Object Oriented Shadow Detection and an Enhanced Method for Shadow Removal

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Abstract— Remote sensing technology derives information about the earth resources from satellite imagery. In urban areas, mainly the elevated objects are the reason for the appearance of shadows. Shadows are created as the light source has been blocked by something. Shadows lower the quality of images or it may affect the information provided by them. Thus for the correct image interpretation or to extract information it is important to detect shadow regions and restore them. Significant researches has been going on in finding the best shadow detection and removal methods. Many algorithms and methods had been developed so far. Most of them are based on pixel level shadow detection and removal. An object oriented shadow detection and removal resolves the shortcomings of pixel level detection. Existing object oriented method suffers from color casting of images even after the correction. A new method for shadow compensation by image inpainting resolves these color casting problem.

Keywords- Shadow detection, shadow removal, Inpainting

I. INTRODUCTION

Satellite images gives significant level of information, which make them a valid and highly vital source for data gathering. One of the basic attributes of remote sensing images are shadows. Shadow detection plays an important role in digital aerial image processing. Shadows can be regarded as a type of useful information in 3-D restoration, height estimation and building location recognition. Shadow can provide geometric and semantic clues about the shape as well as height of its casting object and the position of the light source. Computer operations such as change detection, scene matching, and object recognition are greatly affected due to poor visibility in shadow regions.

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

A shadow is a region where direct light cannot reach due to obstruction by any object. Studies concerning shadow detection and removal have been going on in this field. Here are the basic assumptions of shadows

- The illumination image will be spatially smooth.
- Inside the shadow region no change in the texture of image
- Shadows are reflection image thus pixels inside the shadow regions contain different colors.

Shadow detection and correction is an important pre-processing or image enhancement step. In the shadow detection step we segment the shadow regions from the images where we have to work. Detecting shadow is important as the shadow correction is applied on this detected regions. In the removal stage the image is corrected or recovered from the defects caused by the shadows.

II. RELATED WORK

There were many effective shadow detection algorithms. An invariant color model [1] is used to identify and classify shadows. Shadow candidate regions are extracted first and by using the invariant color features the candidate pixels are classified as cast shadow or as self-shadow points. The shadow areas are estimated according to the space coordinates of buildings which is calculated from digital surface models and also by the altitude and azimuth of the sun. Thus for the accurate identification of shadow, the threshold value is obtained from the estimated grayscale value of the shadow areas [2]

The properties of shadows in their luminance and chrominance space are exploited in [3]. The method is applied in several invariant color spaces, including HCV, HSV, HSI, luma, inphase, and quadrature (YIQ) and YC C models. First the RGB aerial color images are transformed into the invariant color models. Shadow regions are remarkable with increased hue values. For each pixel ratio of Hue over intensity is taken. Thus a ratio image is constructed. Over the histogram distribution of the ratio image an Otsu's method is applied and the threshold for segmenting the regions are determined. To compensate shadow regions from their neighborhoods a two-step histogram matching technique is used.

For accurate shadow detection, instead of using global thresholding scheme a successive thresholding scheme is used in [4]. A ratio map is constructed by the color transformation method explained in [2] and modified by applying exponential function so that the difference between shadow and non-shadow pixels stretches. By applying the global thresholding process the input image is separated into candidate shadow pixels and non-shadow pixels and by using the connected component analysis they are grouped to form candidate shadow regions. Local thresholding process is applied to each region iteratively to detect true shadow pixels from candidate shadow pixels.

Lorenzi [5] proposed a new approach in which shadow areas are detected and classified by means of state of the art support virtual machine. Classifiers (SVM) are trained to detect illumination pairs based on many features. They include comparing their ratio of their intensities, color and texture histograms, their chromatic alignment and their distance in the image. The reconstruction is based on linear regression method by adjusting the intensities of the shaded pixels according to the statistical characters of the corresponding non shadow regions. Apart from pixel or edge information a region based approach is used in [4]. Using graph cut inferences the regions are classified as shadows and non-shadows.

Compared to non-shadow regions, shadow regions possess lower brightness and also have slow gradient change in luminance value. This gradient values of shadow regions are used for shadow detection method based on partial differential equations (PDES) [6]. The algorithm takes the gradient values as parameter of edge detectors. This controls the speed of diffusion of PDES. The calculation is an iterative process. During calculation to protrude shadow regions the algorithm conceal changing pixel values of the non-shadow regions.

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. Due to the shortcomings of shadow detection discussed earlier, we propose a new technique an object-oriented shadow detection and removal method.

