Image processing system based on space transformation

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Abstract

This paper proposes a novel method of shadow fast detection and recovery of remote sensing image based on color spatial alternation in light of the analysis and research on experimental data of remote sensing image on different color space. Compared to traditional shadow detection algorithm on the basis of pixel, this method enhances the precision and scope of application of detection. Meanwhile, on the recovery of shadow information, it is able to recover shadow information rapidly by analyzing the statistical characters of image element within the shadow. This method is to feature high speed, high automation and wide scope of application. Numerous tests on the application of high spatial remote sensing image show that this method has brought about satisfying results.

Keywords: high spatial remote sensing, shadow detection, shadow recovery, image processing

1 Introduction

With the rapid development of sensor technology and computer technology, information fusion technology will increasingly catch people's eyes. Data fusion of information fusion is commonly used in multi-source image composite, image analysis, understanding and so on. It will gain a complex image after registration and re-adoption. Synthesis of the same scene obtained from various sensors enables overcoming or making up the limitation of single sensor image existing in optical spectrum and spatial resolution, and improving image quality. Studies on this field will provide people much more and richer information; moreover, they will make the best use of all kinds of information source we currently have to fully tap its potential and realize its effectiveness.

Shadow processing technology consists of shadow detection and shadow removal. Shadow detection technology is applied in computer vision. Especially, with the gradual popularization of digital image in recent years, many originally different application areas such as video processing and regulation of traffic show interests in this technology. Shadow detection is mainly divided into two types, method based on image and object. When the application of the latter depends on some knowledge tested before or model completed for scene, the former is generally adopted in reality. Shadow removal technology often applies digital image processing method which increases the pixel value within shadow.

Tomaney and Crotts better by lowering the resolution to match the resolution of the picture is poor picture quality from the subtraction images obtained entirely dependent on solving the nuclear transformation, and find the right nucleus is a very delicate process. Tomaney and Crotts made by each bright star contrived image Fourier transform to obtain nuclear transformation. However, due to the high frequency portion of the image is affected by noise, and thus must be used to detect the edge of a Gaussian distribution. This algorithm does not guarantee the operation can be subtracted to obtain good results. Furthermore, the algorithm for complex transformation process PSF poor, and no solution is not the same sky background processing [1]. Then Kochanski proposed optimal algorithm to find a nuclear transformation by making two images Minimize the differences, but the algorithm is a nonlinear least-squares fitting procedure, the computing time is concerned, The algorithm cannot be achieved [2]. Alard and Lupton thought through nuclear transformation based Kochanski decomposition algorithm converts the linear least squares problem, so the algorithm can be applied in practice [3, 4]. ISIS its open source software available for free download (http://www2.iap.fr/users/alard/package.html [5]). However, to complete AST3 project, relying Alard algorithm is still not competent to use ISIS software on a computer college Tianjin University DELL2950 server processing 2K×2K picture needs 40seconds, the most conservative estimate of processing 10K×10K pictures require 40×25=1000second=16.7minutes, most of the time spent on computing, and hardware accelerator handle large data-intensive computing will be the most effective.

The paper proposes a novel method of shadow fast detection and recovery of remote sensing image based on color spatial alternation in the light of the analysis and research study on experimental data of remote sensing image on different color space. Compared to traditional shadow detection algorithm on the basis of pixel, this method enhances the precision and scope of application of detection; meanwhile, on the recovery of shadow information, it is able to recover shadow information rapidly by analyzing the statistical characters of image element within the shadow. High speed, high automation

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and wide scope of application are its features. Numerous tests on the application of high spatial remote sensing image show that this method has brought about good results.

2 Principle of color spatial alternation

Firstly, in-symbol means variable of image analysis. For a colorful image whose height and width are $N\times N$, each pixel point is a three-dimensional vector (namely the three color components like red, green and blue). If we use color vector *P(x,y)* to represent the color of a pixel point locating in the xth rank and yth row, an image is a vector field made up of a $M\times N$ vector. On color image, hue mostly changes in a schistose area, that is, a hue within a small range almost remains unchanged and its dynamic range is rather narrow while the alternation of brightness affects each pixel. Especially in sidelight environment, dynamic range of brightness is huge and therefore, if an image is taken in strong sidelight, alternation of its brightness is more intense than the change of hue. Research shows that people' sensitivity to the change of hue is lower than brightness. Based on that, the paper takes changes of all color information of pixel as the object of study and statistic change of color vector as the measure. Feature space transformation of color image has two steps: first feature space transformation and quadratic transformation.

