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Region Growing Thresholding Based Object-Oriented Shadow Detection and Removal from Urban High-Resolution Remote Sensing Images

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Abstract: *High-resolution remote sensing images offer great possibilities for urban mapping. Unfortunately, shadows cast by buildings during this some problems occurred .This paper mainly focus to get the high resolution colour remote sensing image, and also undertaken to remove the shaded region in the both urban and rural areas. The region growing thresholding algorithm is used to detect the shadow and extract the features from shadow region. Then determine whether those neighbouring pixels are added to the seed points or not. In the region growing threshold algorithm, Pixels are placed in the region based on their properties or the properties of nearby pixel values. Then the pixels containing similar properties are grouped together and distributed throughout the image. IOOPL matching is used for removing shadow from image. This method proves it can remove 80% shaded region from image efficiently.*

Keywords: *region growing thresholding, IOOPL (inner-outer outline profile line)*

1. Introduction

Now a days, the man survive large area of the world, so to monitor land area satellite imaging is used to detect the earth locality from the satellites of IKONOS, QUICKBIRD and RESOURSE3. The shadow is occurred by interfacing of building and sun. A shadow occurs when an object partially or totally occludes direct light from a source of illumination [1]. Shadows can be divided into two classes: self and cast shadows. A self-shadow occurs in the portion of an object which is not illuminated by direct light.A cast shadow is projected by the object in the direction of the light source. The part of a cast shadow where direct light is completely blocked by an object is called the umbra, while the part where direct light is partially blocked is called the penumbra.The shadow formation is shown in Fig.1. This paper mainly focuses on the shadows in the cast shadow area of the remote sensing images by using region growing thresholding.

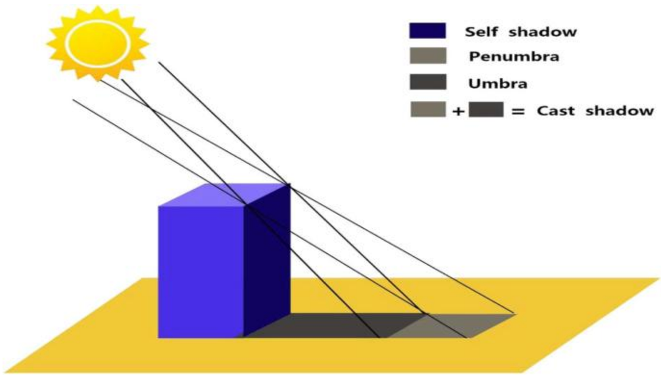

Fig.1. *Principle of shadow formation*

In this process some of the problems occurred, due to the shadow of an urban and rural area. Many effective algorithms have been proposed for shadow detection.Many seminal papers proposed some methods to detect& eliminate shaded region by using edge detection methods, but it has some drawbacks are no image calibration for the intensity and, illumination adjustment. So this paper mainly focus to get the high resolution colour remote sensing image, and also undertaken to remove the shaded region in both urban and rural areas.

Because of the ambient light, the ratios of the two pixels are not same in all three colour channels. These two pixels will be different not only in intensity, but also in hue and saturation. Thus, correcting just the intensity of the shadowed pixels does not remove the shadow, and we need to correct the chromaticity values as well. Using the shadow density, the shadow area is segmented into sunshine, penumbra and umbra regions. Since the lighting colour of the umbra region is not always the same as that of the sunshine region, colour adjustment is performed between them. Then, the colour average and variance of the umbra region are adjusted to be the same as those of sunshine region. In the penumbra, colour and brightness adjustments for small Deb et al.: Shadow Detection and Removal Based on regions are performed the same as they are for umbra region. Finally, all boundaries between shadowed regions and neighbouring regions are smoothed by convolving them with a Gaussian mask.

2. METHODOLOGY

Seeded region growing thresholding method is used for detecting shadows in image. This algorithm follows the below processes to detect the shadows.

A. Pre-processing:

In pre-processing, the input image is under gone for RGB into grayscale image conversion process. The converted grayscale image is resized into specific resolution; hence the resolution is maintained till further process. If any noise is added to image, then the image is not proper visible, so a filter is used to eliminate noise present in the image. In this method, Pre-processing is carried out by resizing the image. Then the resized image is converted into grayscale image. The grayscale image is then converted into the noise free image by using medianfilter. This filtered image is then converted into binary image. The object region is considered as '1' and dark area is considered as '0'.After Pre-processing image look likes as shown in fig 2.

