A Survey Paper on Buildings Extraction from Remotely Sensed Images

[1]Jenifer Grace Giftlin.C,[2]Dr.S.Jenicka
[1]Dept of Computer Applications, Sarah Tucker College,
[2]Department of Computer Science and Engineering, Sethu Institute of Technology, India

Abstract—Building extraction from remotely sensed image involves detecting and separating buildings from other land cover classes. The challenges involved in extracting buildings are different viewing angles, surrounding vegetation, shadows, and other objects which obscure the edges of the buildings which are being detected. Motivated by these challenges in the problem domain, it is planned to do a survey on the existing methods that extract buildings from remotely sensed images addressing a few of these challenges. It is understood from literature that morphological (shape) techniques and segmentation methodologies are widely applied for achieving better results in extracting buildings.

Keywords- *Remotesensing, Morphology, Segmentation, Building Extraction* .

I. INTRODUCTION

Remote sensing is the art of capturing images of earth's surface using satellites. Satellites are artificial objects mounted with powerful sensors. These satellites are launched by launch vehicles or carriers and are set to revolve in earth's orbit. A sensor is an object whose purpose is to detect events or changes in its environment to provide a corresponding output. Remote sensing sensors are equipped with powerful cameras that can capture images of earth's landscape. For example the Indian Remote Sensing satellite, IRS P6 resourcesat launched in 2003, has LISS III, LISS IV, Wide Field Sensor (WiFS) and Panchromatic sensor mounted within it. Generally, the images captured by the satellites are classified into two types. They are multispectral and hyperspectral images. Multispectral remotely sensed image is one that is captured at specific frequencies across the electromagnetic spectrum. Multispectral imagery generally refers to 3 to 10 bands of image data represented in pixels but hyperspectral images have image data consisting of more than 10 bands. So hyperspectral images have numerous bands and wider spectral coverage.

Building extraction using remotely sensed data has the following limitations. In urban areas, the image may have high spectral complexity in the scene, or it may have low and poor contrast or other objects may have similar spectral reflectance as buildings. Moreover building roofs that are non-homogeneous, sloping and flat may cause different spectral properties. Incorrect extraction may come from images containing multiple types of buildings, where the learned model cannot correctly describe the line-building relationship. Shadows also pose challenges. An algorithm cannot efficiently detect buildings in regions where the shadow of one building falls on another building or where self-occlusion occurs for building rooftops. Moreover there may exist non-building objects such as road segments and bridges that cannot be eliminated using height verification but may be mistakenly detected as buildings. Another limitation is that in some residential areas where buildings are located in a dense and crowded manner, multiple separate buildings may be under-detected as a single building.

Building extraction has many useful applications in areas like urban planning, disaster management, flood assessment, distribution of remedial measures to a locality after disaster, fixing of taxes etc. It is also immensely beneficial to agencies such as land management agencies, urban development planners, Military, and others.

The second section gives a detailed literature survey of the existing methods applied in extraction of buildings from remotely sensed data. The third section describes the preprocessing methods and features extracted in various papers. The fourth section draws conclusion.

II. LITERATURE SURVEY

Remotely sensed data, including both airborne and space borne sensor data, vary in spatial, radiometric, spectral, and temporal resolutions. Understanding the strengths and weaknesses of different types of sensor data is essential for the selection of suitable remotely sensed data for building extraction. Some previous literature has reviewed the characteristics of major types of remote-sensing data [8,9]. It requires considering such factors as user's need, the scale and characteristics of a study area, the availability of various image data and their characteristics, cost and time constraints, and the analyst's experience in using the selected image. Scale, image resolution, and the user's need are the most important factors affecting the selection of remotely sensed data. The user's need determines the nature of classification. An object oriented segmentation and classification using high resolution satellite data (Cartosat-1 fused with IRS-1C, LISS IV data) for automatic building extraction was surveyed [1] which employed two approaches for feature extraction like applying different spatial filers and object- oriented fuzzy classification. The resultant merged image was filtered using the different high pass filters like Kirsch, Laplace, Prewitt, Sobel, Canny filtered images to improve the spatial resolution of remotely sensed data. The grab cut method [2] was employed to segment the data which needed human intervention and plotting of bounding box in the image area to be segmented. To make it fully automatic they employed fuzzy landscape which made blobs of shadow areas. Further Gibb's energy minimization iteration in grab cut was done using bacterial foraging optimization. The split and merge segmentation process [3] was employed and the segmented image was filtered by applying different filters. To enhance the resolution of the images network formation was done. A state-of-the-art line segment detector called EDLines [6] was introduced for the real-time accurate extraction of building line segments. A convolutional network formation [4] was adopted for getting better image representation power. A supervised classification approach was adopted [5] where the training areas for supervised classification were selected by automatically determining a buffer zone on each building and Standard deviation thresholding was applied to the Parallelepiped classification method to improve further the accuracy. A novel WSL approach to object detection in optical RSIs [7] where the training sets required only binary labels indicating whether an image contained the target object or not. In building extraction, the classifier was trained to identify the line segments corresponding to the building edges [10] through learning the relationship between the low-level image features and building counts. Although there existed mismatches between resulting line segments and building edges, it was observed that a strong linear relationship existed between the building numbers and line numbers of similar types of buildings. Based on this observation, they predicted the building count for a given image. The Support Vector Machine (SVM) classifier [11] was used for classification addressing the challenge that the rooftops are mislabeled between the building candidates. The Saliency cue as a new feature [12] was used to determine whether there was a rooftop in each segmentation patch obtained from the previous step. The basic idea behind the use of saliency information was that rooftops were more likely to attract visual attention than surrounding objects. Hyperspectral datasets [13] were used for building extraction by using Morphological building index (MBI) and morphological shadow index (MSI). They also employed Advanced Morphological building index (MBI)[14]. Earthquake damage detection on buildings [15] in urban areas was measured using post-earthquake PolSAR data. The detailed literature survey is tabulated in Table 1a,1b and1c.

