RESEARCH REVIEW JOURNALS
Volume-03
Issue-11
November -2018

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com [UGC Listed Journal]

Shadow Detection and classification using image processing: A Review

[*1]Poonam Rathod & [2]Prof. K.V. Warkar

*[*1]Research Scholar, Department of Computer Engineering, B.D.C.E., Wardha (India)*
[2]Professor, Department of Computer Engineering, B.D.C.E., Wardha (India)

ARTICLE DETAILS

Article History
Published Online: 10 November 2018

Keywords
VHR Satellite Imagery, Shadow Detection, Shadow Context, Image Segmentation

[*]Corresponding Author
Email: poonam2030[at]gmail.com

ABSTRACT

Very-High-Resolution (VHR) satellite imagery is a powerful source of data for detecting and extracting information about urban constructions. Shadow in the VHR satellite imageries provides vital information on urban construction forms, illumination direction, and the spatial distribution of the objects that can help to further understanding of the built environment. However, to extract shadows, the automated detection of shadows from images must be accurate. The proposed system reviews current automatic approaches that have been used for shadow detection from VHR satellite images and comprises two main parts. In the first part, shadow concepts are presented in terms of shadow appearance in the VHR satellite imageries, current shadow detection methods, and the usefulness of shadow detection in urban environments. In the second part, we adopted two approaches which are considered current state-of-the art shadow detection, and segmentation algorithms using kmeans and SVM algorithm. In the first approach, we first segment the images into multiple parts using RGB segments and at the same time perform clustering using kmeans algorithm. After segmentation we use SVM algorithm for classification of shadow from VHR Images.

1. Introduction

Very High Resolution (VHR) satellite imagery is considered one of the highest quality currently available from remote sensing satellites because of its ability to offer sub-meter resolution. That means the VHR satellite imageries are capable of providing a high level of detail, which make them a reliable and highly vital source of information. Therefore, the VHR satellite imageries support a range of services, especially in urban areas, for city planning and monitoring, urban change detection, estimation of human activities/population, and urban object/feature detection. However, due to urban constructions which are built above ground, such as buildings and bridges, inter alia, shadows are the most common component accompaniments for these constructions that can be seen in VHR images. In the fact that the incident light rays, typically sunlight, when intercepted by an off-terrain object, shadows will be generated and cast on other urban surfaces/objects at the moment of image capture by optical satellites. Figure 1 presents three conditions (a light source, an object to cast the shadow line, and a surface to receive the shadow line and shadow) that must be met to produce a shadow. In this context, a shadow indicates the shape of the object casting it, and in many ways it can indicate the texture of the surface receiving the shadow (Yee, 2013). In contrast, shade can be defined as the side of an object which is opposite the direction of illumination, which has less colour tone of the full blackness (the value intensity of darkness) compared to the objects' shadows that have very low values of brightness in VHR images, or mostly have zero value (pure black), Figure 1. The fact is that the line that locates and separates the light and shade areas on the object determines the shadow line on a receiving surface. The shadow line, in turn, determines the dark area cast onto the surface on which the object rests and which receives the cast shadow. Therefore, the shadow line and the dark area (shadow regions) in the optical satellite imageries have become one of the crucial topics that has attracted researchers' attention because the dark pixels that belong to the shadow regions in image have received two main aspects of analysis. These two aspects depend on how the shadow regions in VHR images have been treated by researchers: as a curse must be addressed or as a blessing must be exploited. Basically, shadow concept can, therefore, be understood through grasp shadow progressions which start from determining points to lines (being composed of points) to planes (being composed of lines) and lastly to solids (being composed of planes), as shown in Figure 2. In fact, the shadow of a line, a plane, or a solid is most efficiently determined by locating the shadows of the critical points of the line, plane or solid (Yee, 2013). Moreover, if we draw parallel lines (paralines) in the virtual world extended from an object to its cast shadow on a mere and flat surface with sufficient distance between them, the identical size, shape and orientation of the object will be obtained. The basis of this fact is that the greater the distance, the greater the shadow will display. However, the situation is completely different with objects' shadows within urban areas in VHR satellite imageries in terms of urban fabric which often exhibit compact areas of buildings as one factor.