III. OBJECT ORIENTED SHADOW DETECTION AND REMOVAL

A recently evolved system explained here resolves the shortcomings of pixel level shadow detection. The method focuses on object oriented shadow detection and removal. The input is a shadow affected images which is to be corrected. The procedure can be mainly divided into two sections, shadow detection and shadow removal.

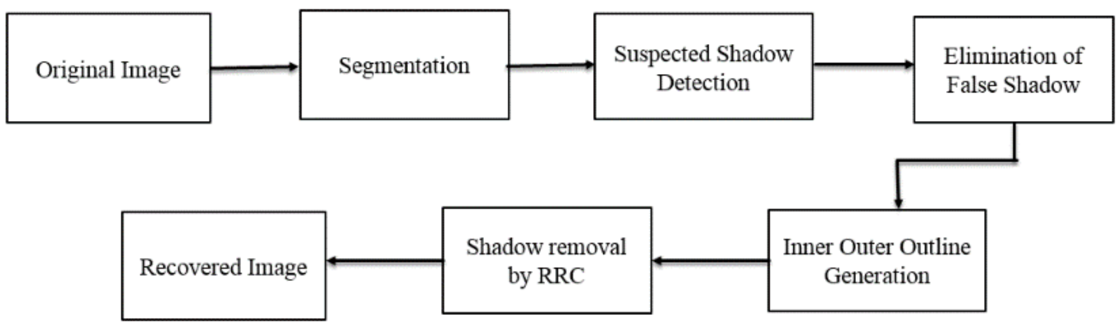

Figure 1. Flowchart of Object Oriented Procedure

A. Shadow Detection

First, the shadow features are assessed through image segmentation, and suspected shadows are detected. Object properties such as geometrical features and spectral features are combined with a spatial relationship in which the false shadows are detected. Shadow detection includes a series of steps.

1) Image Segmentation

Pictures with higher resolution contain wealthier spatial information. The contrasts of neighboring pixels inside an object increment gradually. When considering high resolution images pixel-based strategies focus on details of an object and it is difficult to obtain overall structural information. To utilize spatial data to identify shadows, image segmentation is required. A convexity model (CM) constraint is used for segmentation.

2) Suspected Shadow Detection

Without too many pixels being misclassified an appropriately set threshold can separate shadow from non-shadow regions. There are different methods to find the threshold which accurately separates shadow and non-shadow areas. The threshold is obtained according to the histogram of the original image. The suspected shadow objects are found out by comparing the grayscale average and threshold of each object obtained in segmentation.

3) False Shadow Elimination

Dark objects may be miss detected as shadows. Vegetation, water bodies etc. may be misclassified as shadows Thus accurate shadow detection method are necessary to eliminate this dark objects from the suspected shadows. Thus waveband properties are considered. The portion containing vegetation make the greyscale average at green waveband significantly larger than blue and red wavebands. Thus by comparing $G_b + G_a < G_g$ vegetation can be ruled out, where G_a is the correction parameter.

B. Shadow Removal

This stage deals with the correction of shadow affected areas. This includes the following steps.

1) IOOPL Matching

For the removal of shadow areas from image IOOPL section matching is used. First shadow boundary is considered and let it as R. Contract inwards to get inner line R1 and dilate the boundary outwards to get outer line R2. The greyscale value of each line is taken and compared. Thus the correlation is found out. If correlation is high the area belongs to same object. Section by section the similarity of each line pair is calculated and homogenous and nonhomogeneous sections and are obtained.

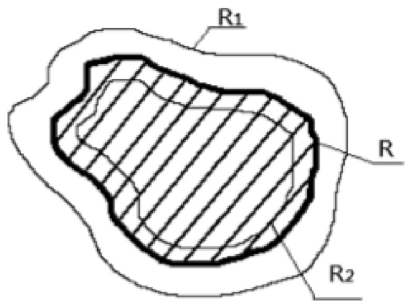

Figure 2. Shadow boundary inner and outer outline lines

2) Shadow Removal By Relative Radiometric Correction

Radiation parameter is calculated according to the homogeneous points of each object and relatively radiometric correction is done. There is a linear relationship between greyscale value digital number (DN) of the picture to be corrected and DN of the reference image. Thus radiation value correction of shadow areas are done. Therefore IOOPL matching effectively restores the information within a shadow area. But because of filming environment obvious color cast can be seen in some parts of shadow areas. IOOPL matching can relieve this problem only to a certain extent.

IV. OBJECT ORIENTED SHADOW DETECTION AND SHADOW CORRECTION BY INPAINTING

Below given figure describes the architecture of proposed method.