Fig.2. *Pre-processed image*

B. Feature Extraction:

Feature extraction is the process of extracting required data's from the region of interest. In this method, shadow feature is extracted by region growing threshold method. Then the object properties such as spectral features and geometric features are combined with a spatial relationship, in which the false shadows are detected and eliminated. In this technique, the feature extraction is carried to extract the features of five major categories.

- Extract average grayscale value of Pre-processed image.
- Extract histogram peak of shadow area.
- Calculatethreshold value of image.
- Extract frequency of image also.
- Extract nearby pixel values from same image.

C. Segmentation:

Segmentation is the process of separating required part from the cluster of unwanted background region. To separate required object, shape factor and colour factor is considered to remove the shadow, but dark region of image should not be eliminated. The parameter of each image is recorded and then variation in the shadow and dark area is noted.

By using the method of region growing threshold algorithm, Pixels are placed in the region based on their properties or the properties of the nearby pixel values. Then the pixels containing the similar properties are grouped together and then the large number of pixels is distributed throughout the image. The aim of region detection is to provide the possibility to characterize the detected object by parameter analysis (shape, position, size...) Edge-based segmentation: borders between regions. Region-based segmentation [6]: direct construction of regions. It is an easy way to construct regions from their borders and it is also easy to detect borders of existing regions. Segmentations resulting from edge-based method and region growing method are not usually exactly the same. Region growing is simplest in region-base image segmentation method. The concept of region growing algorithm is check the neighbouring pixels of the initial seed points, then determine whether those neighbouring pixels are added to the seed points or not.The resultant image is as shown in fig.3

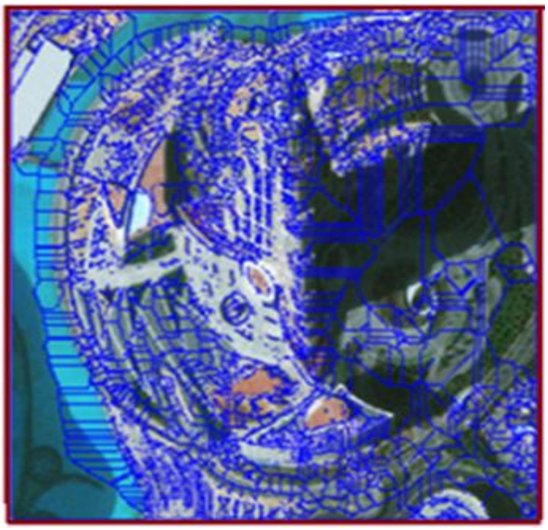

Fig.3. *segmented image*

D. Shadow Detection:

Here main focus is only on the shadows in the cast shadow area ofremote sensing images. Therelationship between shadows and it regions is formalized in order to derive relevant shadow properties.

i. Spectral properties of shadows:

To describe the spectral appearance [7] of a surface in shadow, let us consider the physics of colour generation. The appearance of a surface is the result of interaction among illumination, surface reflectance properties, and responses of a chromatic mechanism. This chromatic mechanism is composed of three colour filters in a colour camera. Ambient light can have different spectral characteristics with respect to direct light. The case of outdoor scenes, where the diffuse light from the sky differs in spectral composition with respect to the direct light from sun.

ii. Geometrical properties of shadows:

The geometric appearance [7] of a shadow depends on objects and scene layout. However, it is possible to identify some geometrical characteristics of shadows, theshadow boundaries, without any knowledge of the structure of the object or of the scene. Shadow boundaries can be classified into four classes: shadow-making lines, shadow lines, occluding lines, and hidden shadow lines. These lines are depicted in Fig.4.