This factor can affect the actual size and shape of urban objects that are presented by their shadows. The reason behind this is the shadow line of the object will be shorter in the case of a rise in a horizontal receiving surface and longer where there is a drop in this surface for the other objects within urban areas. The second factor is the existence of trees and their shadows or even shadows from non-built-up areas, such as vehicles, which can distort the real boundaries of shadows (the geometric form) and give an arbitrary shape to the built-up objects, when they combine with the objects' shadows. Another factor is the shadow regions of objects in images will be larger in the summer season than their counterpart in the winter due to the sun's position in the sky vault and its angle and altitude. Spectrally, non-shadow regions, for instance, water, can present the same pixel intensity values or darkness with shadow regions of the objects in images that can cause an error in detecting shadows. Therefore, shadow detection and its extraction from VHR satellite images are not easy tasks and all image processing techniques for detecting shadows still depend on the estimation of shadow areas but using various developed methods.

2. Objectives

The main objectives of the study are listed below:

- To preprocess dataset for shadow images
- To perform clustering using kmeans algorithm
- To perform classification using SVM Algorithm
- Mapping shadow in original image.

3. Literature Survey

Many pioneering studies for the automated detection of shadows from VHR satellite images were devoted to improve the quality of image after detecting and handling shadows or to utilise shadows as evidence to detect man-made structures within the urban environment. Although, the automated detection of shadow regions from VHR satellite imageries is a challenging task, automatic object detection and extraction is a very active scope of research. However, we confine and summarise the literature review for only the present studies that aimed to detect and extract the shadows of buildings from the VHR optical images automatically.

A review paper on shadow analysis was produced by Dare (2005).

The paper presents the methods of detection, removing the problems of shadowing in high resolution satellite imagery. Four different techniques for separating shadow pixels from non-shadow pixels were described in more detail in the article which are: thresholding, classification, region growing segmentation and three dimensional modelling. The segmentation approach was proposed to detect shadow regions with four step processing included on density slicing, thresholding, region encoding and region filtering which applied on IKONOS and Quickbird panchromatic images. Thereafter, radiometric enhancement technique was chosen between two other presented techniques to remove shadow areas from IKONOS and Quickbird images. It is concluded that although, the quality of image can be improved through the techniques of detection and removal of shadow areas, results can be image-dependent.

In one of the latest studies, Wakchaure and Raut (2014) reviewed a range of techniques for shadow detection and de-shadowing from VHR images. The study included the proposal of a processing chain based on binary classification. Canny edge detection algorithm was used to detect shadows and differentiate their areas from non-shadow areas in the image with clear boundaries. Thereafter, the calculation of mean and standard deviation values for both pixels in the shadow and non-shadow areas and the normalization process were suggested as potential improvements for the final results of removing shadow pixels and appearing non-shadow pixels by increasing their brightness and shadow intensity values. However, the algorithm has not been applied on any VHR image in order to evaluate its performance and its suitability in detecting shadows. The segmentation approach is one of many different approaches that are used to detect shadow regions from single VHR multispectral images.

Ma et al. (2008) presented an approach in shadow segmentation and compensation that was implemented on an IKONOS image through a normalizing Saturation-Value difference index (NSVDI). The approach was based on analysis Hue-Saturation-Value (HSV) color space to detect shadow regions of buildings and a histogram matching technique was exploited to retrieve the information under shadow. The results of segmentation illustrate that the shadow areas were effectively extracted from the IKONOS image. Nevertheless, the approach was not able to distinguish between dark objects, such as water and shadow regions due to the similarity of spectral values of pixels and the lack of the validation of final results. It was concluded that multiple images can be better in use for compensating the information under the shadow regions because it was found that the retrieval information from a single image is not sufficient to this end.

