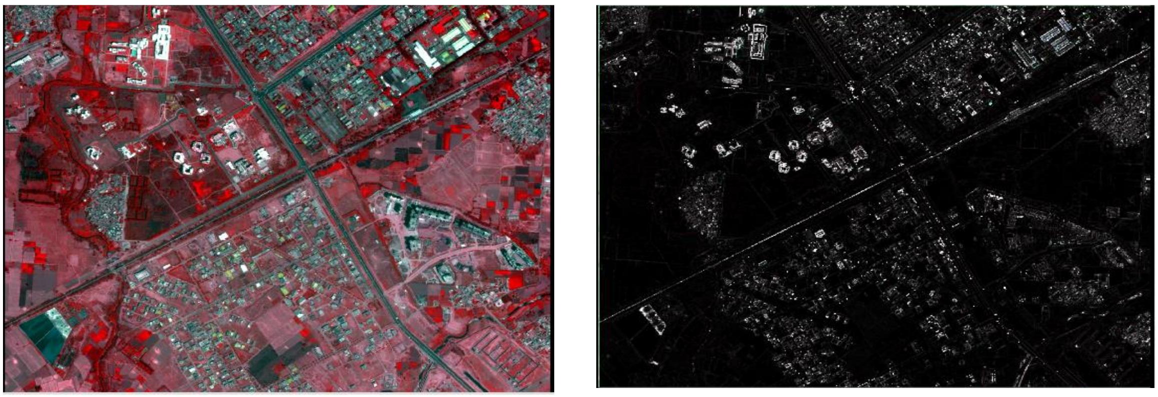
3. Results and Discussion

The results are illustrated in Figure 2 and 3. The DEM (Figure 2a) has brighter tones both for buildings and Roads. Low elevation areas are in black and agriculture areas, grasslands are grey. It was observed that variance, angular second moment (Figure 2c) were able to separate roads from buildings; variance, entropy and grey level co-occurence matrix (GLCM) correlation (Figure 2d) were useful in extracting building footprint. The PAN sharpened image is presented in Figure 3a and variance of the same in Figure 3d also indicates that buildings and roads are distinguishable from other features using this texture. The multiresolution segmentation using fractal net evolution approach (FNEA), scale parameter converged to 220 which was found suitable for both larger and smaller buildings. Since the main aim was to extract urban features mainly buildings, vegetation (Trees and grass land) was eliminated using normalized difference vegetation index (NDVI). The quality measures were computed which address the problem of completeness and correctness of the extracted road network. The results attained are completeness 93.47%, correctness of 92.94% with the overall quality being 90.79%.

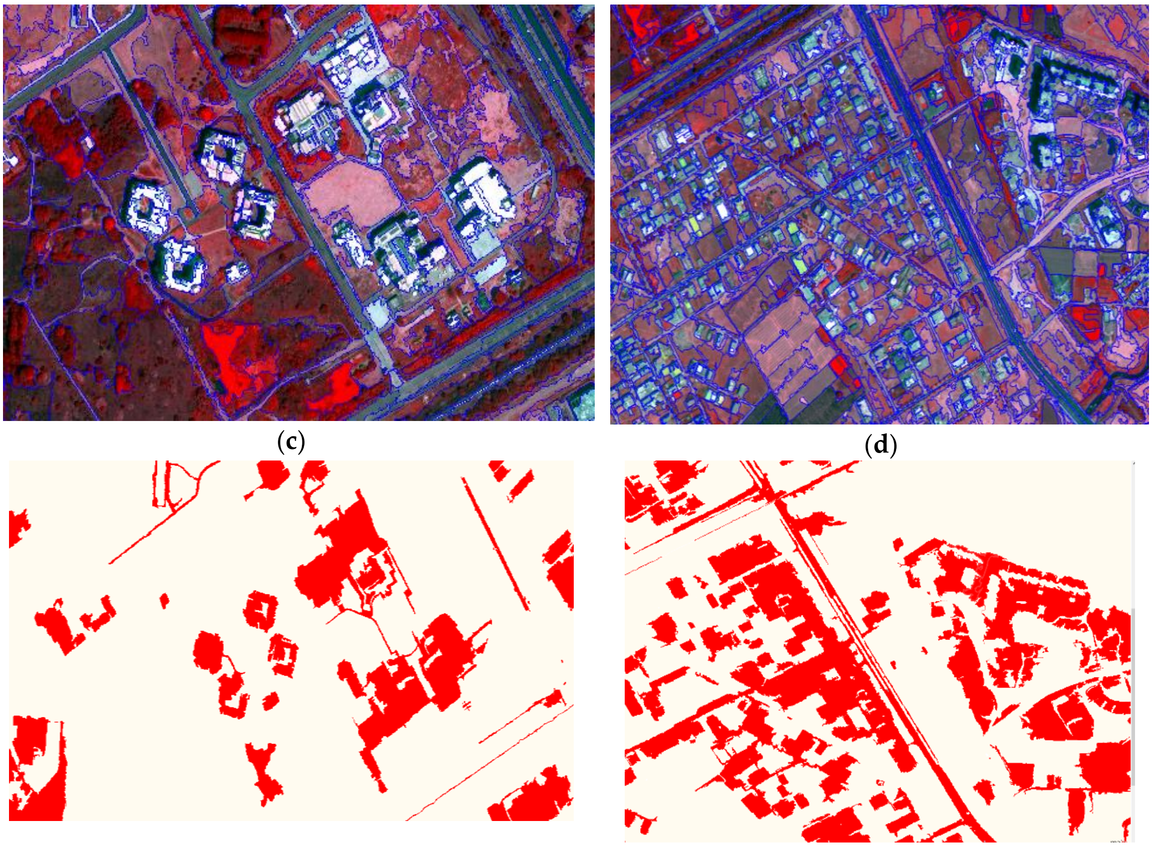


(a) (b) (c) (d)

Figure 2. (a) DEM, (b) Variance, (c) Angular Second Moment and (d) FCC (R: GLCM Correlation, G: Entropy B: Variance)



(a) (b)



(c) (d)

(e) (f)

Figure 3: (a) Fused FCC Orthoimage, (b) FCC-GLCM Variance, (c, d) Segmented Images (e, f) Extracted Buildings

4. Conclusions

As evident from the achieved RMSE values for the satellite triangulation, the bundle block adjustment based on RFM is of good quality. The block is thus able to produce good DEM and orthoimages for the feature extraction as observed from visual interpretation of clearly identifiable drainage networks and built-up regions in the DEM and orthoimages. Generic Rulesets which can be transferable for each and every dataset can have the limitations of terrain areas. Therefore, the rulesets are having restriction in different feature extraction. Slope, Altitude and nature of terrain plays important role in urban feature Interpretation. In this paper, an approach to extract buildings road from very high resolution orthoimage using was carried out using a DEM and various texture parameters extracted from DEM and raw images. The method described above worked well in those area also which contained shadows. The obstacle encountered were shadows of high buildings fall on smaller building rooftops and the tone of the road spectrally mixing up to with building rooftops. Higher dimension dataset (texture and transforms) were found useful in most of the problems encountered. It was observed that overall accuracy was higher (> 93%) in areas having larger building and sparse built-up as compared to areas having smaller buildings and dense built-up. The method worked well to extract fine building boundaries both in highly dense and rural areas.

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Conflicts of Interest: "The authors declare no conflict of interest."

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