Detection and Removal of Shadow from Urban High-Resolution Remote Sensing Images Using Object-Oriented Technique

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Abstract — In this paper, an object-oriented shadow detection and removal method is used. For the characteristics of urban high-resolution remote sensing images this is forward method . In this method, during image segmentation, shadow features are considered. After that according to statistical features of the images, suspected shadows are extracted. Generally some dark objects are taken as shadows by mistake. These dark objects are known as false shadows. These false shadows are ruled out according to object properties and spatial relationship between objects. From this method shadow is detected from image. For the removal of shadow, inner-outer outline profile (IOOPL) matching is used. First, IOOPLs are obtained from the boundary lines of shadow. Removal of shadow is then performed according to the homogeneous sections. Homogeneous sections are attained through IOOPL similarity matching. This object-oriented shadow detection and removal method gives shadow-free urban high resolution images.

Keywords — **Change detection, image segmentation, inner–outer outline profile line (IOOPL), object-oriented, shadow detection, shadow removal.**

I. INTRODUCTION

The presence of shadows has been responsible for reducing the reliability of many computer vision algorithms, including segmentation, object detection, scene analysis, tracking, etc. Therefore, shadow detection and removal is an important pre-processing for improving performance of such vision tasks. For the observation of Earth and the rapid development of some aerial platforms such as airships and unmanned aerial vehicles, high spatial-resolution satellites such as IKONOS, Quick-Bird, Geo-Eye, and Resource 3 are available. There has been an increasing need to analyze high-resolution images for different applications. In urban areas, surface features are somewhat complex, objects and shadows formed by elevated objects such as high buildings, bridges, and trees. Although shadows themselves become a type of useful information in 3-D reconstruction, building position recognition, and height estimation. They can also interfere with the processing and application of high-resolution remote sensing images. For example, shadows may cause errors and incorrect results during change detection. In the applications of urban high-resolution remote sensing images like object classification, object recognition, change detection and image fusion detection and removal of shadow is important [1][2].

The obstruction of light by objects creates shadows in a scene. An object may cast a shadow on itself, called self-shadow. The shadow areas are less illuminated than the surrounding areas. In some cases the shadows provide useful information, such as the relative position of an object from the source. But these shadows can cause problems in computer vision applications like segmentation, object detection and object counting. Thus shadow detection and removal is a pre-processing task in many computer vision applications. Based on the intensity, the shadows are of two types − hard and soft shadows. The soft shadows retain the texture of the background surface, whereas the hard shadows are too dark and have little texture. Thus the detection of hard shadows is complicated as they may be mistaken as dark objects rather than shadows [1].

In most of the cases, the optical images are contaminated with shadow. In optical images cast shadows are obtained from light source being blocked by objects and self shadows are on the side that is not facing the light source, Therefore parts of image are not illuminated by direct light. These regions are mostly taken as darkest areas in an image and can be misclassified as dark objects for example water. So to avoid this type of errors and incorrect results detection and removal of shadows is necessary [3].

II. PROPOSED METHODOLOGY

A] Description:

When light source has been blocked by something it causes shadows. There are two types of shadows:

1) Self-shadow

2) Cast shadow

The shadow on a subject on the side that is not directly facing the light source is known as self-shadow. The cast shadow is defined as the shadow of a subject falling on the surface of another subject because the former subject has blocked the light source. In this paper, main focus is on the shadows in the cast shadow area of the remote sensing images.

Here object-oriented shadow detection and removal method over the pixel-level shadow detection is used. In the first step, shadow features are evaluated through image segmentation and after that suspected shadows are detected with the threshold method. In the second step, to remove the false shadows from image, object properties such as spectral features and geometric features are combined with spatial relationship. It gives the allowance to real shadows to be detected in subsequent steps. For the removal of shadow extraction of the inner and outer outline lines of boundary of shadow. With the help of inner-outer outline profile lines (IOOPLs) the grayscale values of corresponding points on the inner and outer lines are indicated. Through IOOPL sectional matching homogeneous sections are obtained. Finally by using the homogeneous sections, the relative radiation calibration parameters between the shadow and non-shadow regions are obtained. And then shadow removal is performed.

B] Methodology:

An image of any object contains false and true shadow. Detection and removal of shadow from images is divided into two phases:

I) Shadow Detection

II) Shadow removal

1. **Shadow Detection:**
   In the phase of shadow detection, we will eliminate false shadow from image. Detection of shadow contains segmentation of shadow, detection of suspected shadow and elimination of false shadow. The schematic flow of shadow detection is shown in figure 1.

