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A Review on Different Shadow Detection and Removal Methods

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Abstract

Remote sensing technology extracts information about the earth resources from satellite imagery. The elevated objects are the reason for the appearance of shadows. Shadows are created as the light source has been blocked by something. Shadows degrade the quality of images or it may affect the information provided by them. Thus for the correct image interpretation it is important to detect shadow regions and restore their information. Significant researches has been going on in finding the best shadow detection and removal methods. Many algorithms and methods had been developed so far. This paper is aimed at the study of different shadow detection and removal algorithms.

***Keywords**: Shadow detection, shadow removal*

1. Introduction

Satellite imageries provides a high level of description, which make them a vital and highly reliable source of information. One of the basic features of remote sensing images are shadows. Shadow detection plays an important role in digital aerial image processing. Shadows are useful information that can be used in building location recognition, 3-D restoration, and height estimation Shadow can provide semantic and geometric information about the height and shape of its object and the position of the illumination light. The poor visibility in shadow regions influences computer operations such as change detection, scene matching, object recognition and true orthophoto generation.

Shadows are of two types one is self- shadow, in which the shadow of subject is falling on the side of the image that is not directly facing the light source. The other is the cast shadow, which is the shadow of subject falling on the surface of another subject because former subject has blocked the light source. The shadowing effect are commonly seen in regions where there are vivid changes in surface elevation mostly in urban areas. The problem of shadowing is significant in Very High-resolution satellite imaging. It plays an important role in applications of urban high resolution remote sensing images such as image fusion, object reorganization, change detection, and object classification. Hence shadows need to be properly detected and removed for the correct image interpretations.

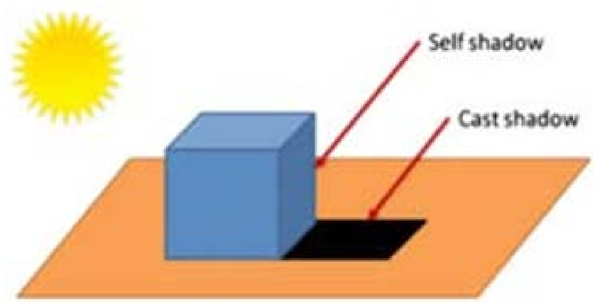

Fig. 1 Illustration of self and cast shadows

A shadow is a region where direct light cannot reach due to the obstruction by an object. There have been few studies concerning shadow detection and removal. Here are the basic assumptions of shadows

1) The illumination image will be spatially smooth.
2) No change in the texture of image inside the shadow region.
3) Due to the reflectance image pixels inside the shadow regions contain different colors, not the illuminated one.

Shadow detection and removal is an important pre-processing or image enhancement step. The shadow detection steps segment the shadow regions from the images where the work has to be performed. Detecting shadow is important as the shadow removal process is applied on this detected regions. In the shadow removal stage the image is corrected or recovered from the defects caused by the shadows. Here we have looked different shadow detection and removal methods and provided a detailed summary.

2. Literature Survey

Many effective shadow detection algorithms have been proposed. A novel approach for shadow detection and classification is discussed in [1]. The method uses invariant color models to identify and classify shadows. Shadow candidate regions are extracted first and then the candidate pixels are classified as self-shadow points or as cast shadow points by using the invariant color features. Here invariance properties of some color transformations are exploited for shadow detection. These transformations describe the color configuration of each image point disregarding shadings, shadows and highlights. Even if there is a change in the imaging conditions like viewing direction, illumination condition and object's surface orientation the transformations are invariant. The luminance properties of shadows are exploited on the edge map obtained by applying the Sobel operator on input image. The luminance values of shadow regions are smaller than those in the surrounding lit regions. Like this shadow regions are extracted. The classification is done as cast shadows, if they belong to the scene background or as self-shadow if they are part of an object.

The properties of shadows in luminance and chrominance are exploited in [2]. This method is applied in several invariant color spaces, including HSI, HSV, HCV, luma, inphase, and quadrature (YIQ) and YC C models. First the RGB-based aerial color images are transformed into the photometric invariant color models. Shadow regions contains increased hue values. Thus ratio of Hue over intensity for each pixel is taken and a ratio image is constructed. Then Otsu's method is applied over the histogram distribution of the ratio image to determine the threshold for segmenting the regions. It implements a two-step histogram matching technique to compensate shadow regions from their surrounding neighborhoods. The method eliminates the requirement of a prior information or geometric knowledge about the scene and the source of illumination. But it is difficult to determine an optimal threshold using Otsu's method for the differentiation of dark shadow in the image and dark object.

Instead of using global thresholding scheme a successive thresholding scheme is used in [3] for accurate shadow detection. The input aerial image is converted into ratio map by the color transformation method explained in [2]. The ratio map is then modified by applying exponential function so that the gap between shadow and non-shadow pixels stretches. A coarse shadow map is obtained by applying the global thresholding process. This separates the input image into candidate shadow pixels and non-shadow pixels. The candidate shadow pixels are grouped to form candidate shadow regions by using the connected component analysis and then local thresholding process is applied to each region iteratively to detect true shadow pixels from candidate shadow pixels. To check whether the remaining candidate shadow pixel is the true shadow pixel or not, a fine-shadow determination process is applied.

Apart from pixel or edge information a region based approach is used in [4]. The appearance of the local and surrounding regions are considered. Determine a shadow region by comparing it with the others that are likely to be of same material. Like that, regions of same material are determined and check whether they have same illumination conditions. By connecting illumination pair a relational graph is constructed and shadows are detected. Classifiers (SVM) are trained to detect illumination pairs based on comparing their color and texture histograms, their chromatic alignment, the ratio of their intensities, and their distance in the image. The regions are classified as shadows and non-shadows using graph cut inferences. The shadow removal is done by lighting process. Estimated the ratio of direct to environmental light together with the shadow coefficient and thus a shadow-free image be recovered. But only the foreground image is considered here and also single image is considered to remove the shadow.