Table 1 (a)

Sl. No	Paper title	Journal Detail	Methods Used	Inference	Challenges
1	**Remote sensing the urban area: Automatic building extraction based on multiresolution segmentation and classification**	**2015 - pdfs.semanticscholar.org**	**Spatial filers, and object-oriented fuzzy classification.**	**Multiresolution segmentation of an image into a network of homogeneous image regions at any chosen resolution.**	**The clear edges of buildings were not extracted but coincided with the original image of urban buildings.**
2	**Automatic Building Detection Using Modified Grab Cut Algorithm from High Resolution Satellite Image**	**" Photogrammetric Engineering & Remote Sensing 80, no. 9 (2014): 873-883.**	**Grab Cut Algorithm, Gibb's energy minimization.**	**Fuzzy landscape, foreground and background pixels are automatically determined and a bi partitioning was obtained using a graph based algorithm called Grab cut.**	**In some cases, shadow detection was a challenge in the proposed methodology.**
3	**Building Extraction from High Resolution Satellite Images**	**" International Journal of Computing Science & Communication Technologies 5, no. 2 (2013): 829-834.**	**Split and merge segmentation and clean up methods are used**	**A method for automatic building extraction from high resolution satellite image was proposed.**	**To increase the extraction rate, some more parameters like shape, shadow (if shadow is present in the image), texture etc. can be used in the extraction process.**
4	**Automatic Building Extraction in Aerial Scenes Using Convolutional Networks.**	**arXiv preprint arXiv:1602.06564 (2016).**	**Convolutional network formation**	**For automatic building extraction from aerial and satellite imagery, a convolutional network was designed.**	**Attaining a universal building extractor addressing various issues was a challenge reported in the paper.**
5	**Automatic building detection based on supervised classification based on high resolution Google earth images**	**International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences 40, no. 3 (2014): 101.**	**Parallelepiped supervised classification.**	**A novel approach to detect the buildings by automization of the training area collecting stage for supervised classification.**	**Improving the accuracy of the shadow detection results was the challenge reported in the paper.**

6	An Efficient Approach for Automatic Rectangular Building Extraction From Very High Resolution Optical Satellite Imagery	In Image Processing (ICIP), 2015 IEEE International Conference on, pp. 1483-1487. IEEE, 2015.	Segment detection	A new approach for rapid automatic building extraction from very high resolution (VHR) optical satellite imagery was proposed.	More accurate extraction of arbitrarily shaped buildings on larger data sets was a challenge reported in the paper.

Table 1 b

7	ObjectDetection in OpticalRemote Sensing ImagesBased onWeakly Supervised Learning and High-level Feature Learning.	IEEE Transactions on Geoscience and Remote Sensing 53, no. 6 (2015): 3325-3337.	Deep Boltzmann Machine (DBM)	A novel and effective geospatial object detection framework was proposed by combining the weakly supervised learning (WSL) and high-level feature learning.	Combining the rich spectral and spatial information for more accurate and robust object detection was a challenge reported in the paper.
8	Automatic building extraction based on multiresolution segmentation	ISPRS Journal of Photogrammetry and Remote Sensing 63, no. 3 (2008): 365-381.	Cartosat-1 fused with IRS-1C, LISS IV data.	A new multiresolution segmentation method was proposed for image object extraction.	Segmentation of an image at any chosen resolution was a challenge addressed in the paper.
9	Automatic rectangular building detection from VHR aerial imagery using shadowand image segmentation.	Image Processing (ICIP), 2015 IEEE International Conference on, pp. 1483-1487	MRF segmentation method	The paper proposed a novel approach for the automated detection of rectangular buildings from monocular very high resolution (VHR) aerial images.	Shadow detection was a challenge addressed in the paper.
10	Learning to Count Buildings in Diverse Aerial Scenes	International Conference on Advances in Geographic Information Systems, pp. 271-280. ACM, 2014	Linear Regression	This paper addresses the problem by learning the relationship between low-level image features and building counts.	Deriving more information for buildings based on low-level features was the objective of the research work.
11	Object counting in high resolution remote sensing images with OTB	2009 IEEE International, IGARSS 2009, vol. 4, pp. IV-737.	Support Vector Machine (SVM) classifier. The input data is a pan-sharpened Quickbird image (60 cm. resolution and 4 spectral bands).	The work focuses on building counting in dense areas.	The challenge reported in the paper is that the large buildings where different parts of the roof have different illuminations, can be detected as different buildings.

