

Shadow Removal From Remote Sensing Images By Efficient Inpainting Method

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Abstract

Remote sensing images from satellite are useful for many different applications like change detection, identification of topological components shadow. Shadows have to be removed from the satellite images before it has to be processed for feature extraction. This paper proposes an efficient approach for shadow detection and removal in remote sensing images on urban areas. In our proposed work the image is first converted into HSV color model, shadow is detected by threshold based on Otsu's method and subsequent boundaries are extracted. For shadow removal, inner-outer profile line (IOPL) is generated with respect to obtained boundaries obtained. Then shadow regions are masked, in painting algorithm is implemented to restore the original image. Thus new method accurately detects and removes shadow in remote sensing images.

Keywords— Remote Sensing Images, IOPL, in painting, Shadow Detection, Shadow Removal.

I. INTRODUCTION

In recent years the accessibility of high spatial-determination satellites like, IKONOS, GeoEye and QuickBird find the perception of Earth. There has been an expanding need to dissect high-determination pictures for diverse applications. In urban territories, surface peculiarities are complex, with an incredible block of items and shadows structured by hoisted protests like, high structures, bridges, buildings and trees. In spite of the fact that shadows themselves can be viewed as a kind of valuable data in 3-D reproduction, building position recognition and

Tallness estimation, shadow information can also used for transforming high-determination remote sensing images. But for some cases, shadows may cause mistaken results and change recognition. Hence, the identification and evacuation of

shadows assume a vital part in application of urban high resolution remote sensing images like change detection, image fusion, object classification etc. Basically, change detection [9] is a principal operation for programmed GIS upgrades in the cartographic environment. The identification of shadows as changes is an issue in change discovery. To take care of this issue shadows must be uprooted in the remote sensing images.

II. LITERATURE SURVEY

Numerous viable calculations have been proposed for shadow recognition. Existing shadow identification techniques can be generally grouped into two [3]: model-based routines and shadow-property based routines. The first method uses earlier data for example, scene, moving targets, and cam elevation to develop shadow models [4]. This method of systems is regularly utilized as a part of some particular scene conditions, for example, aeronautical picture investigation. The second technique distinguishes shadow regions with data, for example, dark scale, brightness, immersion, and composition.

A few improvement strategies were examined to restore shadows free image, in particular, gamma amendment, LCC, and histogram coordinating [10]. This related examination, was used to produce a superior methodology. This view determines a straight relationship between shadow classes and the concerning no shadow classes [11]. In addition, a matched area based methodology is utilized to distinguish and evacuate the shadows in a single picture by figuring the contrast between the shadows and nonshadow districts of the same sort [12]. Shadows can be recovered by multisource information using previously stated procedures.

At this point, nonshadow pixels of the comparing district are utilized to restore the shadow pixels. This last approach is helpful in low-determination pictures.

III. PROPOSED WORK

In the proposed method image is first converted to HSV color model and then shadow is removed using exemplar based in painting method. The approach explained in the Fig.1. Overall architecture. An RGB image is given as input. The input image is converted from RGB to HSV space as Hue-Saturation-Value color space is invariant to shadow [2]. Shadow segmentation is done using Otsu's method of thresholding this separates shadow and non shadow. Next IOPL [1] is generated along the boundaries of shadow image. And areas within the profile line is masked out, in painting [5, 6, 8] is applied to remove the shadow, each of these steps are discussed in the next sections.

IV. SHADOW DETECTION

In remotely sensed images shadows are created because the light source has been blocked by something, here we mainly concentrate on shadows caused on urban high resolution remote sensing images.

A. SHADOW FEATURES

Images with shadow consist of high saturation and hue content which is used for segmenting images. In HSV [2] color space, shadows hold some different spectral properties and as follows:

- low value because the direct light from the Sun is occluded by elevated objects
- high saturation with short blue-violet wavelength due to atmospheric Rayleigh scattering effect
- High hue values because shadow areas are dark.