In the same context, segmentation algorithm based on contour model and isolation was proposed by Elbakary and Iftekharuddin (2014) to detect man-made structures by their shadows. The approach was applied on a panchromatic image, which was created from a VHR multispectral image with spatial resolution of 1∊1 meter for this application. Thereafter, post-processing based on optimal Thresholding and geometric filter were implemented to determine the real shadows from other objects. Although, the algorithm was used to detect and segment the shadow regions using the gray-level satellite image without depending on the color information and to handle the difficulty of shadow detection in satellite images, the problem of separating water bodies, such as lake, from shadow regions is not solved. This is because they exhibit similar intensity feature characteristics. In other recent studies, a classification-based approach has been used to detect shadows regions.

Wen and Yamazaki (2012) proposed a method in shadow detection using an object-based classification that employs brightness values and their relationship with the neighboring area, which has been applied on Quickbird and WorldView-2 (PAN and multispectral images). A method for the correction of these detected shadow areas has also been proposed using a linear function to remove shadows from images. The idea is to classify images into four classes (vegetation, road, roof and shadow) and modify shadow pixels through three levels of darkness (dark, medium and light), which is derived from the twenty-six radiance measurements in order to demonstrate the nature variability of the radiance ratio. A linear-correlation function and NDVI were used to attain a smoothly restored image. The overall classification accuracy for sunlit areas was 74.94%, while for the corrected shadows areas it was 71.87%, and the comparison between these results illustrates that the proposed shadow correction method is effective in correcting the radiance in shadow areas. Nevertheless, the detection step was completely based on the results of the supervised classifier, which was the main reason for the moderate shadow regions. Moreover, a bright roof in light-shadow, small shadows cast by trees, and material with high reflectivity in shadow areas were not extracted and observed properly by the object-based classification method.

Later, the morphological filtering approach for shadow detection with a shadow reconstruction approach was suggested by Song et al. (2014) to improve the classification performance applied on Quickbird and WorldView-2. Shadow detection comprises three steps: Thresholding, morphological filtering and edge compensation for the derived shadow mask as a first stage in this approach. In the second stage, a Markov random field (MRF) was used to sample shadow and non-shadow pixels manually to produce a library for both types of pixels as a training stage. The final stage was to compensate and reconstruct the underlying land cover pixels using the Bayesian belief propagation algorithm to address the MRF. The supervised ISODATA classification method was adopted and applied before and after shadow construction to verify the performance of the proposed shadow removal approach. The results indicate that the constructed images can be classified more accurately than images before shadow reconstruction. However, the chain of image processing for shadow detection might affect the quality of the actual geometric shape and edge of shadows areas. Because of the morphological filtering in the shadow detection stage, some small shadow areas were not removed and were remained in the classification map after shadow reconstruction.

Another different recent work, a new index for detecting shadows regions, was introduced by Teke et al. (2011). In this approach the use of near-infrared information in combination with visible information (especially, green and red bands) of VHR satellite images is utilized to generate a false color image. The processes of normalization and transformation were implemented on this false color image to compute the Hue Saturation-Intensity (HIS) space and a ratio map. In their approach, Otsu’s method was applied to the histogram of the ratio map in order to detect the shadow regions because the used Thresholding scheme is able to detect both shadow and vegetation regions at the same time. The final step in the approach is to derive a binary shadow mask through subtracting the regions of vegetation cover in an image. Although, the results exhibited success in detecting shadow regions, post processing is required to improve the shape and boundaries of the derived shadow mask from VHR satellite image. This is so especially in cases where the shadow regions are used as evidence of the structure and location of the elevated objects within the urban area, such as buildings.

The same approach has been used by Ok et al. (2013) to detect shadow regions for identifying the regions recognized as buildings and roads, implemented on a set of Quickbird and Geoeye-1 VHR images. A post-processing shadow mask, which included a constrained region growing process on detected shadow regions and probabilistic landscape approach (Ok, 2013a), was achieved using three different thresholds: intensity, ratio and height in order to obtain a regular shape identical to reality and eliminate the unwanted shadow areas.

