Review: Shadow Detection and Removal Techniques in Remote Sensing Urban images

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Abstract

Shadow detection and removal in real scene images are always a significant problem. Shadow is one of the important problems in remotely sensed imagery which reduces the accuracy of information extraction and change detection. There are many algorithms and methods that help to detect a shadow in image and remove such shadow from that image. In remote sensing images (urban), shadows are usually created by elevated objects such as various cultural features (buildings, bridges, towers, etc.) when they are illuminated by the Sun at the time of exposures. This paper is aimed to give a comprehensive and critical review on shadow detection and removal methods. Also the advantages and disadvantages of the various methods are included. This paper will use as a quick reference for the researchers working in the same field.

Keywords: shadow detection, shadow removal, remote sensing images

1. INTRODUCTION

Over the last decades several approaches were introduced to deal with shadow detection and removal. In remote sensing images (urban), due to the presence of elevated objects such as (buildings, bridges, towers, etc.) shadows should be formed, when they are illuminated by the Sun at the time of exposures. Although shadow itself can be considered as a type of useful information in 3-D reconstruction, recognition of building position, and estimation of height [1]. The major problem caused by shadows is either a reduction or loss of information in an image. Also the shadow causes reduction of reliability of computer vision algorithm such as object classification, segmentation, object identification, and image analysis etc. Therefore the shadow detection and deshadowing are important pre-processing technique for improving the presence of such vision task.

Shadow detection and removal have different application in change detection, object and position detection from remote sensing images, help to detect the damage due to calamities like avalanche, volcanic eruption, tsunamis, earthquakes etc. Also shadows obstruct the accurate extraction of buildings and shadows cause incorrect detections. So different types of shadow detection and deshadowing techniques have been developed to produce the shadow free images. This paper explains different

types of shadow detection and removal techniques also discuss its advantages and disadvantages.

1.1 SHADOW DEFINITION

A shadow is made when an object blocks light. The object is either translucent or opaque to make a shadow. A transparent object does not make any shadow, because light passes through it directly. Shadows are of two types: self shadow and cast shadow. A cast shadow is projected by the object in the direction of the light source; a self shadow is the part of the object which is not illuminated by direct light. Cast shadows are of two types' umbra and penumbra. The part of a cast shadow where direct light is completely blocked by its object is called umbra, while the part where light is partially blocked can be named as penumbra.

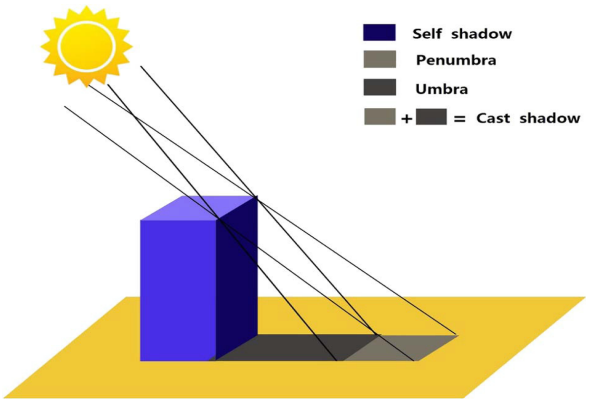


Fig 1: Types of Shadow

2. LITERATURE SURVEY

2.1 SHADOW DETECTION METHODS

In order to separate shadow pixels from non-shadow pixels different shadow detection algorithm should be used. Each of these procedures is described in more detail below.

2.1.1 Thresholding

Thresholding is the simplest method for shadow detection [2]. In this type of method each pixel in the image is replaced with black pixel if the intensity less than a particular threshold and each pixel in the image is replaced with white pixel if the intensity greater than threshold. Here error should be occurred while selecting the suitable threshold value is a major problem. It is computational inexpensiveness, simple, quick and easy but it cannot well identify shadow regions from other dark objects

2.1.2 Region Growing Segmentation

Image segmentation is the process by which division of an image into regions or categories, which corresponds to different objects or parts of an object. In region based segmentation algorithm operates iteratively by growing together pixels which have similar values and splitting groups of pixels which are heterogeneous in values.