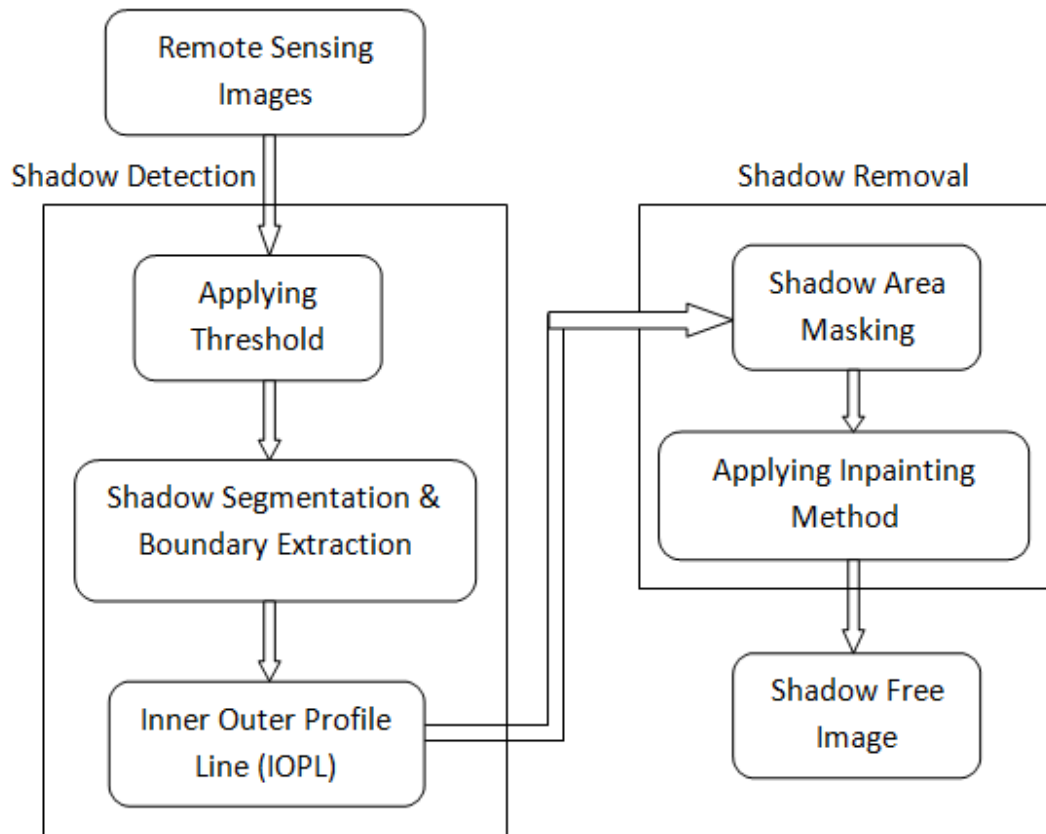


Fig.1. Overall architecture

Hue which is an attribute associated with the wavelength in a mixture of light waves. Saturation refers to relative purity or the amount of white color light mixed with hue. Thus, shadow areas have maximum value of saturation and the minimum value component in HSV color space.

B. DETECTION OF SHADOW

Shadow detection is done by properly set threshold which can separate shadow from non shadow. One of the most successful methods for thresholding image is Otsu's threshold method [7]. It is one of the better threshold selection methods for images.

Otsu's thresholding chooses the threshold to minimize the intraclass variance of the thresholded black and white pixels in other words method is based on selecting the lowest point *between two classes* (peaks)

It uses the frequency and mean for analysis of total variance which is given by.

$$\sigma_t^2 = \sum_{i=0}^T (i - \mu)^2 P(i) \quad (1)$$

Where μ , $P(i)$ stands for mean value for number of pixels P . The between-classes variance (δ_b^2). The variation of the mean values for each class from the overall intensity mean of all pixels

$$\delta_b^2 = \omega_0 (\mu_0 - \mu_t)^2 + \omega_1 (\mu_1 - \mu_t)^2 \quad (2)$$

Substituting $\mu_t = \omega_0 \mu_0 + \omega_1 \mu_1$, we get

$$\delta_b^2 = \omega_0 \omega_1 (\mu_1 - \mu_0)^2 \quad (3)$$

ω_0 , ω_1 , μ_0 , μ_1 stands for the frequencies and mean values of two classes, respectively. All possible thresholds are evaluated as above, and the one that maximizes index is chosen as the optimal threshold

C. SEGMENTATION & BOUNDARY EXTRACTION

After setting up the threshold next process is separating the shadow areas from the original image. The image obtained after the above process will be binary image where shadow areas are shaded in black and non shadow area with white thus we segment the shadow areas from the original image. Next process is to draw the boundaries along the shadow areas. This is marked in green color.