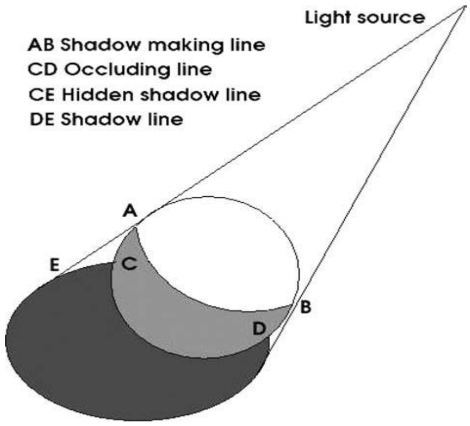

Fig.4.*Shadow lines definition.*

iii. Detection of Shadow Areas:

In this method,shadow feature is extracted with region growing threshold method.Then object properties such as spectral features and geometric features are combined with a spatial relationship, in which the false shadows are detected and eliminated.

Researchers have used several different methods to find the threshold to accurately separate shadow and non-shadow areas.By the method region growing thresholding, detection of shadow and non-shadow areas and correctly separating the regions that have same properties are easily carried out.In the Histogram splitting provides a feasible way to find the threshold for shadow. In the histogram averageof the two peaks is adopted as the threshold. The shadow objects are found by comparing the threshold and grayscale average of each object obtained in segmentation. In addition, atmospheric molecules scatter the blue wavelength most among the visible rays (Rayleigh scattering). So for the same object, when in shadow and non-shadow, its grayscale difference at the red and green wavebands is more noticeable than at the blue waveband. Thus, a suspected shadow is retrieved with the threshold method at the red and green wavebands. Specifically, an object is determined to be a suspected shadow if itsgrayscale average is less than the thresholds in both red and green wavebands. The resultant image as shown in fig.5.

Fig.5. *shadow detection*

E. Elimination of False Shadows

Dark objects may be included in the suspected shadows, so more accurate shadow detection results are needed to eliminate these dark objects. Rayleigh scattering results in a smaller grayscale difference between a shadow area and a non-shadow area in the blue (B) waveband than in the red (R) and green (G) wavebands. Consequently, for the majority of shadows, the grayscale average at the blue waveband *Gb*is slightly larger than the grayscale average at the green waveband *Gg*. Also, the properties of green vegetation itself make *Gg*significantly larger than *Gb*, so false shadows from vegetation can be ruled out by comparing the *Gb* and *Gg*of all suspected shadows. Namely, for the object *i*, when *Gb*+ *Ga* <*Gg*, *i*can be defined to be vegetation and be ruled out. *Ga* is the correction parameter determined by the image type.

After the elimination of false shadows from vegetation, spatial information of objects, i.e., geometrical characteristics and the spatial relationship between objects is used to rule out other dark objects from the suspected shadows. Lakes, ponds, and rivers all have specific areas, shapes, and other geometrical characteristics. Most bodies of water can be ruled out due to the area and shape of the suspected shadows of the object that they produce. However, the aforementioned method still cannot separate shadows from some other dark objects. Spatial relationship features are used to rule out dark objects in the suspected shadows. Dark objects are substantive objects, while shadows are created by taller objects which block the light sources and may be linked together with the objects that result in the shadows. An obscured area (i.e., a shadow) forms a darker area in an image. The object blocking the light forms a lighter area in an image. At the same time, the sun has a definite altitude angle, and a shadow boundary reflects the boundary of a building and the position of a light source. Buildings, trees, and telegraph poles are the main objects creating shadows in urban remote sensing images. Their shadow boundaries usually have a certain direction. To retrieve shadows using spatial relationships, the linear boundaries of suspected shadows are first analysed to predict the probable trend of a shadow, according to which the approximate position of a large object is predicted. To determine whether it is a shadow, the proximity of a dark object to a light object within this azimuth is measured. An average spectral difference can be used to decide whether there are light objects linked around a shadow.After elimination of false shadows the image is as shown in fig.6