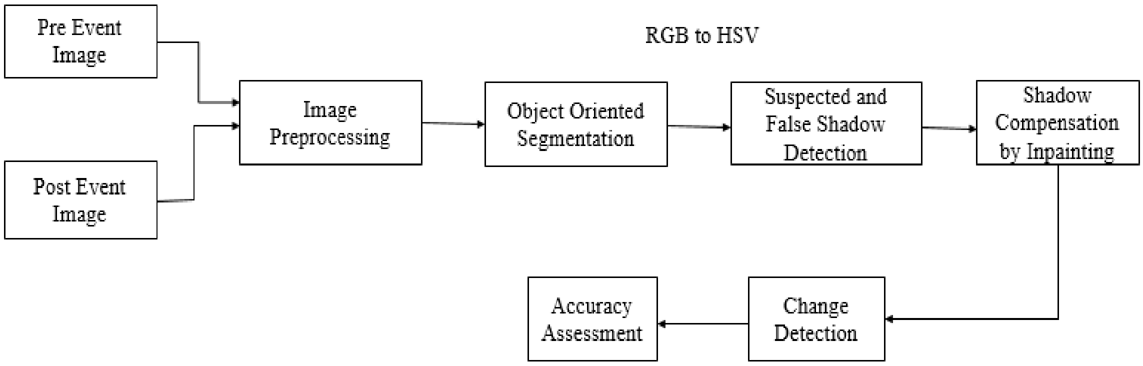

Figure 3. Architecture of proposed system

The above gives the architecture of the proposed system. The shadow features are evaluated through segmentation. The shadow detection is object oriented. Thus shadows are extracted object by object. No need to check pixel by pixel whether each pixel is affected by shadow. The colored image is converted into the HSV space. Hue-saturation-value (HSV) is one of the finest cylindrical-coordinate representations of points in an RGB color model. HSV colors are described by their hue, saturation, and intensity, not on the basis of percentages of primary colors. RGB is the way computers treats color ie, it deals with implementation details regarding how RGB displays the color, and HSV try to capture the components of the way humans perceive color.

In HSV color space, the dominant wavelength is represented as H. There is a big chromaticity difference between ambient and diffuse light, but the value of H remains nearly the same. If RGB is used instead of HSV, a high threshold will be needed to accommodate to this difference. Two chromaticities with two different dominant wavelengths may be considered as similar in RGB. This is because of the weak chromaticity constraint and lack of representation of dominant wavelength. There are more chances of false positive errors in algorithms using RGB color space. The thing doesn't differs if the object reflectance coefficient to a distinct wavelength is notably greater than the reflection coefficients to other wavelengths. Thus light reflecting from these objects, whether there is a shadow or not always have the same dominant wavelength. But in HSV spaces for both cases, the chromaticities of the pixels in the image have a high value of saturation. Thus suspected shadow detection is very easy.

Dark objects may be mis-detected as shadows in the suspected shadows so more accurate shadow detection results are needed to eliminate these dark objects from the suspected shadows. This represents the false shadow detection. Vegetation and water bodies are ruled out by considering the blue and green waveband properties in HSV space. Also spatial relationship between objects and geometrical characteristics are used to rule out other dark objects from suspected shadows.

Shadow compensation is to recover the shadow areas in an image. Shadow compensation is done by performing image inpainting. It refers to the application of sophisticated algorithms to replace lost or corrupted parts of the image data. Median diffusion inpainting is performed here. The technique uses median filter which is one of the most popular nonlinear (order statistics) filters. For the Laplacian distribution the median is maximum likelihood estimate of location. Hence, the inpainting algorithm proceeds by diffusing median value of pixels from the exterior area into the inner area to be inpainted. An important property needed during inpainting is the preservation of edges which the median filter do well. This technique is stable. Shadow areas can be restored like this.

As an extension to the shadow detection and removal, change detection can be added to the procedure. The pre event and post event images are for performing the change detection. It describe, and quantify differences between images of the same scene which is taken at different times or under different conditions. It is useful in many applications such as land use changes, habitat fragmentation, urban sprawl and other cumulative changes. For that first the image need to be preprocessed. There are many change detection methods. Produce the change map by each methods. Some of the methods include image rationing, image differencing, watershed and texture transformation. After that combine the change map for the final result. Accuracy assessment is done by incorporating different change detection method results.

V. CONCLUSION

There are various methods for shadow detection and removal. Many of them methods 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. Thus came the object oriented shadow detection and removal. But in the existing method even after the shadow removal color casting of the image is a problem. This problem can be effectively resolved by image inpainting as this method fills holes in the image by searching for similar patches in nearby areas.

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