Table 1c

12	**Building Extraction from Remotely Sensed Images by Integrating Saliency Cue**	**IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 10, no. 3 (2017): 906-919.**	**Support Vector Machine (SVM) classifier. The input data is a pan-sharpened Quickbird image (60 cm. resolution and 4 spectral bands).**	**This work focuses on a novel two-step building extraction method from remote sensing images by integrating saliency cue.**	**Investigating more intelligent saliency estimation method to further improve the accuracy was the future work reported in the paper.**
13	**Efficient implementation of morphological index for building/shadow extraction from remotely sensed images**	**The Journal of Supercomputing 73, no. 1 (2017): 482-494.**	**Morphological building index (MBI) and morphological shadow index (MSI)**	**A computationally efficient implementation of MBI and MSI algorithms was developed for commodity graphic processing units using NVIDIA CUDA.**	**Improving the accuracy and the computational performance of the proposed approaches was the future work reported in the paper.**
14	**A New Building Extraction Postprocessing Framework for High-Spatial-Resolution Remote-Sensing Imagery**	**IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 10, no. 2 (2017): 654-668.**	**Advanced Morphological building index (MBI)**	**The post processing framework was proposed for studying the characteristics of various areas, including urban, mountainous, rural, and agricultural areas.**	**Studying the characteristics of buildings with accuracy is a challenge addressed in the paper.**
15	**Building Earthquake Damage Information Extraction from a Single Post-Earthquake PolSAR Image**	**Remote Sensing 8, no. 3 (2016): 171**	**Polarization Orientation Angle (POA)**	**This paper is focused on rapid building earthquake damage detection in urban areas using post-earthquake PolSAR data.**	**Improving the accuracy of building extraction is a issued addressed in the paper.**

III METHODS

The building object can be extracted from high resolution satellite images. Some of the steps adapted in extraction are discussed in this section.

A. Pre-processing Methods

Prior to data analysis, initial processing on the raw data is usually carried out to correct any distortions that occur due to the characteristics of the imaging system and imaging conditions. Depending on the user's requirement, some standard correction procedures may be carried out by the ground station operators before the data is delivered to the end-user. These procedures include radiometric correction to correct uneven sensor responses over the whole image and geometric correction to correct geometric distortion due to Earth's rotation and other imaging conditions (such as oblique viewing). In order to aid visual interpretation, visual appearance of the objects in the image can be improved by image enhancement techniques such as grey level stretching to improve the contrast and spatial filtering for enhancing the edges. The factors that are to be consider are:

– *Brightness* The brightness of a pixel is defined as the maximum value of the pixel in all the contained spectral bands. Building area is characterized by high brightness scores, while shadow area’s brightness should be smaller due to their low spectral reflectance.

–*Contrast* Building areas are generally characterized by their high contrast, due to the difference between the spectral reflectance values of roof and spatially adjacent shadows.

– *Size and directionality* To assist with the removal of spectrally similar structures, a series of linear structuring elements (SEs), should be designed to measure the size and directionality of structures .

B. Spatial Features Extraction

In high spatial resolution imagery, details such as buildings and roads can be seen. The amount of details depends on the image resolution. In a very high resolution image, even road markings, vehicles, individual tree crowns, and aggregates of people can be seen clearly. Pixel-based methods of image analysis will not work successfully in such an image. In order to fully exploit the spatial information contained in the imagery, image processing and analysis algorithms utilising the textural, contextual and geometrical properties are required. Such an algorithm makes use of the relationship between neighbouring pixels for information extraction. Incorporation of a-priori information is sometimes required. A multi-resolutional approach (i.e. analysis at different spatial scales and combining the resolution) is also a useful strategy when dealing with very high resolution imagery. In such a case, pixel-based method can be used in the lower resolution mode and merged with the contextual and textural method at higher resolutions. The following are to be considered in feature extraction process:

– *Shape* The most widely adopted shape descriptor for building areas is the rectangle. Therefore, the length–width ratio can be used to filter out the structures with similar spectral responses.