The first step in region growing segmentation [2] is selection of seed points. Here selection is based on the criteria such as gray scale intensity of a pixel. Region is grown

from the seed pixels by adding the neighbouring pixels that are similar, thus increasing the size of region. Growth of one region stops only after we simply choose another seed pixel which does not yet belong to any region. This whole continued until all pixels belong to some region.

Advantages

1) This method correctly separates the regions.
2) It provides good segmentation results.
3) Concepts are simple and only need small no: of seed points.
4) It performs well with respect to noise

Disadvantages

1) Computation is time consuming.
2) Selection of seed point is important

2.1.3 Dual Pass Otsu Method

Otsu method [3] is a clustering based image thresholding. The Otsu method is designed to select the optimum threshold for separation in to two populations based up on maximising the variance between them. The first application of the Otsu's method separates the pixels in to high and low intensity populations. The low intensity consists of both cast and self shadow. In order to separate these two shadow types, a second thresholding of the lower intensity population is performed. Cast shadow pixels are replaced by background pixels.

Advantages

1) It is less expensive method.

Disadvantages

1) Poorest Performance.
2) This algorithm fails when the global distributions of the target and backgrounds vary extensively.

2.1.4 Dare Method

This method [2] has been developed for extracting shadows from high resolution images. Shadow should be separated from non shadow by using predetermined thresholding and further post processing is accomplished. Dare method consist of four steps. They are:

1) Density Slicing

Density Slicing [4] is the process in which the pixel values are sliced in to different ranges and for each range a single value is assigned in the output image. It is also known as level slicing. It should be used for enhancing images in which pixel values are within a narrow range. Slicing may be displayed as areas bounded by contour lines.

2) Thresholding

Bimodal Histogram splitting method should be used for finding the accurate threshold and separate shadow and non shadow.

3) Region Encoding

To obtain the unique identity for both shadow and non shadow regions encoding is used. This helped for removing potential blunders.

4) Region Filtering

In order to separate shadow from non shadow filtering is performed. For example: water should be falsely detected as shadow, because water and shadow have same radiometric characteristics. To separate them variances is used, because variances of the shadow region is higher then the variances of water region.

2.1.5 Blackbody Radiator Model

Here, illumination is based on two main light components direct sunlight and the atmospheric scattered light. So the same object in a scene can be under direct light and can be shadowed. First determine the shadow border irrespectively [5] (done in either manually or automatically). Then find the shadowed and illuminated region. Then calculate chromaticity of shadowed and illuminated region.

$$i_r = I_R / I_B$$

$$i_g = I_G / I_B$$

Then this chromaticity values should be compared with the threshold and shadow should be detected.

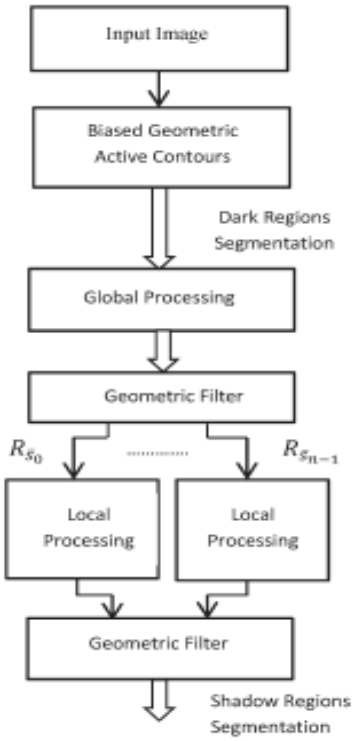
2.1.6 Invariant Color Model

This method [6] also be used for shadow detection. Here spectral information of an image (hue, saturation, intensity) is used to segment shadow. But there is a problem in which dark blue object and other dark object should be incorrectly segmented. In paper [7] proposed a method that applies separation of spatial frequency components and shadow segmentation in the RGB space. This method clearly detects shadow but the drawback is instability for certain color values which lead to the misclassification of the non shadow as shadow pixels.