D. IOPL GENERATION

The boundary extracted image is given as input here; inner outer profile line is generated along the boundary of shadow area. This inner outer profile line is generated to classify that suspected shadow area lies within the profile line generated. It gives the additional conformation that shadow areas are plotted exactly.

V. SHADOW REMOVAL

After detection process next is removal of shadow in the image. Here removal of shadow takes two procedure first is masking shadow area and, second applying exemplar based in painting technique.

A. MASKING SHADOW AREA

Shadow areas which are detected by above process are masked. For the experimental purpose green color is used. This processed output will be used in next step for

shadow removal.

B. EXEMPLAR BASED INPAINTING TECHNIQUE

Generally an exemplar based in painting[6], algorithm involves two main process,

Patch priority – highest priority for patch indicates perfect structure

Texture synthesis – only maximum similarity between known patch and current patch are used to fill in , the following are algorithm steps:

1. Initialize the target region. Generally done or the process of in painting. This is done by marking the target region in some special color.
2. Find the boundary of the target region.
3. Computing patch priority, the priority values are assigned to each patch. The priority computation is based toward those patches which: (i) are on the continuation of strong edges and (ii) are surrounded by high-confidence pixels.
4. A patch is selected from the region to be inpainted. The size of the patch should be larger than the largest distinguishable texture element in the image. We denote patch as ψp .
5. Find a patch which matches best from the image (highest priority) the selected patch, ψp . This matching patch can be selected using a suitable error metric. We use the Mean Squared Error to find the best matching patch.

$$MSE = \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N [C_{ij} - R_{ij}] \quad (4)$$

Where C_{ij} represents the element of the patch ψp and R_{ij} represents the patch element for which MSE is to be calculated. N is the total number of elements in the patch.

6. Update the image information according to the patch found with minimum error in it.

By performing the above process iteratively we get the shadow free image. The enhanced efficient in painting method proposed here is the calculation for variance of pixel with respect to mean squared error.

VI. EXPERIMENTAL RESULT

Following experiment is tested in Matlab2010 to validate the proposed method. The images used in this proposed method are from U.S. Geological Survey which is remote sensing image gallery. Fig.2 (a) shows the RGB remote sensing image which contains shadow in it caused by elevated buildings. Fig.2 (b) shows the shadow region detected shadow region is black in color.

Fig.2 (c) shows the boundary extracted on the original image which is marked as green color. Fig.2 (d) in which inner and outer profile line is extracted inner line is

marked in blue color and outer line is marked in red color. Fig.2 (e) is the shadow free image obtained after implementing in painting technique over the shadow areas. The Fig.2(e) shows that shadow present are removed efficiently.