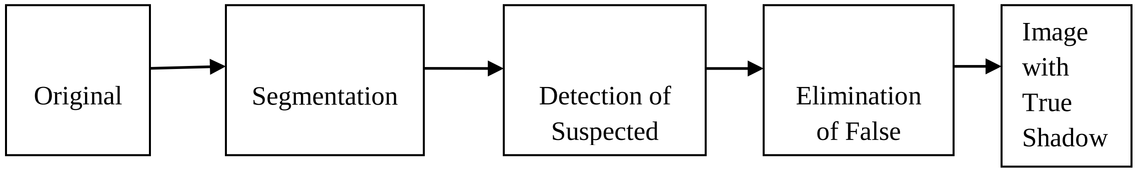

Figure 1: Block Diagram of Shadow Detection

ISSN: 2231-5063.

1.1. Segmentation:

Traditional image segmentation method results in insufficient segmentation, which makes it difficult to separate shadows from dark objects. In this paper, Convexity model (CM) based for segmentation along with colour factor and shape factor is used in which distinguish between the shadows and dark objects. The parameters of every object will be recorded, including grayscale average, variance, area, and perimeter.

1.2. Detection of suspected shadow:

To find the threshold for shadow detection, binomial histogram splitting is feasible way. The mean of two peaks of histogram is taken as threshold. It will attain the threshold according to histogram of original image. Then it will find the suspected shadow objects by comparing threshold and grayscale average of each object which is obtained in segmentation. Then it will choose the grayscale value with minimum frequency in the neighborhood of the two peaks as threshold using equation (1) and (2)

$$Gq = \frac{1}{2}(Gm + Gs) \qquad (1)$$

$$h(T) = \text{Min}\ \{h(Gq-\varepsilon),\ h(Gq+\varepsilon)\} \qquad (2)$$

Where, Gm- Average grayscale value of an image

Gs - Left peak of the shadow in the histogram

T - Threshold, where $T \in [Gq-\varepsilon, Gq+\varepsilon]$

ε - Neighborhood of T

$h(I)$- Frequency of I , where $I = 0, 1, \ldots, 255$.

After conducting large number of experiments, it has found that to replace the right peak, the average of grayscale values are used. To simplify this operation Gs i.e. left peak of the shadow in the histogram can be replaced by half of the grayscale average, when the left peak is not required. To avoid the influence of abnormal information, some pixels on left and right sides of histogram are not included. For the same object, when in the shadow and non-shadow area, their grayscale difference at the red and green wavebands is more noticeable than at the blue waveband. Thus, it retrieve a suspected shadow using the threshold method at the red and green wavebands.[1]

1.3. Elimination of False Shadow:

In the suspected shadows, dark objects may be included. So for the more accuracy of shadow detection, elimination of dark objects is necessary. Rayleigh scattering gives result in smaller grayscale difference between shadow and non-shadow area in the blue (B) waveband than in red (R) and green (G) waveband. Consequently, for the majority of shadows, grayscale average at blue waveband is slightly greater than grayscale average at green waveband. Also, properties of green vegetation itself make green waveband significantly greater than blue waveband. So, false shadow from vegetation can be eliminated by comparing blue waveband and green waveband of all suspected shadows.

2. Shadow removal:

In the phase of shadow removal, it will remove true shadow from the image. Removal of shadow comprises boundary extraction, implementation of shadow removal.

The schematic flow of shadow removal is shown in following diagram.

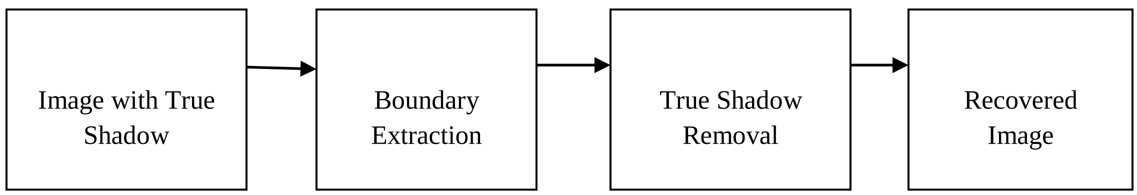

Figure 1: Block Diagram of Shadow Removal

2.1. Boundary Extraction:

There will be large probability of both shadow and non-shadow areas in close range on both sides of shadow boundary belong to same type of object. By contracting the shadow boundary inward and outward gives the inner and outer outline of shadow image. To determine the radiation features of same type of object on both sides of shadow boundary, the inner and outer outline profile lines (IOOPL) are generated along inner outer outline lines. In shadow detection we will get vector line of shadow detection. Non-shadow area will be expanded outward from shadow boundary and shadow area will be contracted inward from shadow boundary. There is one-to-one correspondence between nodes along inner and outer outline. It gives the extracted boundary of shadow image.