– *Texture* Texture is a measure of variation in pixel intensities in each local neighbourhood of a building structure.

C. Steps in Overall Methodology

Considering all the above mentioned factors the overall methodology for extraction of buildings is described below.

–*Selection of training samples* Training samples are usually collected from the fieldwork, or from fine spatial resolution aerial photographs and satellite images. Different collection strategies, such as single pixel, seed, and polygon, may be used, but the nature of selection influences the classification results, especially for extractions with fine spatial resolution image data. When the landscape of a study area is complex and heterogeneous, selecting sufficient training samples becomes difficult. This problem would be complicated if medium or coarse spatial resolution data are used for extraction, because a large volume of mixed pixels may occur. Therefore, selection of training samples must consider the spatial resolution of the remote-sensing data being used, availability of ground reference data, and the complexity of landscapes in the study area.

–*Data preprocessing* Image preprocessing may include the detection and restoration of bad lines, geometric rectification or image registration, radiometric calibration and atmospheric correction, and topographic correction. If different ancillary data are used, data conversion among different sources or formats and quality evaluation of these data are also necessary before they can be incorporated into an extraction procedure. Accurate geometric rectification or image registration of the remotely sensed data is a prerequisite before processing it.

–*Feature extraction and selection* Selecting suitable features is a critical step for successful implementation. Many potential features may be used in image extraction. They can be textural or contextual information. The experimental data may be multi temporal images, multi sensor images and ancillary data. Due to different capabilities in land-cover separability, the use of too many features in a classification procedure may decrease the extraction accuracy.

–*Segmentation* Segmentation involves partitioning the remotely sensed image into meaningful land cover classes. The major land cover classes are land, vegetation and water.

CONCLUSION

We have surveyed various methodologies reported in the literature for performing building extraction of multispectral remotely sensed images. From the papers studied, it is understood that shape features and morphological operators have been widely applied for building extraction from remotely sensed images. In order to improve the segmentation accuracy, in addition to multispectral images LIDAR data have been used as ancillary data in some papers. A universal object detector algorithm which can work on any objects is still a challenge faced in the real world. In each paper, some of the challenges involved in building extraction were addressed while others were left unexplored.

References

[1] Remote-sensing the urban area: Automatic building extraction based on multiresolution segmentation and classification N Shrivastava, PK Rai - 2015 - pdfs.semanticscholar.org.

[2] Automatic building detection based on Purposive FastICA (PFICA) algorithm using monocular high resolution Google Earth images S Ghaffarian, S Ghaffarian-2015.

[3] Building Extraction from High Resolution Satellite Images S Dahiya, PK Garg, MK Jat - International Journal of Computing …, 2013.

[4] Automatic building extraction in aerial scenes using convolutional networks J Yuan - arXiv preprint arXiv:1602.06564, 2016.
[5] Automatic building detection based on supervised classification using high resolution Google Earth images S Ghaffarian - The International Archives of Photogrammetry, …, 2014.
[6] An efficient approach for automatic rectangular building extraction from very high resolution optical satellite imagery J Wang, X Yang, X Qin, X Ye… - IEEE Geoscience and …, 2015.
[7] Object detection in optical remote sensing images based on weakly supervised learning and high-level feature learning J Han, D Zhang, G Cheng, L Guo… - IEEE Transactions on …, 2015.
[8] Automatic fuzzy object-based analysis of VHSR images for urban objects extraction.I Sebari, DC He - ISPRS Journal of Photogrammetry and Remote …, 2013.
[9] Automatic rectangular building detection from VHR aerial imagery using shadow and image segmentation TT Ngo, C Collet, V Mazet - Image Processing (ICIP), 2015
[10] Learning to count buildings in diverse aerial scenes J Yuan, AM Cheriyadat - Proceedings of the 22nd ACM SIGSPATIAL …, 2014.
[11] Object counting in high resolution remote sensing images with OTB E Christophe, J Inglada - Geoscience and Remote Sensing …, 2009.
[12] Building extraction from remotely sensed images by integrating saliency cue E Li, S Xu, W Meng, X Zhang - IEEE Journal of Selected Topics …, 2017.
[13] Efficient implementation of morphological index for building/shadow extraction from remotely sensed images LI Jiménez, J Plaza, A Plaza - The Journal of Supercomputing, 2017.
[14] A new building extraction postprocessing framework for high-spatial-resolution remote-sensing imagery X Huang, W Yuan, J Li, L Zhang - IEEE Journal of Selected …, 2017.
[15] Building earthquake damage information extraction from a single post-earthquake PolSAR imageW Zhai, H Shen, C Huang, W Pei - Remote Sensing, 2016.