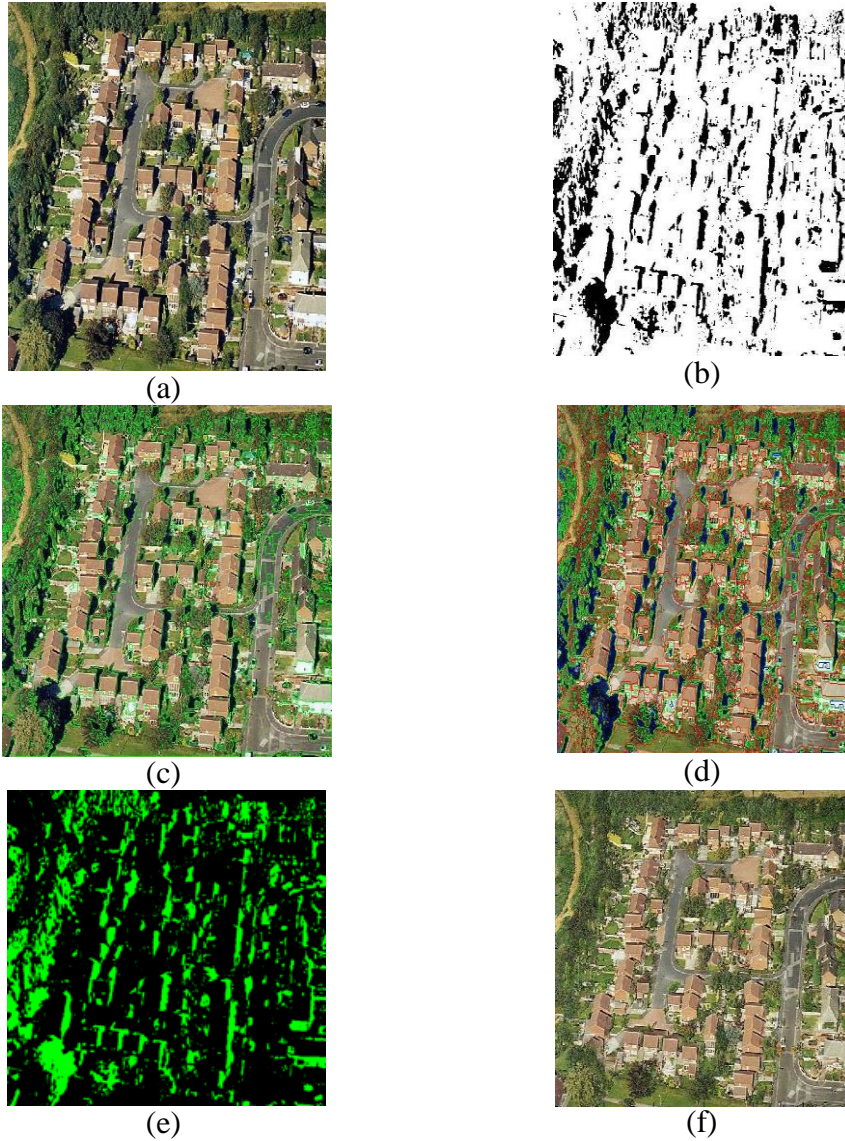


Fig.2 (a) Original image with shadow, (b) shadow segmented image, (c) boundary extracted over shadow area, (d) inner outer profile line generated, (e) masked image, (f) Shadow free image

Let us test another image of Husker stadium. Fig.3 (a) RGB shadow image, Fig.3(b) shows shadow region segmented, Fig.3(c) boundary extracted over shadow area, Fig.3(d) IOOPL generated image

