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Satellite Image Enhancement Technique by Shadow Detection and Shadow Removal by AHE Technique

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ABSTRACT: According to the characteristics of urban high- resolution image remote sensing, we can work on shadow detection and removal method considering the object orientation. In this project work, shadow affected area are taken segmentation, and according to the statistical features the suspected shadows are extracted. After that, the dark objects which could be mistaken for shadows are taken off according to object properties and spatial relationship between objects. For the object detection we apply new technique which might be extension of Tsai method. In this method we apply color image transformation and global thresholding, morphological erosion convolution filtering. Experimental result shows that the accuracy of the new method is more. For shadow removal we use avalanche histogram equalization.

I. INTRODUCTION

In the last ten or more years, with the availability of high resolution satellites, the observation of Earth and the rapid development of some platforms such as airships and nonhuman-aerial vehicles, there is an increasing need of analyzing high-resolution images for different applications. If we consider the urban areas then we can easily get that, surfaces are quite complex, shadows formed by elevated objects like some tall buildings, bridges and trees. In one consideration shadows themselves can be useful for the information in 3-D reconstruction, building position, height estimation [1], [2], but it can also interfere with the processing and for high-resolution remote sensing images [3]–[5]. For example, shadows cause incorrect results during change detection. So, the detection and removal of shadows play an important role in applications of urban high-resolution sensing images such as object classification and recognition, change detection and image fusion.

There are number of algorithms for the detection of shadow. Existing shadow detection methods can be generally categorized into two groups [6]: first is model-based and second is a feature-based method. In model-based group it is based on information such as moving targets, and camera altitude to construct shadow [7], [8]. The second method identifies shadow areas with information of gray scale, brightness, saturation, and texture. By combining the two methods we can make improved algorithm. At start, shadow area are estimated by space coordinates of buildings or objects calculated from digital surface models, the altitude and azimuth of the sun. Then, to identify shadow accurately, the threshold value is calculated from the estimated grayscale value of the shadow areas. Generally most shadow algorithms for detection are based on shadow features. For example, the shadow region is appears like low grayscale value in the image, and for the threshold value is chosen between two peaks in the grayscale histogram of the image data to separate the shadow from the nonshadow region [3], [9]. According to many theories, images are converted into different invariant color forms like Hue-Saturation-Value (HSV), HCV, Luminance- Inphase-Quadrature (YIQ) to obtain shadows with Otsu's algorithm [11]. This helps to prevent the false shadow created by vegetation in certain invariant spaces. According to that work, for the shadow detection a successive thresholding scheme was proposed. To remove the false shadows, normalized difference vegetation index, the normalized saturation–value difference index and the size and shape of the shadow area are considered. Recently, to detect shadows, a hierarchical supervised classification scheme was used.

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In detection by Tsai algorithm, the input image can be transformed into hue-saturation-intensity (HSI) or other like luma, blue-difference chroma, red- difference chroma (YC_bC_r) or in hue, chrome and value (HCV) color model [5-6]. With the help of transformed invariant color model, ratio map is construct by calculation of ratio of hue over the intensity and then the global thresholding is used to identify the shadow. Tsai algorithm detection performance is more accurate for HSI model by comparing with previous work. In our new method at first we transform RGB color image in to the gray image and then apply the global thresholding scheme using otsu's method to create a shadow map used for the classification of input color image into the shadow pixels and non-shadow pixels. By applying both the methods on same image, we observe that the accuracy of the new technique is more than the previously available Tsai method.

II. RELATED WORK

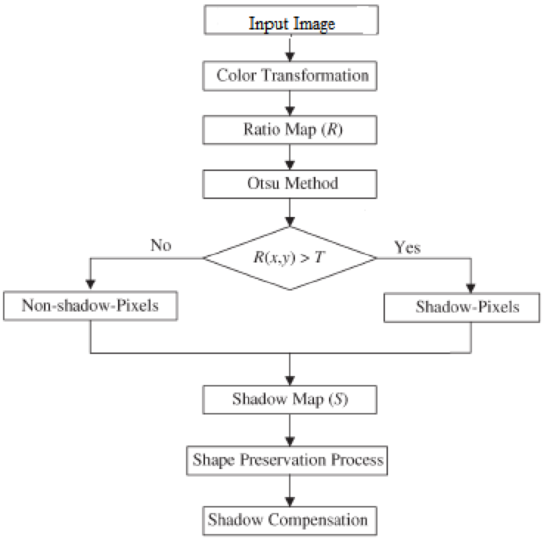

Fig. 1: Tsai algorithm

In shadow detection the flow chart of the Tsai method is shown in fig.1. In this algorithm color transformation is applied on the input RGB color image into invariant color model like HIS, HCV, YIQ, orYC_bC_r. to transform the RGB color image into his color model following formula is used:

$$\begin{bmatrix} I \\ V1 \\ V2 \end{bmatrix} = \begin{bmatrix} \frac{1}{3} & \frac{1}{3} & \frac{1}{3} \\ \frac{-\sqrt{6}}{6} & \frac{-\sqrt{6}}{6} & \frac{-\sqrt{6}}{3} \\ \frac{1}{\sqrt{6}} & \frac{-2}{\sqrt{6}} & 0 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$H = \begin{cases} \tan^{-1}(\frac{V_2}{V_1}) & if\ V_1 \neq 1 \\ H & is\ undefined \end{cases} \quad (1)$$