2.2. True Shadow Removal:

Shadow removal method is based on inner-outer outline profile line (IOOPL) matching. When the correlation between both inner and outer outlines is close enough, there is large probability that this location belongs to same type of object. The grayscale value of corresponding nodes along inner and outer outline at each waveband will be collected to obtain inner outer outline profile line (IOOPL). IOOPL matching will be used to recover shadow areas in an image. IOOPL will divide into average sections with same standard to rule out non-homogeneous sections. Then similarity of each line pair will be calculated section by section using equation (3). In this equation similarity of set A and set B is expressed.

Similarity,

$$(A, B) = \frac{\sum_{i=1}^{n}(c_i^A - \overline{c^A})(c_i^B - \overline{c^B})}{\sqrt{\sum_{i=1}^{n}(c_i^A - \overline{c^A})^2 \cdot \sum_{i=1}^{n}(c_i^B - \overline{c^B})^2}} \qquad (3)$$

Where, A= Curve representing one set

B= Curve representing another set

c_i^x = Grayscale of node i on curve X

$\overline{c^{x}}$ = Grayscale average of all nodes on curve X

In IOOPL matching, if the correlation coefficient is large, then IOOPL line pair belongs to same type of object, and thus considered to be matching. And if correlation coefficient is small, then some different types of objects exists in this section. So these parts will be ruled out. [1]

In the implementation of true shadow removal, true shadows are removed with the help of homogeneous sections obtained by line pair matching. There are two approaches for the shadow removal. One approach is relative radiation correction which calculates the radiation parameter according to homogeneous points to each object. Second approach is polynomial fitting which collects and analyze all homogeneous sections and retrieves all shadows directly with obtained fitting parameters.

III. RESULT

The results of this methodology are shown through images.

Step 1:- In the first step, input image is taken. The input image can be colour image or grayscale image. If image is taken colour then it will be converted into grayscale image. It is shown in fig. 3.

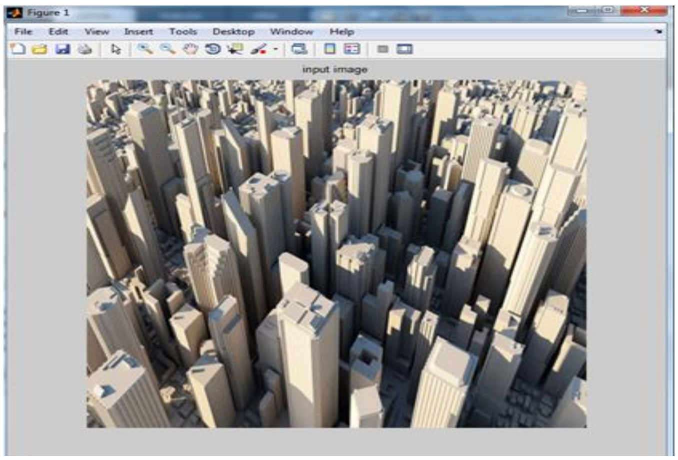

Figure 3. Input Image

Step 2:- In second step, segmentation is done. The segmented image is shown in fig. 4.

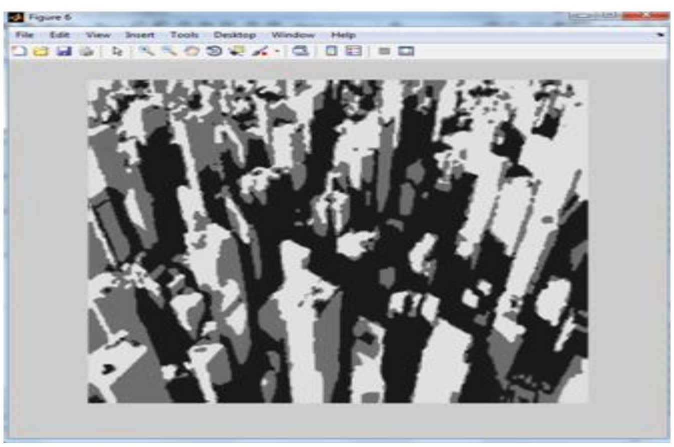

Figure 4. Segmented Image

ISSN: 2231-5063.

Step 3:- In third step, suspected shadow is detected. And after that false shadow is eliminated. The suspected shadow detection and elimination of false shadow id show in fig. 5.

