SHADOW REMOVAL IN REMOTE SENSING IMAGES USING FEATURES SAMPLE MATTING

Lei Ma[1,2⋆], *Bitao Jiang*[2], *Xinwei Jiang*[1], *Ye Tian*[1]

[1]Institute of Automation, Chinese Academy of Sciences, 100190,China;
[2]Beijing Institute of Remote Sensing Information, Beijing, 100192, China

ABSTRACT

Remote sensing images often suffer from shadow duo to partially or totally occludes direct light from an illumination source. In this paper, we propose a novel shadow removal algorithm. The trimap could be generated automatically by morphological subtraction method according to the result of shadow detection. Then, the weighted color and texture sample selection image matting method is applied in order to obtain the accurate shadow coefficient. The experiment results are illustrated with practical examples and verify the efficacy of this algorithm.

***Index Terms*—** Shadow Removal, Image matting, Feature sample

1. INTRODUCTION

With the spatial resolution of overhead imagery from satellite and aircraft is increasing, the volume of images data is growing dramatically. It is a novel opportunities for advancing remote sensed image analysis and understanding. However, a lot of shadowed areas in remote sensing images of urban areas have affected the tasks, such as image classification, object detection and recognition. It is very useful if the radiance of shadowed areas is corrected to the same radiance level of shadow-free areas.

A shadow is created when an object partially or totally occludes direct light from an illumination source. Due to the difference occlusion and light intensity, the shadow region can be partitioned into two kind of regions: umbra and penumbra regions. The umbra of a shadow is created when the direct light source to the surface of object is completely obscured by the occluding object, such as high building or mountains. So the shadow intensity is uniform. Otherwise, the penumbra of a shadow is created when light source is only partially occluded, the shadow intensity vary in the penumbra areas.

Many shadow removal methods were proposed for natural image. Eli Arbel and Hagit Hel-Or [1] provided a comprehensive survey of shadow removal and analyzed the challenge especially for a single image. In order to improve the classification accuracy on remote sensing imagery, [2] proposed a new method to alleviate the effect of the shadow that causes loss of the color and hence loss of feature information for objects in the shadow areas. [3] investigated the spectral characteristics of sunlight depending on measurement of radiance in sunlit and shadowed area, then proposed the shadow detection and removal method. [4] detect and remove shadow by the special context relationships of interaction between neighboring pixels automatically using the FengYun-3, moderate spatial resolution and HuanJing-1 satellite data. [5] described a shadow removal method based on the probability shadow map, the color of that part of the surface is then corrected so that it matches the lit part of the surface. For shadow removal, innerCouter outline profile line (IOOPL) matching was used[6].

On the other hand, a new framework for shadow removal is presented to find the correct scale factor using Cubic smoothing splines. Ruiqi Guo *et al.* [7] proposed a novel shadow model where lighting consists of directed light and environment light. An image matting method is applied to estimate a factional shadow coefficient value, then the ratio of direct to environmental light is estimated. Han Gong *et al.* [8] presented a user-aided method which retains shadowed texture and preforms well on highly-uneven shadow boundaries, non-uniform umbra illumination, and non-white lighting. It produced improved umbra recovery and improved processing given uneven shadow boundaries. However, these shadow removal method can not work well in remote sensing images due to the distinct characteristics. Huifang Li *et al.* [9] proposed approach compensate information in shadow based on a spatially adaptive regularizations. Due to illumination often changes gradually along shadow and result of detection are inaccurate near the boundaries of regions. It is very important to estimate accurate shadow coefficient and get smooth changes between non-shadow regions and recovered shadow regions. So soft matting could be applied. In [7], a closed form solution image matting method[10] is used. However, this method do not perform well if there is an overlap because color cannot distinguish between these regions. In order to select samples which can reliably estimate the matte, [11] propose texture as a complement feature to improve the matting, and combine local sampling with a local and global sampling scheme.

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In this paper, we propose a novel shadow removal algorithm. First, the trimap could be generated automatically using morphological subtraction method according to the result of shadow detection. Second, in order to obtain the accurate shadow coefficient, weighted color and texture sample selection image matting method is applied. Experiments are carried out on aerial images and demonstrate the capabilities of our algorithm.

2. METHOD

The proposed algorithm can be described as follows. First, we represented the shadow model based on [7] by the formula below.

$$I_i^{shadow-free} = (k_i L_d + L_e) R_i$$

where $I_i^{shadow-free}$ is the value of the i-th pixel in an shadow-free image, k_i is shadow coefficient for the i-th pixel. There are two type of light source: direct light L_d and environment light L_e. R_i is the surface reflectance of that pixel.

In order to estimate a fractional shadow coefficient value k_i for each pixel i, matting technique is applied. It is different from [7], which using a closed form method, we obtain accurate k_i by weighted color and texture sample selection matting [11].