After this we calculated the ratio map R by using formula no. (2), which is used to decide whether pixel is shadow pixel or non-shadow pixel by comparing with threshold 'T'.

$$R(x,y) = \frac{H_e(x,y)+1}{I_e(x,y)+1} \quad (2)$$

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Where R(x, y), H_e(x, y) and I_e(x, y) are pixel position at (x, y) of R, image H_e and image I_e respectively. In Tsai method the range of R(x, y) is [0-255].

For the calculation of threshold 'T', Otsu method is used. After calculation of T and comparing it with ratio map R, we take decision about shadow pixel like if the R is less than threshold then it is non shadow pixel and if it is greater than threshold then that pixel is shadow pixel.

$$S(x,y)=\begin{cases}1, & R(x,y)>T\\ 0, & Otherwise\end{cases}$$

The new technique of shadow detection algorithm for the color aerial image is as shown in fig.2.

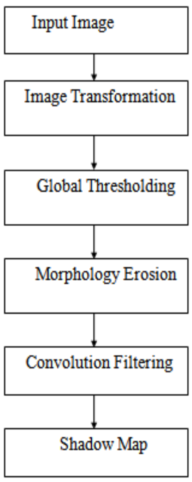

Fig. 2: New algorithm for the shadow detection

According to this method first we transform the input RGB image into gray image. After that using Otsu's method we calculate threshold T for the gray image which is obtained by first step to obtain ratio map R . Then to refer more information about shadow to increase more accuracy, morphological erosion with 5×5 square structuring element is applied. In next step to alleviate the noise effect without blurring the boundaries between shadow and non-shadow region convolution filtering is used.

III. SHADOW REMOVAL ALGORITHM

To remove shadow, which is detected by our new shadow detection method, Shadow removal (algorithm) method is presented in this section. The flowchart of Shadow removal technique is given below. According to the input image shadow map is obtain by Shadow detection method. In next step shadow region is selected to get only shadow image. After that to enhance the contrast of image, we can apply adaptive histogram equalization technique and image adjustment technique on only shadow image.

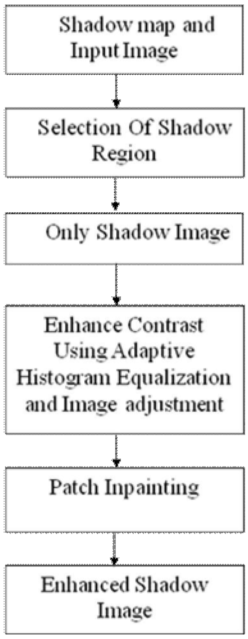

Figure 5: Shadow removal flowchart

IV. EXPERIMENTAL RESULTS

To demonstrate the comparative result of both Tsai method and our new method we apply these algorithms on some images for detection of shadow.

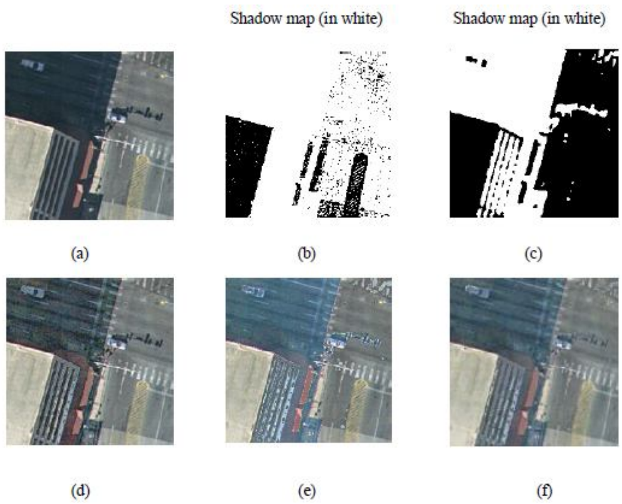

Figure 4-(a) Original image.(b) Shadow detection by Tsai's algorithm. (c) Shadow detection by our new analysis based algorithm.(d) Shadow removal (Enhanced shadow image) using adaptive histogram equalization. (e) Shadow removal (Enhanced shadow image) using image adjustment. (f) Final shadow removal for image (a)

In Figure 4-(a) Show original image, in which shadow is formed on road due to high building on roadside and car in shadow not visible clearly. Shadow detection by tsai's algorithm shown in Figure 4(b).In that white portion nothing but shadow regions and dark portion is non-shadow regions. Shadow detection by our new analysis based algorithm shown in Figure

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4(c).In which white portion is shadow regions and dark portion is non-shadow regions. Image enhancement using adaptive histogram equalization and image adjustment shows in Figure 4(d) and 4(e) respectively. Figure 4(f) shows Final shadow removal for original image (a).