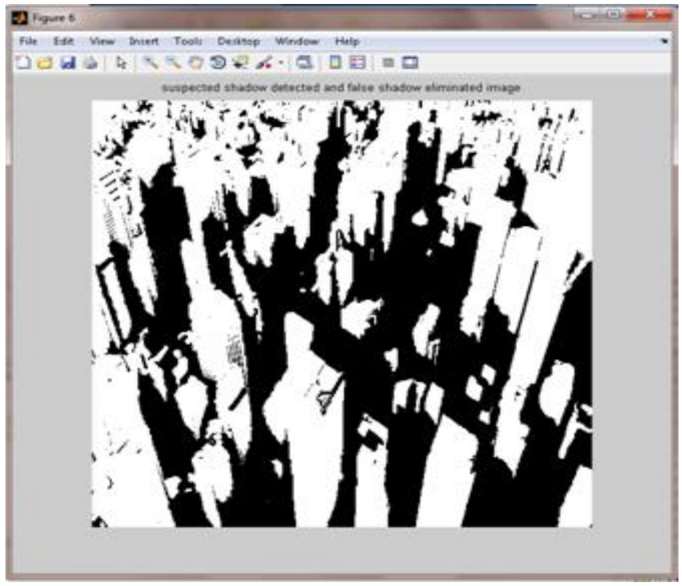

Figure 5. Suspected Shadow Detected and False Shadow Eliminated Image

Step 4:- In the fourth step, inner and outer outline line generation is done. For shadow removal IOOPL (Inner and Outer Outline Profile Line) is used. The graphical representation of IOOPL is shown in fig. 6.

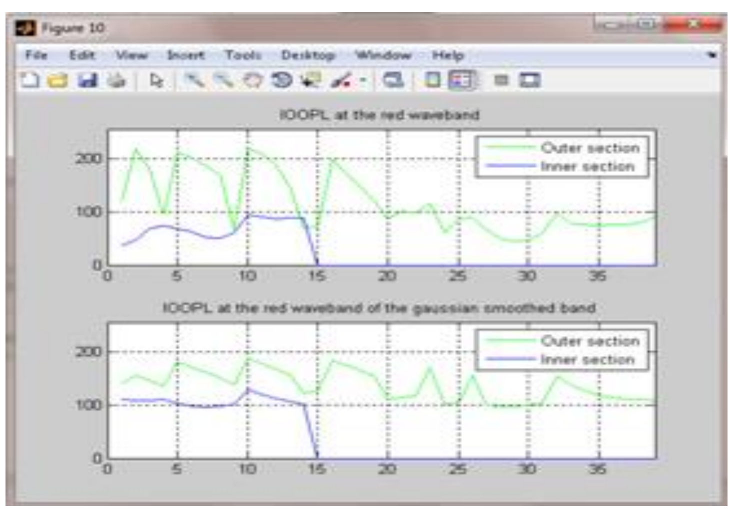

Figure 6. IOOPL Graph Generation

Step 5:- In the fifth step, shadow removal is done with the help of RRN (Relative Radiometric Normalization) and PF (Polynomial Fitting). Thus the final output i.e. recovered output image is shown in fig 7.

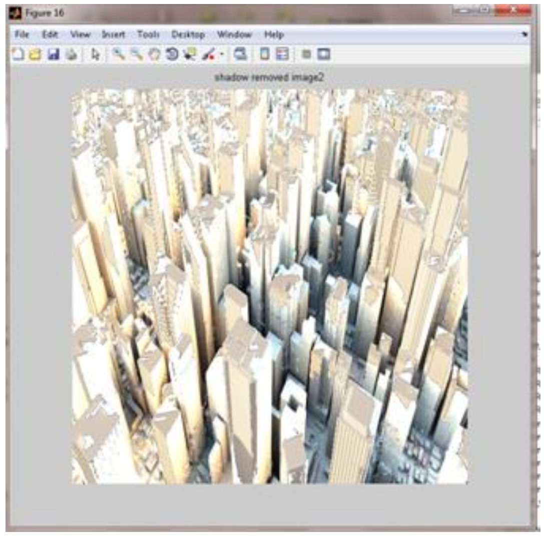

Figure 7. Output Image

IV. CONCLUSION

Shadow detection method is proposed for stable and accurate identification of shadows. Shadow detection is done with the help of threshold method. The object-oriented shadow detection method is used for shadow detection which makes full use of spatial information of an image. It is simple but effective way to ensure shadow detection in an image. With the help of boundary extraction we get the shadow free image. Here for shadow removal IOOPL matching method is used. From this process shadow free image is obtained.

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