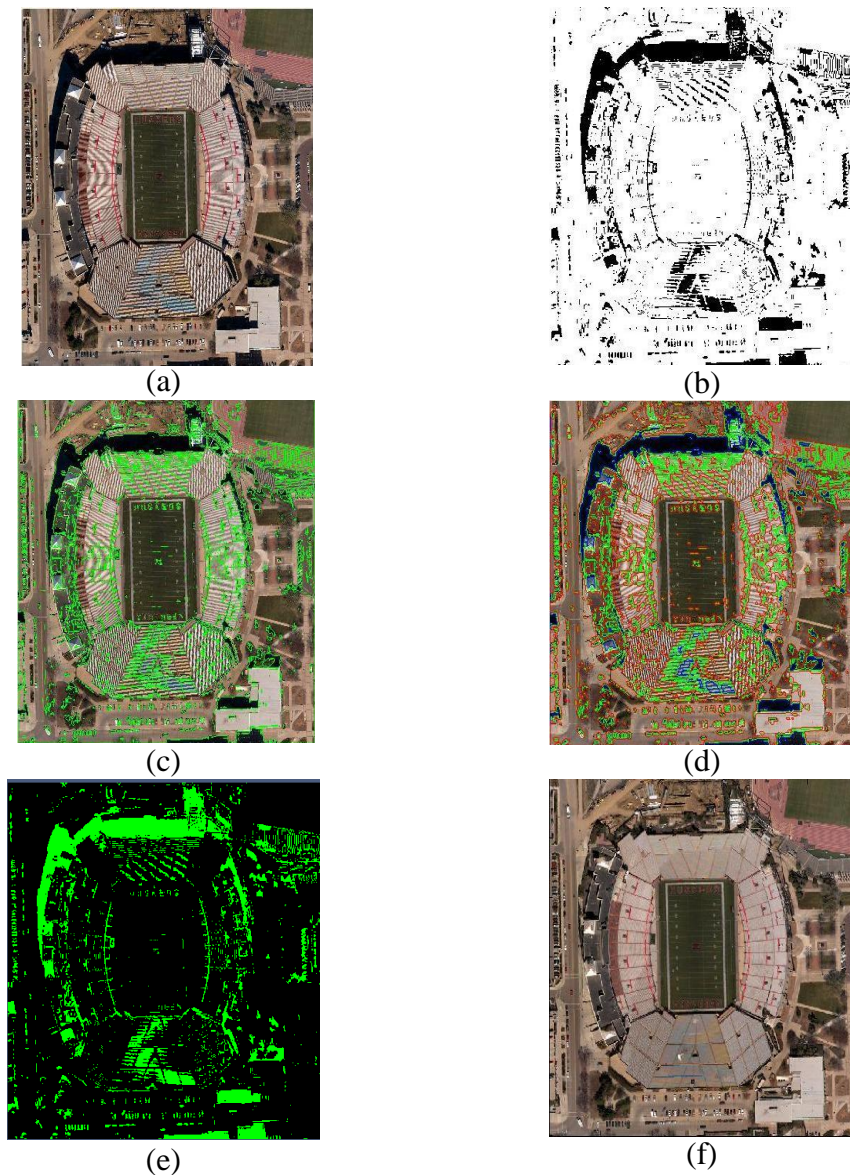
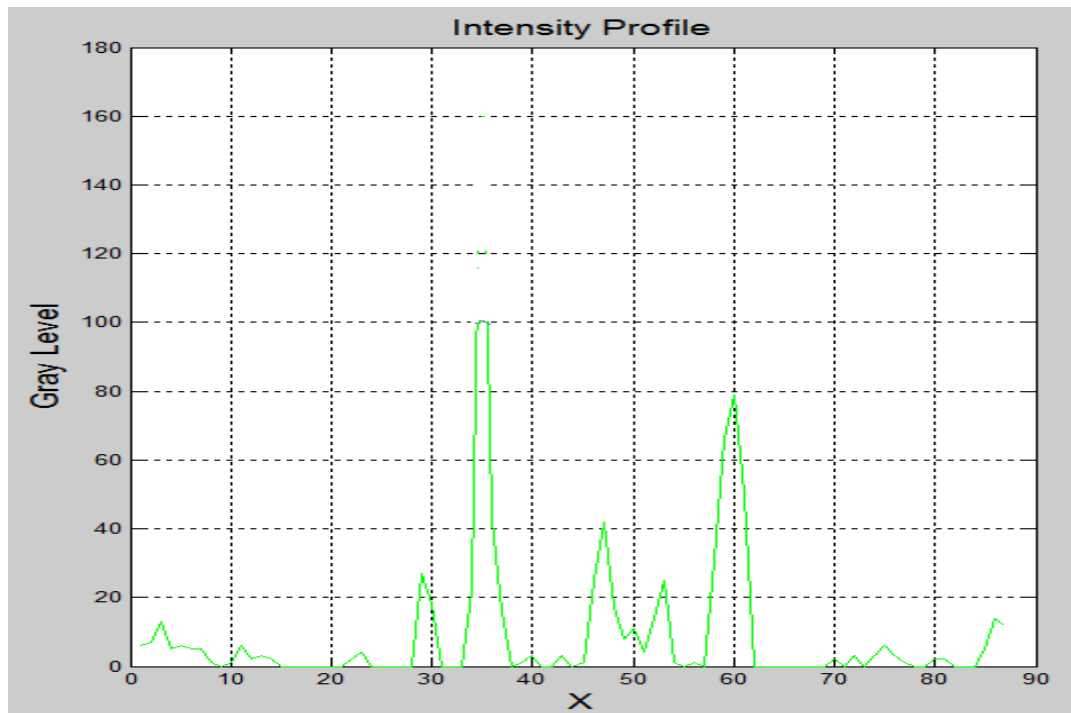
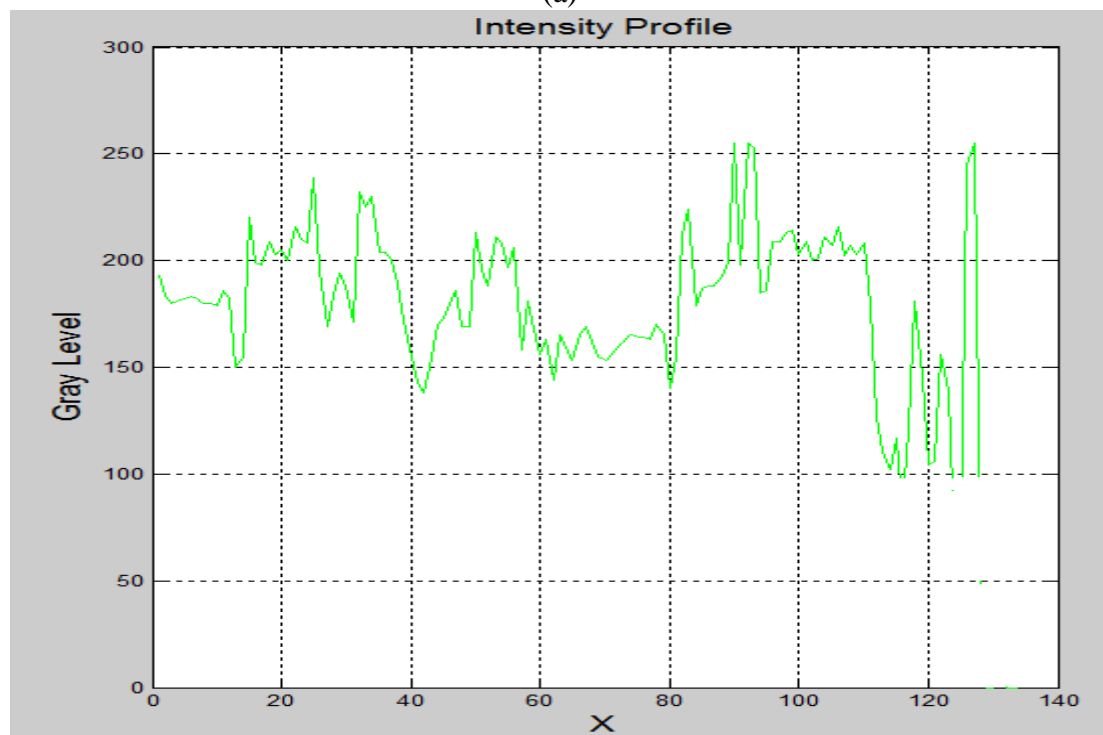