A. Subjective Evaluation

Figure 6(a)-7(a) show the two testing images, and the corresponding manually interpreted shadow maps, which are used as the ideal shadow maps to evaluate the shadow detection performance, are shown in Figure 6(b)–7(b), respectively. The shadow detection results of the algorithm of Tsai's algorithm and our proposed algorithm are demonstrated in Figure6(c)–7(c), and Figure6 (d)–7(d), respectively.

Figure6: (a) Original image. (b) Ideal shadow map. (c) Shadow detection using Tsai's algorithm. (d) Shadow detection using our based algorithm.

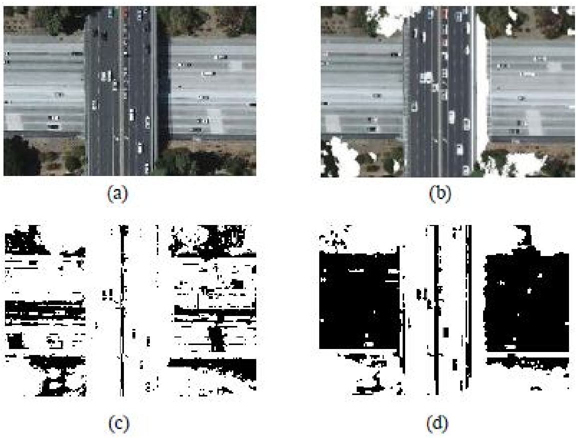

Figure7: (a) Original image. (b) Ideal shadow map. (c) Shadow detection using Tsai's algorithm. (d) Shadow detection using our based algorithm.

In two testing images as shown in Figure 6(a)-7(a), it is observed that our proposed algorithm has the best accuracy performance than Tsai's algorithm and the detection results by our proposed algorithm are close to the ideal shadows marked in Figure 6(b)-7(b) respectively.

B. Objective Evaluation

In this section there are three types of accuracy, first is producer's accuracy, second is user's accuracy and last one is overall accuracy for Tsai's and our algorithm are used in the objective evaluation. The three types of accuracy are described as follows.The first type of accuracy is the producer's accuracy, which contains two parameters defined by

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$$\eta s=TP/(TP+FN)$$
$$\eta n=TN/(FP+TN)$$

where true positive (TP) denotes the number of true shadow pixels which are identified correctly; false negative (FN) denotes the number of true shadow pixels which are identified as nonshadow pixels; false positive (FP) denotes the number of nonshadow pixels which are identified as true shadow pixels; and true negative (TN) is the number of nonshadow pixels which are identified correctly. The parameter ηs (ηn) denotes the ratio of the number of correctly detected true shadow (nonshadow) pixels over that of total true shadow (nonshadow) pixels. The second type of accuracy is the user's accuracy parameters are defined as

$$ps=TP/(TP+FP)$$
$$pn=TN/(TN+FN)$$

The parameter ps (pn) denotes the ratio of the number of correctly detected true shadow (nonshadow) pixels over that of the total detected true shadow (nonshadow) pixels, and thus, the user's accuracy can be used to measure the precision of the shadow detection algorithm. Combining the accuracies of the user and the producer, the third type of accuracy (overall accuracy) τ defined as follows can be used to evaluate the correctness percentage of the algorithm:

$$\tau=(TP+TN)/(TP+TN+FP+FN)$$

Where TP + TN denote the number of correctly detected true shadow and nonshadow pixels; TP + TN + FP + FN is equal to the number of total pixels in the image.

Table 1
(Shadow Detection Accuracy Measurements for Figure 6(a))

Method	Producer's accuracies		User's accuracies		Overall accuracies
	ηs (%)	ηn(%)	ps (%)	pn (%)	τ (%)
Proposed	96.39	88.74	88.74	96.39	92.41
Tsai's	94.63	65.27	65.27	91.63	76.24

Table 2
(Shadow Detection Accuracy Measurements for Figure 8(a))

Method	Producer's accuracies		User's accuracies		Overall accuracies
	ηs (%)	ηn(%)	ps (%)	pn (%)	τ (%)
Proposed	99.57	54.65	54.65	99.57	70.56
Tsai's	99.16	31.87	31.87	99.16	48.23

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Table 3
(Average accuracies measurements for Table 1-2)

Method	Overall accuracies (Table 1)	Overall accuracies (Table 2)	Average accuracies
Proposed	92.41	96.17	94.29
Tsai's	76.24	93.19	84.68

From the aforementioned three types of accuracy, Table 1-2 show the accuracy comparison between Tsai's algorithm and our new algorithm for Figure 6(a)-7(a), respectively. Table 3 shown average accuracies of our proposed and tsai's algorithm for Table 1-2 shown that accuracy of our new method is better than tsai's algorithm. Hence overall shadow detection using our new method gives better results than tsai's.

V. CONCLUSION

For shadow detection and removal in urban high-resolution remote sensing image we have put forward a systematic and effective method. Using the shadow detection and removal method proposed in this paper it is possible to accurately identify and remove shadows. Experimental result shows the effectiveness of our method which is more than previous work.

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