J. Huang, W. Xie et al. [5] another method which doesn't require prior knowledge. Shadows have large hue values, low values in B channel and small difference between G and B channels. Histogram threshold technique are used to distinguish them. To compensate the shadow Retinex technique is used, which is originally used for the removal of differences existing between images and direct observation of real scenes. It needs illumination thus we apply Retinex to shadowed and non-shadowed region separately. Then they are combined together as compensated image.

Lorenzi [6] proposed a new approach in which shadow areas are detected and classified by means of state of the art support virtual machine. It is a classifier so it’s a best tool to differentiate shadow and non- shadow part. It gives the better accuracy than other methods. The linear regression method is used for reconstruction. According to the statistical characters of the corresponding non shadow regions shadow pixel intensities are adjusted. Adaptive morphological filters are used for borders. In the reconstructed image for the prevention of possible border artifacts linear interpretation is done. Advanced kernel function is required and it causes high computational burden.

Y. Wang and S. Wang [7] proposed a shadow detection method based on partial differential equations (PDES). Shadow regions possess lower brightness and also have slow gradient change in luminance value than non-shadow regions. Based on these gradient values shadow regions are obtained. The algorithm takes the gradient values as parameter of edge detectors. This controls the speed of diffusion of PDES. Canny’s approach has been used here as they have light computational cost and is stable under the noise, but have difficulty in establishing the connected edge. The boundaries of segmented shadow regions are preserved and thus the information of non-shadow region remains unaffected. Shadow detection is an iterative calculative process. During calculation to stand out shadow regions the algorithm suppress changing pixel values of the non-shadow regions. The method is simple to apply, and additional information except the image itself is not required.

Shadow detection based on physical properties of a black body radiator is introduced in [8]. The parameter for a particular scene is calculated. One can work with many images obtained with different illumination condition and different sensors. Objects of scene can have varying reflectance characteristics and can be illuminated by either direct sunlight or scattered light. By calculating the illumination source properties we can separate the area illuminated by direct sunlight and the shadowed area. Using surface illumination and material chromaticity the temperature of blackbody illuminants are calculated. Then the mask for the shadowed regions are calculated and it is dependent on the temperature of the black body radiators. All the parameters of the model are calculated directly from the input data. Thus the method is adaptive. Application of this method is not limited to remotely sensed data it can be easily applied to other imagery from different sources and in the areas of image recognition.

Sarabandi [9] introduces a shadow detection and radiometric restoration in high resolution images. A new transformation which enable us to detect boundaries of cast shadows in high resolution satellite images is introduced. Single band of data doesn’t give enough information to distinguish between shadows and dark objects. Hence multiband information is used to discriminate them. A set of color invariant indices are used in order to apply a non-linear transformation to the data and distinguish the dark regions. For the detection of boundaries of shadows the variance measure is used as a local statistics for the texture filters. This enables to highlight the sudden changes between pixels. To radiometrically restore, either gamma correction, linear correlation or histogram matching is used. Gamma correction considers shadows as a multiplicative noise source which degrade the brightness of the hidden pixels. If the shadow is a combination of additive and multiplicative noise, a linear function can be used to restore the brightness of shadow pixels to the first order. Histogram matching are used in order to bring brightness distribution of two given images as close as possible.

A shadow removal method which uses an illumination recovering optimization method is discussed in [10]. According to the shadow distribution the input image is decomposed into overlapped patches. An optimized illumination recovering operator is constructed by building the correlation between the shadow patch and the lit patch according to the texture similarity. Shadows are effectively removed and the texture details under shadow patches are recovered. High quality shadow free results with constant illumination can be produced based on reasonable optimization processing among the adjacent patches. This method can process shadows with rich texture types.

Shadow detection by a graph cut segmentation method is introduced in [11]. A shadow detection using near infrared (NIR) and kernel graph cut method is familiarized here. In the NIR approach the ratios between the NIR and the visible bands on a pixel by pixel basis are computed. This helps to distinguish between shadows and dark objects. The object that are dark in the visible spectrum often have a much higher reflectance in the NIR band. Most of the taken illuminants in the shadow formation process have a very distinct range in the NRI band. The next approach discussed in the paper is the multi region image segmentation based on parametric kernel graph cuts. The basic idea of this method is to increase the dimension of the feature space image data, making it higher via kernel function in order to accomplish a better separability ideally linear.

A shadow detection and removal using normalized differential index (NDI) and morphological operators is discussed in [12]. The input image is converted to HSV color space. Shadows have properties like high saturation value, high hue value. Then the image is segmented into shadow and non-shadow regions. For this NDI is calculated using the S and V components of HSV image model. The image obtained after this is the binary image with all shadow pixels set to 1 and all non- shadow pixels set to 0. Shadow is removed using a buffer area around the shadow. Buffer area is computed using morphological dilation operation and image subtraction operation. Buffer area is used to compensate the shadow using the mean and variances of the buffer area and the shadow region.

4. Conclusions

A comprehensive survey of shadow detection and removal is provided. Various methods used for shadow detection and removal are explained. Aforementioned methods really deals with pixels of the images. In pixel level shadow detection some useful spatial information is lost. There is a possibility that noise and dark pixels be mistaken as shadows. Images are converted into different invariant color spaces to obtain shadows. The pixel intensity value is susceptible to illumination changes which leads to less accuracy and efficiency.

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