3 First feature space transformation

As for gray-scale map of traditional image processing, it usually uses gradient method as spatial processing method to highlight details of image. On the account of field theory, if we set a function *f(x,y)*, gradient of coordinate *(x,y)* can be defined as a measure. Grey-scale map usually adopts scalar function $G[f(x,y)]$, that is, the module of gradient represents gradient [5].

$$grd[f(x,y)] = \begin{bmatrix} \partial f/\partial x \\ \partial f/\partial y \end{bmatrix} \tag{1}$$

As for digital image processing, it applies the discrete form which replaces differential operation with difference. First feature space transformation aims at calculating the gradient of color vector. In a near section (we adopt 3×3), scalar function $A[f(x,y)]$ is used to measure the gradient of color vector of the center point:

First feature space transformation aims at calculating the gradient of color vector. In a near section (we adopt 3×3), scalar function $A[f(x,y)]$ is used to measure the gradient of color vector of the center point:

$$A(x,y) = \max\{f_1(P_{(x,y)} + P_{(x+i,y+j)}) \mid i = -1,0,1;\ j = -1,0,1]\} \tag{2}$$

In the equation, $P(x,y)$ refers to the color vector of coordinate (x,y) and the function $f_1(P_{(x,y)} + P_{(x+i,y+j)})$ indicates the distance of two color vectors. $Bd(x,y)$ implies a two-dimension variable derived from first feature space transformation of the original image in the feature space. Each feature value represents the gradient of color vector in function (x,y).

4 Quadratic transformation

In the image processing, alternation of color of each pixel point in the near section always means graphic feature so it needs to give the two-dimension feature variable $Bd(x,y)$ mentioned above. It is a further processing named quadratic transformation. Taking $Bd(x,y)$ as the center, *n*2-1 feature values in its near sector present circular distribution. *r* refers to the number of cycle, feature values in a same cycle take the same weights---wr when feature values in the near section take n=5. Furthermore, $Rtf(x,y)$ implies a new two-dimension variable. Computational formula of new feature value lying in the *i*-th rank and *j*-th row is shown as followed:

$$\text{Rtf(x,y)} = \sum_{r=1}^{n-1} \frac{sum-ring(r)_{(i,j)}}{8r} + Bd(i,j)\,. \tag{3}$$

sum-ring$(r)(i,j)$ in Equation (3) represents the sum of feature value and weight in the Orth circular section. It can be calculated with the Equation (4):

$$\text{sum-ring(r)(i,j)} = \sum_{k=i-r}^{i+r} \sum_{l=j-r}^{j+r} (w_r \cdot Bd(k,l)^{l2})\,. \tag{4}$$

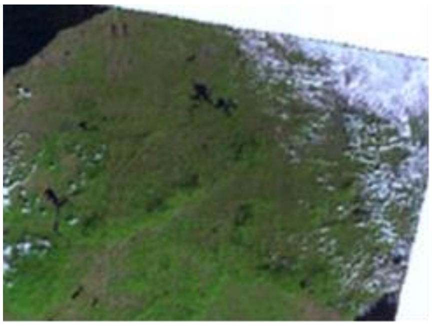
In order to give more perceptual knowledge to two two-dimension feature variables after having transformed twice in feature space transformation, We use a two $Bd(x,y)$ represents a corororiginal feature space after the initial transform in the feature space color feature vector of variable dimension, each eigenvalue represents the coordinates (x,y) on the color represented by the gradient of $Bd(x,y)$, which can get Gradient color of a two-dimensional feature vector of the original image after the first variable-color-space transformation characteristics obtained in the feature space.

5 Shadow detection technology based on color spatial alternation

Shadow detection technology is applied in computer vision. Especially, with the gradual popularization of digital image in recent years, many originally different application areas such as video processing and regulation of traffic show interests in this technology. Shadow detection algorithm that is most often adopted currently takes advantages of the double-hump feature of the shadow of route sensing image mentioned above, separating shadow by analyzing the threshold value of route sensing image histogram. The analysis of histogram abides by two principles, 1) if the distance between two wave crests is rather far in a histogram, there will appear a trough of wave between these wave crests. The place of this trough of wave can be used as the threshold value distinguishing dark region and unshaded region; 2) if the distance between two wave crests is rather close in a histogram, there will appear another wave crest between these wave crests. The place of this wave crest can be used as threshold value. Take the image of Figure 1(a) as an example, you can find that in this image, trough of wave appears around 36 by analyzing histogram and the shadow separated by regarding this value as threshold value is shown as Figure 1(b). From the Figure 3-1, we can find that it can extract obvious shaded region in the image perfectly by using the "double -hump" feature of shadow.