Let I_i is a value of i-th pixel, F is proportion of the non-shadow and B represents shadow proportion of shadow, I_i can be represented as:

$$I_i = \alpha_i F_i + (1 - \alpha) B_i$$

Once the best F and best B sample is selected, the k_i for the pixel i is given by

$$k_i = \frac{(I_i - B)(F - B)}{||(F - B)||^2}$$

For obtain the best (F, B) pair, an objective function that takes advantage of gray and texture features is applied as:

$$J(k) = (G_k)^{e_G} \times (T_k)^{e_T}$$

where G_k is a measure of grey value fitness of (F, B) and T_k is a measure of the compatibility of gray value and texture feature. Parameters e_G and e_T are calculated as same as [11].The trimap can be automatically obtain by morphological subtraction, dilated image subtract eroded image.

At last, the shadow-free pixel value is given by:

$$I_i^{shadow-free} = (L_d + L_e) R_i = \frac{r + 1}{k_i r + 1} I_i$$

where $r = \frac{L_d}{L_e}$ is the ratio between direct light and environment light.

3. EXPERIMENTAL RESULTS

In this section, we present a number of experimental results in order to demonstrate the efficacy of the proposed method. The shadowed aerial images origin from the database of the University of Central Florida, with referenced hand-labeled shadows. The aerial images of this database is from the overhead Imagery Research Dataset (OIRDS), and size of them is 257×257.

Fig.1, Fig.2 and Fig.3 show the results of 3 test images. (a) shows the original image, (b) shows the shadow label, (c) shows the shadow coefficient by [7], (d) shows the result of [7], (e) shows trimap by morphological subtraction. (f) shows the shadow coefficient of proposed method, at last, (g) shows the shadow removal result by proposed method. In our method, trimap can be created by morphological substraction quickly, as a guidance for image matting. From (c) and (f), we can see that the weighted color and texture sample selection image matting method is more advantageous to describe the shadow coefficient than [7]. It can be seen that the proposed algorithm gives better removal results, compared to the results of the other methods.

4. CONCLUSION

This paper presents a new method to remove the shadow in remote sensing imagery. Weighted color and texture sample selection image matting method is applied to obtain the better shadow matting. Compared with the previous algorithms, experimental results can demonstrate that the proposed shadow removal method has better performance. In the future, we will explore more feature information to estimate more accurate the shadow coefficient, and obtain better result of shadow removal.

5. REFERENCES

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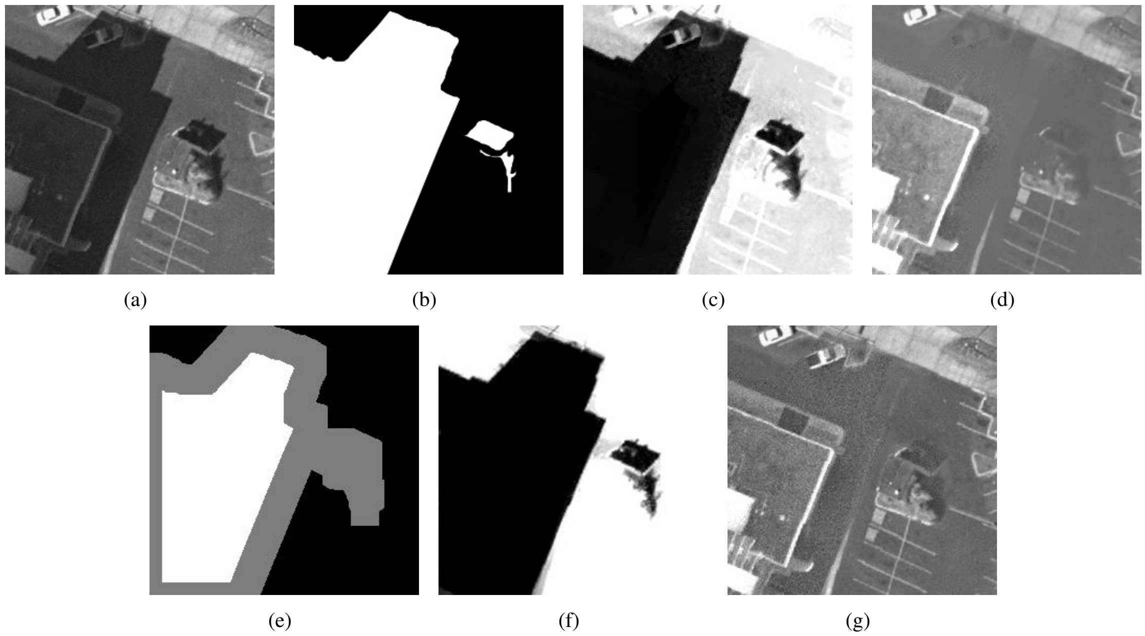

Fig. 1. Results of Image 1 with different methods. (a) Original image. (b) shadow label. (c) shadow coefficient of [7]. (d) result of [7]. (e) trimap. (f)shadow coefficient of proposed method. (g)shadow removal result of proposed method.