Fig.3 (a) Original image with shadow, (b) shadow segmented image, (c) boundary extracted over shadow area, (d) inner outer profile line generated, (e) masked image, (f) Shadow free image

Fig.4 shows the comparison graph for gray scale level of remote sensing image shadow 4(a) and non shadow area 4(b). x axis is the pixel range y axis is the gray scale level at each pixel range. This graph shows the result for Fig.2 (a)



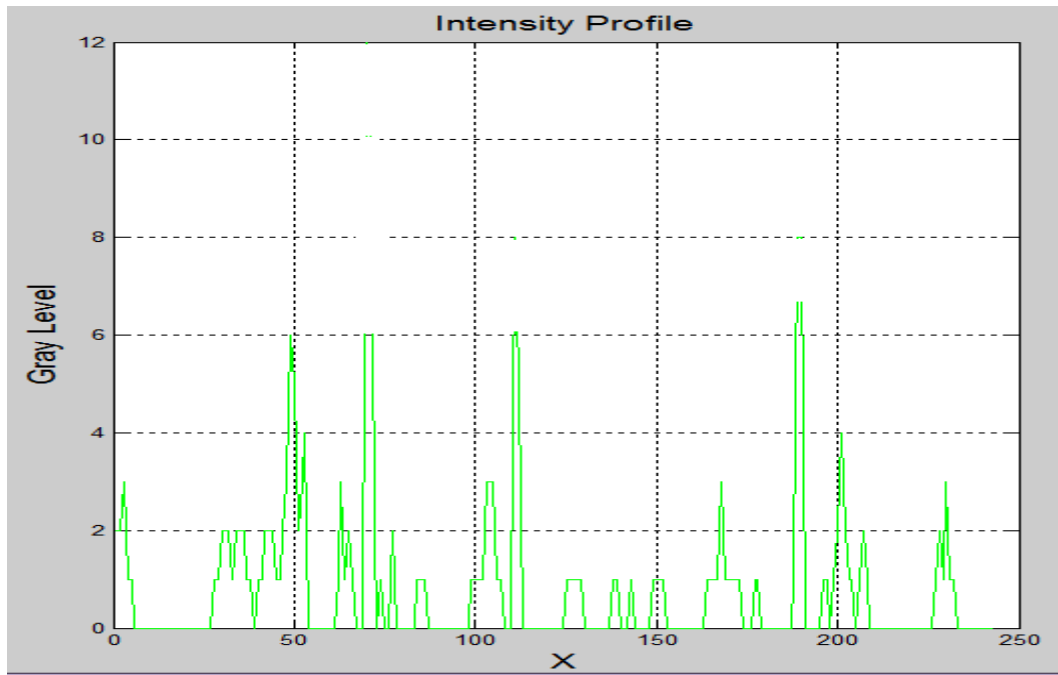
(a)