Overlapping area correction method and the proposed method are treated corrected image mean and variance of each band were modified. And the results are similar to histograms overlap area correction method is also trying to be corrected image data of the statistical distribution of each band corrected to the reference image similar. However, due to reasons of each band between the overlapping area of the relevant bands of calibration results and the reference data is distributed, whether the distribution of the image data and the reference image is compared to the data distribution compared to the overlapping area there is a big difference. The data presented herein and the method for correcting the results are distributed over the various bands and the reference Figure 1 Very similar to the distribution of the image data.

a) Original image



b) Extractive shadow

FIGURE 1 Extracting Shadow by threshold value of traditional histogram

6 Color spatial alternation

Algorithm mainly uses HSV space. The alternation formula of HSV space and RGB space are shown as Equation (4). Please note, the input pixel value of RGB in algorithm lies in a normal interval [0, 255], but the range of HSV value after alternation is $H \in [0, 360]$, $S \in [0.0, 1.0]$, $V \in [0.0, 1.0]$. Rendering the original image color spatial alternation is the first step of shadow detection algorithm. Optical spectrum of shaded image in HSV space is that we make the original image have an alternation through pixel by pixel, making it transform from RGB space to HSV space. In particular, after an alternation, values of Hue, Saturation and Value are set within the interval [0, 255] and saved in three channels of RGB, which is convenient for second alternation. The second transformation exerts the same color spatial alternation on the outcome of the first alternation and still sets its result within the interval [0, 255].

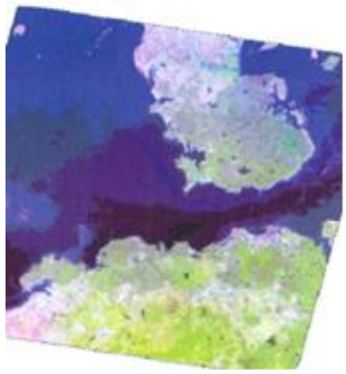
7 Extraction of dark region

We adopt the feature of shaded image in HSV space to extract dark region. An effective strategy is to distinguish threshold values of various sections by analyzing the histogram of the image, which is a method often be adopted. The disadvantage of this method is that it extremely depends on the selection of the empirical value, adaptability being unfavorable. However, by the analysis of shaded image in SV space, if the image undertakes two transformations continuously, we can distinguish two sections clearly because the requirement of the accuracy of threshold value that separates shadow is flexible and not high, which is the advantage of this method. Ways for reference are (1) take 128 as threshold value. We observe by experiment that 128 is a highly safe threshold value under an ideal separation circumstance, using it to cut; (2) scan the whole histogram. Taking gray-scale value, the height of far right side (far left side is also right) exceeds a certain empirical value as threshold value. Compared to the first way, it is more flexible.

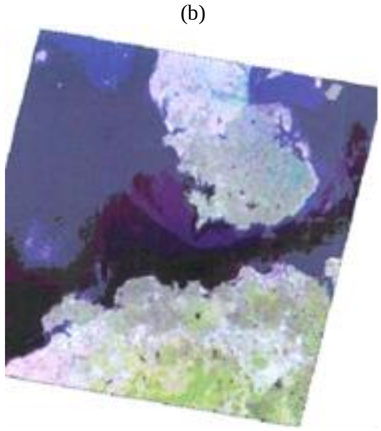
8 Removal of noise

After extraction of dark region, it needs to wipe off noise of the dark region. Due to methods based on pixel, some "gaps" inevitably appear in the found area. Details can be referred as Figure 2. In the Figure 2a, part marked out by green line is noise brought about by "gaps". If we ignore noise, it will lead to the incomplete extraction of shadow directly, finally influencing the recovery of image. We can find out this obviously by comparing Figures 2b and 2c.

(a)



(b)



(c)

FIGURE 2 Graphical representation of removal of noise

As can be seen from Figure 2, due to seasonal variations and the reference image to be Correcting image color and brightness of vegetation and water bodies are different. Wherein the reference image is a dark green fall Figure 2a; the correction to be Positive image was tender spring green, as shown in Figure 3b; the methods described herein are preferably used in the correction Is the difference of color between the two panorama images shown in Figure 2c.