2.1.7 Geometric Active Contour Model

This method clearly detects the shadow by using geometric active contour [8]. Here, first shadowed image should be segmented by using biased geometric active contour. Then global processing is performed to detect the false shadow and geometric filter remove it from the image. Then the image is divided into different parts and

each part is individually local processed. After that geometric filter is used to remove false shadow and finally detect the shadow.. The flow chart of this method is



2.2 SHADOW REMOVAL

During the processing of shadowed image, information cost is occurred. So shadow removal plays an important role in object classification, object recognition, image fusion etc. Each of these procedures is described in more detail below.

2.2.1 Histogram Matching

Histogram matching is a method in image processing of color adjustment of two images using the image histograms. It is the process by which improving the brightness of the image based on the referenced images. In this method [9] given two images the referenced and adjusted images. Each pixel in the adjusted images should be mapped to the corresponding level [10]. It is possible to use histogram matching to balance detector responses as a relative detector calibration technique. Generally this method normalizes two images, when the images captured at the same local illumination (such as shadows) over the same location, but by different sensors, atmospheric conditions or global illumination. (HM) is a common approach for finding a monotonic mapping between a pair of histograms. Given two histograms (PDFs) the algorithm finds a color mapping that optimally transforms one histogram into other. HM is a simple and very effective algorithm but it suffers from a number of shortcomings: First, it is limited to only two histograms and cannot deal with multiple histograms simultaneously. Second, HM approximates the optimal solution with respect to the L1 norm over the cumulative histogram pair, but is unable to provide an optimal solution for other metrics. Finally, the HM solution is designed for continuous PDFs and may produce non-optimal solutions in the discrete histogram case.

2.2.2 Gamma Correction

The Gamma correction is used to adjust the lightness/ brightness

of the image. The amount of correction is specified from 0.0 to 10.0 [9] [10]. Recovered DN values of the shadow region is

$$DN_{recovered} = (DN_{shadow})^{\frac{1}{\gamma}}$$

Where γ is the parameter. It is an important technique for displaying the image accurately in the monitor. It not only removes the shadow but also maintain the ratio of red to green to blue.

2.2.3 Linear correlation Correction

Shadow is considered as a combination of additive and multiplicative noise. Using the linear function brightness of the shadow pixels should be restored [9]. Linear function used to remove the shadow is represented as

$$DN_{recovered} = \frac{\sigma_{non-shadow}}{\sigma_{shadow}}(DN_{shadow} - \mu_{shadow}) + \mu_{shadow}$$

Where μ is the mean value and σis the standard deviation of the shadow or non-shadow region.

2.2.4 Multi Source Data Fusion

This method can be used to reduce the effect of shadow in high resolution satellite images. Here each shadow pixel should be replaced by non shadow pixels in the same image that should be taken from different time. In paper [11] this method should be compared with another two methods and results showed that multi source data fusion technique detect the shadow more accurately.

2.2.5 Model Based Shadow Removal

Model Based Shadow Removal is a simple shadow removal in which each pixel is replaced by new value. We know that two types of light sources direct and ambient light. Direct light comes directly from sources while ambient light comes from the reflection of surrounding surfaces. Here the shadow model is represented as[12]

$$l_i = (t_i \cos\theta_i L_d + L_e)R_i$$

Then each pixel is replaced by new value computed in [13], thus shadow free image should be computed.

2.2.6 Additive Shadow Removal

Another simple method for shadow removal is additive technique. Here, color intensity in the shadow area should be corrected. The average pixel intensity in the shadow (E_{shadow}) and lit area of the image (E_{lit}) should be computed [12]. Then find the differences and added this value to the pixels in the shadow area.

2.2.7 Combined Shadow Removal

This method can accurately be removed the shadow by using he combination of above two methods.

Convert the image in to YCbCr color space. Then to correct the Y channel, additive method is used and Cb, Cr channels model based technique is used.

3. CONCLUSION

This paper aimed to provide a review on various algorithms for shadow detection and removal with their advantages and disadvantages. Removing the shadow from images improves the performance of various tasks like segmentation, object detection, target detection, object tracking etc. This is considered as a preprocessing technique for any vision task. Thresholding is a common method for shadow detection but due to the limitation of this method various other methods should be implemented. Each of the methods has its own advantages and disadvantages. Also discuss about various types of shadow removal and its features. All these methods falsely detect the black car as shadow is a major problem. So in future find a new method for solving this problem.

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