Fig.6. *elimination of false shadows*

F. Inner and Outer Outlines:

To recover the shadow areas in an image, we use a shadow removal method based on IOOPL [3] matching. There is a large probability that both shadow and non-shadow areas in close range on both sides of the shadow boundary belong to the same type of object. The inner and outer outlines can be obtained by contacting the shadow boundary inward and expanding it outward, respectively. Then, the inner and outer outline profile lines are generated along the inner and outer outline lines to determine the radiation features of the same type of object on both sides. As shown in Fig. 7, *R* is the vector line of the shadow boundary obtained from shadow detection, *R*1 is the outer outline in the non-shadow area after expanding *R* outward, and *R*2 is the inner outline in the shadow area after contracting *R* inward. There is a one-to-one correspondence between nodes on *R*1 and *R*2. When the correlation between *R*1 and *R*2 is close enough, there is a large probability that this location belongs to the same type of object. The grayscale value of the corresponding nodes along *R*1 and *R*2 at each waveband is collected to obtain the IOOPL. The outer profile lines (OPLs) in the shadow area are marked as inner OPLs; OPLs in the non-shadow area are marked as outer OPLs (Fig. 7). The objects on both sides of the shadow boundary linked with a building forming a shadow are usually not homogeneous, and the corresponding inner and outer outline profile line sections are not reliable. In addition, the abnormal sections on the inner and outer outlines that cannot represent homogeneous objects need to be ruled out. Consequently, similarity matching needs to be applied to the IOOPL section by section to rule out the two kinds of non-homogeneous sections mentioned previously. The parameters for shadow removal are obtained by analysing the grayscale distribution characteristics of the inner and outer homogeneous IOOPL sections.