9 Separation of shadow and water

Radiant quantity received by sensor can be divided into three parts, shown as below:

$$R=Ra+Rdr+Rsr. \quad (5)$$

R means the total quantity received by sensor. Ra refers to energy of atmospheric reflectance. Rdr represents the reflective energy that sun radiates on objects on the ground directly. Rsr implies energy that objects on the ground reflect ambient light.

For objects on the ground within shaded region, we have Rdr=0. Meanwhile, as the radiation value of atmospheric reflectance is far higher than the radiation value of ambient light that objects on the ground reflect, so we have Rdr>Rs. it is the feature of spectral value of the shaded region.

Here we have a set of calculated mode that calculates the index of shadow and water (Table 1). When the threshold value reaches 3.4, it is most effective to separate shadow from the dark region extracted before.

TABLE 1 Calculated mode of calculating the index of shadow and water

1	0.5(G+NIR)/R-1
2	(G-R)/(R+NIR)
3	(G+NIR-2R)/(G+NIR+2R)
4	(R+B)/G-2
5	Abs(R+B–2G)

Algorithm Flow:

In order to reduce the influence of noise, a pre-processing procedure for lowering noise is ahead of these steps. Figure 3 is the flow chart of shadow detection algorithm.

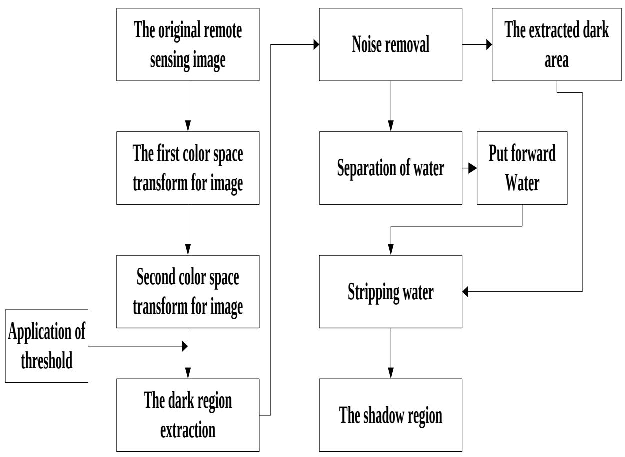


FIGURE 3 Flow chart of shadow detection algorithm

10 Emulation and verification of shadow detection algorithm

The emulation program, wpfTool, integrates image processing algorithm which is often used and therefore, it can rapidly form the algorithm in need. Open the program and then pick two HistogramViewer, two HSBViewer, one ChannelSplitter and one AreaExtractor little tools from the tab, Shaders, in the right side---Toolbox and put them in the operating space to form a shadow detection flow line. After the flow line is established, click the little tool, BasicSrc, and select files that need to be processed from the attribute area of Toolbox. If everything goes well, you can see a picture like Figure 4.

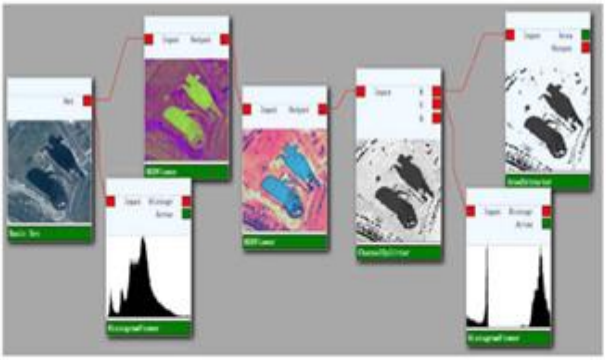


FIGURE 4 Emulation of shadow removal algorithm

In order to wipe off noise, you can process the dark region extracted from the little tool, AreaExtractor, as shown in Figure 5. Firstly, select little tool, OutlineShrinkShader, from Toolbox to exert erosion processing on the extracted dark region. Secondly, use tool, OutlineRepairShader, to execute expansion processing. Finally, use green to represent the extracted shaded region in AreaViewer. You can find that it improves to a large extent if you compare it with the original dark region.