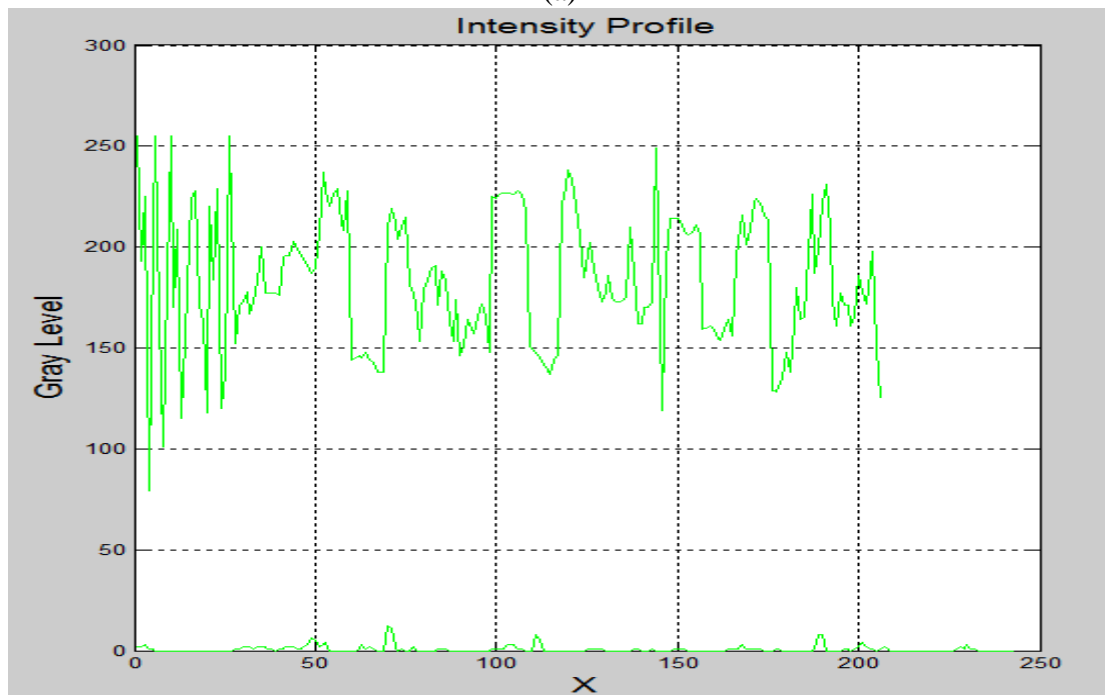
(b)

Fig 4. (a) shadow area intensity profile fig.2(a), (b) non shadow area intensity profile fig.2(a)

Fig.5 shows the comparison graph for gray scale level of remote sensing image shadow 5(a) and non shadow area 5(b). This graph shows the result for Fig.3(a)



(a)



(b)

Fig 5. (a)shadow area intensity profile fig.3(a), (b) non shadow area intensity profile fig.3(a)

To verify the effectiveness of our proposed work we have compared the performance time with conventional Criminisi algorithm. Table.1 shows the comparative result for proposed and existing Criminisi method.

Table.1: Comparison of In painting Algorithm with Criminisi Algorithm

	Existing [Criminisi Algorithm]		Proposed [Inpainting Algorithm]	
	Image size in pixel	60492	44100	62500
Percentage of shadow area removed	2.80	2.12	2.2	1.9
Time taken in seconds	200	134	126	72

Two set of images which have nearer pixel values related to Criminisi method is taken for analysis. We infer from the table that both the methods work for good of job. Same time we understand that clarity is equally good in our proposed algorithm. The overall time by means of our algorithm apparently depends on how much area is selected to be inpainted. Thus the in painting method utilizes the resource efficiently

VII. CONCLUSION AND FUTURE WORK

The proposed methods efficiently detect and remove the shadow present in remote sensing image. The results are effective and it show that shadow present in the remote sensing image are detected and removed acceptably. The shadow free image is also quite effective and the areas under the shadow are convoluted.

We are looking forward to improve the proposed algorithm so that the computational complexity is improved meanwhile to retain the process time much better than stated in the table. We can also make the algorithm more robust so that ideal comparison is done to bring out various issues.

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