SVM Algorithm

In machine learning, support vector machines (SVMs, also support vector networks) are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis. Given a set of training examples, each marked as belonging to one or the other of two categories, an SVM training algorithm builds a model that assigns new examples to one category or the other, making it a non-probabilistic binary linear classifier (although methods such as Platt scaling exist to use SVM in a probabilistic classification setting). An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible.

References

1. Ahmed Abdelhafiz,” Accurate Shadow Detection From High-Resolution Satellite Images” IEEE Geoscience and Remote Sensing Letters Volume: 14, Issue: 4, April 2017
2. Bergamasco, L. and Asinari, P., 2011. Scalable methodology for the photovoltaic solar energy potential assessment based on available roof surface area: Further improvements by ortho image analysis and application to Turin (Italy). Solar Energy 85, pp. 2741-2756.
3. Dare, P.M., 2005. Shadow analysis in high-resolution satellite imagery of urban areas. Photogrammetric Engineering & Remote Sensing 71, pp. 169-177.
4. Elbakary, M.I. and Iftekharuddin, K.M., 2014. Shadow Detection of Man-Made Buildings in High-Resolution Panchromatic Satellite Images. Geoscience and Remote Sensing, IEEE Transactions on 52, pp. 5374-5386.
5. Izadi, M. and Saeedi, P., 2012. Three-Dimensional Polygonal Building Model Estimation From Single Satellite Images. Geoscience and Remote Sensing, IEEE Transactions on 50, pp. 2254-2272.
6. Jo, J.H. and Otanicar, T.P., 2011. A hierarchical methodology for the mesoscale assessment of building integrated roof solar energy systems. Renewable Energy 36, pp. 2992-3000.
7. Lee, T. and Kim, T., 2013. Automatic building height extraction by volumetric shadow analysis of monoscopic imagery. International Journal of Remote Sensing 34, pp. 5834-5850.
8. Ma, H., Qin, Q. and Shen, X., 2008. Shadow segmentation and compensation in high resolution satellite images, Geoscience and Remote Sensing Symposium, 2008. IGARSS 2008. IEEE International. IEEE, pp. II-1036-II-1039.
9. O., 2013a. Automated detection of buildings from single VHR multispectral images using shadow information and graph cuts. ISPRS Journal of Photogrammetry and Remote Sensing 86, pp. 21-40.
10. O., 2013b. Automated Extraction of Buildings and Roads in a Graph Partitioning Framework. ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences 1, pp. 79-84.
11. O., 2014. A new approach for the extraction of aboveground circular structures from Near-Nadir VHR satellite imagery.

Geoscience and Remote Sensing, IEEE Transactions on 52, pp. 3125-3140

12. O., Senaras, C. and Yuksel, B., 2013. Automated Detection of Arbitrarily Shaped Buildings in Complex Environments From Monocular VHR Optical Satellite Imagery. Geoscience and Remote Sensing, IEEE Transactions on 51, pp. 1701-1717.
13. Otsu, N., 1975. A threshold selection method from gray-level histograms. Automatica 11, pp. 23-27.
14. Raju, P., Chaudhary, H. and Jha, A., 2014. Shadow Analysis Technique For Extraction of Building Height Using High Resolution Satellite Single Image and Accuracy Assessment. ISPRS-International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences 1, pp. 1185-1192.
15. Redweik, P., Catita, C. and Brito, M., 2013. Solar energy potential on roofs and facades in an urban landscape. Solar Energy 97, pp. 332-341.
16. Rufenacht, D., Fredembach, C. and Susstrunk, S., 2014. Automatic and accurate shadow detection using near-infrared information. Pattern Analysis and Machine Intelligence, IEEE Transactions on 36, pp. 1672-1678.