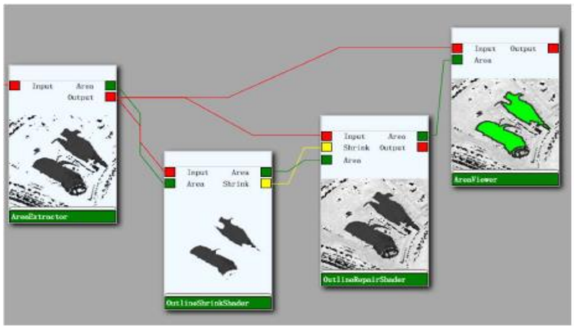
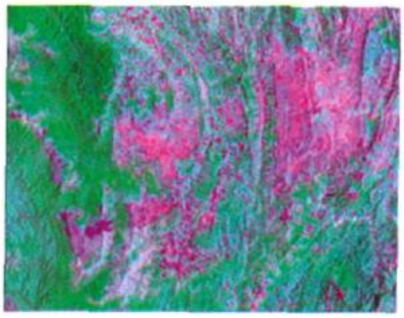


FIGURE 5 Emulation of shadow removal algorithm

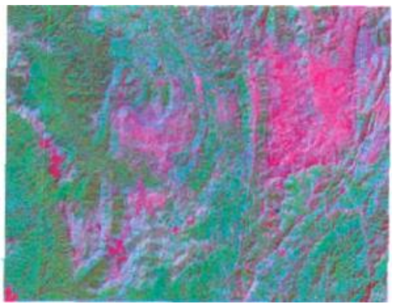
Apply two ordinary RGB three-brand remote sensing images for experiment ad analysis so as to verify its effectiveness. Resolution ratios of these two images are 396×532 and 582×582. The first picture is a classic countryside scene which has houses, fields and roads, while the other one is a typical urban scene. It has a large number of gray areas of roads and roofs and some green lands and soils. We firstly exert shadow detection algorithm on these pictures and the result is shown as Figure 6.

In Figure 6a, we mainly aim at testing the application effect of shadow detection algorithm on outdoors. In this image, houses beside the rice paddy reflect obvious shadows and the covered background of these shadows is rather complicated, including some landforms with different features. In view of the result shown in Figure 6b, the algorithm succeeds in extracting a majority of obvious shadows and the result is consistent with the result that people explain. However, if we compare 6a and 6b carefully, we can find that the algorithm still has some flaws, especially shadows reflecting on the ground cannot be extracted. We think the reason may be that differences of the absorptivity of sunlight to ground and soil are large so the differences of spectral characteristics of shadow on the ground and on the surrounding shaded region are large, too.



(a) Original Image

(b) Corrective graphics



(c) This paper deals with image

FIGURE 6 Effect Drawing of Shadow Algorithm Processing

Based on the four conceptions mentioned above, we count three statistics, namely PA (Producer's Accuracy, also called as sensitivity), CA (Consumer's Accuracy), OA (Overall Accuracy).

It can find that TP+FN means shaded data in the image; FP+TN refers to unshaded data. PA implies the possibility that algorithm extracts shadow from shaded data in a right way. CA represents the proportion of right data in the detected shaded data. Statistical analysis of the former images is shown as Table 2.

TABLE 2 Data analysis of experiment

	TP	FN	FP	TN	PA	CA	OA
Figure(a)	39656	0	11580	203757	100%	77.40%	95.46%
Figure(b)	31006	111	4102	346939	99.64%	88.32%	98.80%
Figure(c)	13081	5325	0	25832	71.07%	100%	87.96%

There is a contradictory between PA and CA. It is impossible to make both of them have high values. It is ready to explain it. PA refers to the proportion the extracted shadow accounting for all shadows and CA means the proportion the right extracted shadow accounting for extracted shadow. To draw shadow as much as possible, it asks to improve the sensitivity of our algorithm. Once the sensitivity is enhanced, some wrong signals can be also abstracted. The increase of PA is in parallel with the decrease of CA.

11 Conclusion

Results and Discussion: To give a complete set of shadow removal flow of remote sensing image, it has faced two key difficulties: how to gain the best balance of accuracy and efficiency of all relevant technology involved in shadow detection to removal. It has purposed a novel shadow detection algorithm based on color spatial alternation. This method has solved those problems which traditional ways like histogram threshold value cannot deal with under the circumstance that it has not increased calculative complexity. Meanwhile, it has undergone numerous experiments and verifications, showing its good performance.

Acknowledgments

Shadow processing technology has consisted of shadow detection and shadow removal. Shadow detection technology has been applied in computer vision. Especially, with the gradual popularization of digital image in recent years, many originally different application areas like video processing and regulation of traffic has started showing interests in this technology. Shadow detection has been mainly divided into two types, method based on image and object.

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