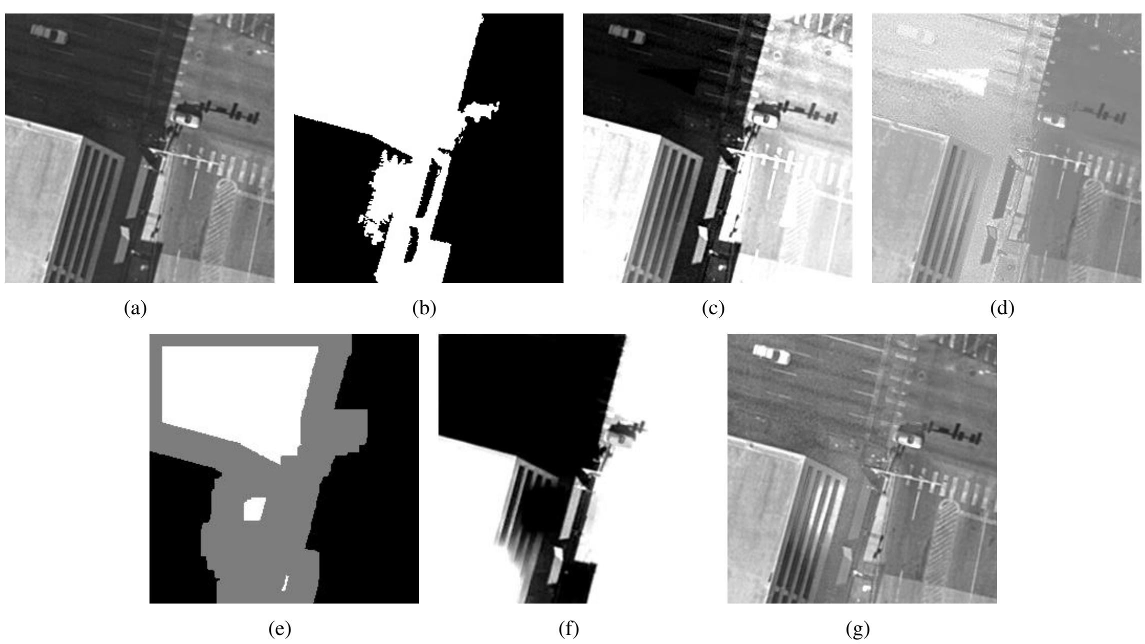

Fig. 2. Results of Image 2 with different methods. (a) Original image. (b) shadow label. (c) shadow coefficient of [7]. (d) result of [7]. (e) trimap. (f)shadow coefficient of proposed method. (g)shadow removal result of proposed method.

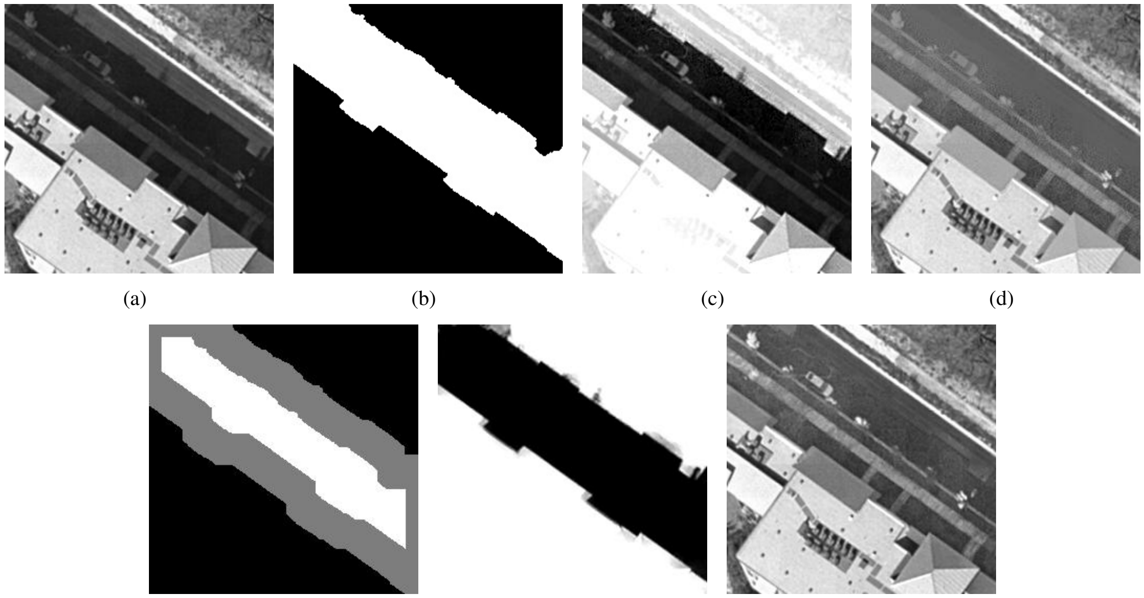

Fig. 3. Results of Image 3 with different methods. (a) Original image. (b) shadow label. (c) shadow coefficient of [7]. (d) result of [7]. (e) trimap. (f)shadow coefficient of proposed method. (g)shadow removal result of proposed method.

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