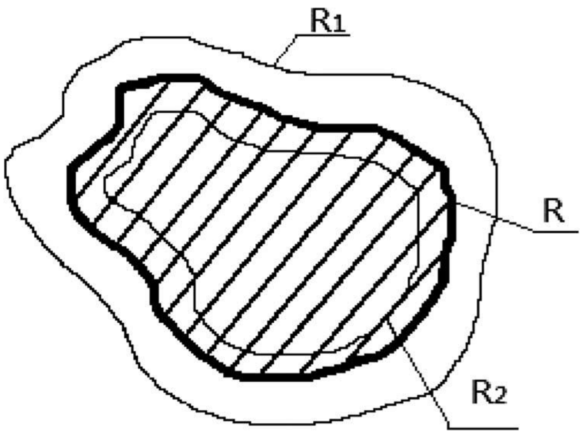

Fig.7. *Diagram of shadow boundary, inner, and outer outline lines.*

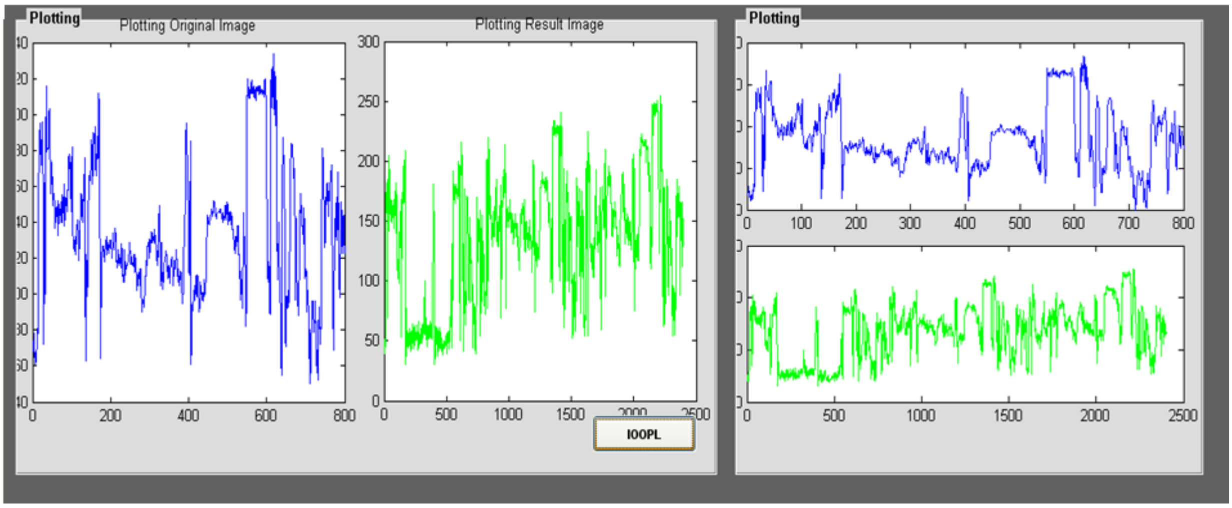

Fig.8. *IOOPL Matching*

G. IOOPL Matching:

IOOPL matching is a process of obtaining homogeneous sections by conducting similarity matching to the IOOPL section by sectionis shown in fig.8. Gaussian smoothing is used to simplify the view of IOOPL. The Gaussian smoothing template parameters were $\sigma = 2$ and $n = 11$.To rule out the non-homogeneous sections, IOOPL is divided into average sections with the same standard, and then, the similarity of each line pair is calculated section by section. If correlation coefficient is large, it means that the shade and light fluctuation features of the IOOPL line pair at this section are consistent. If consistent, then this line pair belongs to same type of object, with different illuminations, and thus is considered to be matching. If correlation coefficient is small, then some abnormal parts representing some different types of objects exist in this section.

3. IMPLEMENTATION OF SHADOW REMOVAL

Shadows are removed by using the homogeneous sections obtained by line pair matching. There are two approaches for shadow removal. One approach calculates radiation parameter according to the homogeneous points of each object and then applies the relative radiation correction to each object. The other approach collects and analyses all homogeneous sections for polynomial fitting (PF) and retrieves all shadows directly with the obtained fitting parameters.

Evaluation Criteria

Relative radiation correction generally assumes that a linear relationship exists between the grayscale value digital number (DN) of the image to be corrected and the DN of the reference image

$$\text{DNref} = a \times \text{DNrect} + b.$$

DNref is the DN of the object in the reference image, DNrect is the DN of the object in the image to be corrected, and a and b are the gain and offset respectively.

The gain and offset of the linear function can be estimated by the DN of the homogeneous sections. DNrect is the DN of the outer homogeneous sections, and DNrect is the DN of inner homogeneous sections. The radiation correction coefficients of the mean and variance method are

$$a_k = \frac{s_{yk}}{s_{xk}}; b_k - \overline{y_k} - a_k . \overline{x_k}$$

where $\overline{x_k}$ is the grayscale average of the inner homogeneous sections at the waveband k, $\overline{y_k}$ is the grayscale average of the outer homogeneous sections at the waveband k, $s_{xk}$is the standard deviation of the inner homogeneous sections at the corresponding waveband, and $s_{yk}$is the standard deviation of the outer homogeneous sections at the corresponding waveband. All points of the shadow are corrected according to

$$\text{DNnonshadow} = a_k \times \text{DNshadow} + b_k ,$$

where *DN*nonshadow stands for the pixel gray scale of the Shadow after correction, *DN*shadow stands for the pixel gray scale of the shadow before correction, and $a_k$and $b_k$are the coefficients of the minimum and maximum method or mean variance method calculated with the homogeneous points of the object.

In PF, the grayscale value of the shadow area is directly obtained with the fitting parameters, as shown in

$$f(x) = ax3 + bx2 + cx + d$$

After transforming the grey scale of the shadow area through $f(x)$, the shadow removal result can be obtainedand is shown in fig.9.

Fig.9. *Resultant image*

Analyse shadow and removal using mean and standard deviation as shown in below.

Table 1. *Sample analysis*

	Mean	Standard deviation
Original image	115.05	59.3875
Recovered image	139.03	48.0605

4. CONCLUSION

This paper proposed a forward method for shadow detection and removal in a single urban high resolution remote sensing images is REGION GROWING ALGORITHM for detecting shadow in images. Based on this methodto check neighbouring pixels of the initial seed points and then determine whether those neighbouring pixels are added to the region or not by this we can eliminate false shadows. For shadow removal based on IOOPLmatching can effectively restore the information in a shadow area. The homogeneous sections obtained by IOOPL matching can show the radiation grey scale of the same object in a shadow area and a non-shadow area. The parameters calculated by using the radiation difference between inner and outer homogeneous sections can retrieve a shadow very effectively.

Further improvements are needed in the following ways.

Region growing algorithm is better than previous methods for clear edges with good segmentation results. But still exist it power consumption and time consuming.Because of the filming environment or some other reasons, obvious colour cast can be seen in some parts of a shadow area. IOOPL matching could relieve this case to a certain extent but not completely resolve the problem.

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