One Kind of Multi-scale Algorithm Based on Wavelet Integration

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Abstract. At present, people universally adopt MSR algorithm to make restoration for degraded and weak light image, but when MSR algorithm makes process on degraded image, it can not effectively make recovery on details and colors of image at the same time, so this paper puts forward one kind of new MSR improvement algorithm to make process on degraded image. It is based on information integration strategy based on wavelet transformation domain to replace linear weight strategy of multi-scale reflected image in MSR algorithm, the basic idea of integration is as follows: firstly, it decomposes wavelet of 2 layers waiting for integration and then take maximum value of absolute in high-frequency component to stress details of image, low-frequency component adopts method based on local power to adjust background and color, realize fidelity effect. Finally, through subjective observation and objective evaluation, it indicates: on recovery for degraded image, algorithm in this paper will have better effect on detail recovery and fidelity aspect than the traditional MSR algorithm.

Introduction

Under condition of weak light, contrast ratio and color of scene in outdoor have degraded, computer visual system can not correctly test and track target in the scene, it needs to make restoration process for degraded image or video. Image restoration is to purposely recover the complete or partial characteristic according to physic model of image degradation so as to improve visual effect of image or meet demand [1] of special analysis. Retinex theory and relevant algorithm are the new idea [2] for image restoration. Its theory base is the constancy of color, means cognition of people on things depends on characteristic of reflected light on surface of object, and it is irrelevant to incident light. Retinex algorithm regards image waiting for restoration composed of reflecting component and incident component, it gets incident component by brightness comparison among pixel, so that further gets reflecting component to restore original appearance of object and realize image restoration. According to degradation mechanism of degraded image, it can regard degraded image composed of factor part of weak light source and part of reflecting original characteristic of scene, which provides reasonable base to use Retinex algorithm and relevant theory to solve problem of degraded image restoration.

At present, Retindex algorithm has developed many kind of forms, the usual ones are McCann's 99 Retinex[3],multi-scale Retinex(Multi-Scale Retinex,MSR)[4] and MSR with color restoration (Multi-Scales Retinex with Color Restoration,MSRCR)[5],variable frame model Retinex[6] etc. These algorithms all have certain limitations; McCann's 99 Retinex adopts idea of iteration, so its complication is very higher. MSR algorithm is one with better restoration effect in Retinex algorithm. However, the current MSR algorithm and its improvement algorithm is strategy of linear weight and synthesize Gaussian function of different scales. Linear weight strategy is one kind of harmonic and mean strategy, which can not well stress each advantages of Gaussian function with different scales. Therefore, it puts forward one kind of new MSR improvement algorithm and applies strategy[7-9] based on wavelet integration into MSR algorithm, replaces linear weight part in MSR algorithm so as to stress merits of Gaussian function of different scales.

Multi-scale Algorithm (MSR): Multi-scale algorithm adopts σ_i with different scales to make linear weight average, realize details restoration and balance among color fidelity, the formula is as follows:

$$\log R(x, y) = \sum_{i=1}^{k} W_i \{\log I(x,y) - \log[I(x,y)*F_i(x,y)]\} \tag{1}$$

k is the total number of scale parameter σ , W_i is weight value，meets requirement that $\sum_{i=1}^{k} W_i = 1$. Under normal condition, MSR takes high, medium and low scales，that is $k = 3$. $F_i(x, y)$ indicates Gaussian function of scale parameter σ_i .

Here we regard standard deviation σ in Gaussian function as scale parameter. The size of σ will directly affect estimation of reflecting component. When σ takes bigger value, Gaussian mould is relatively bigger, performance of Gaussian function is relatively mild, the produced estimation of incident component is relatively smooth after convolution, the expression is low-frequency color and fidelity ability is better, but detail restoration of high-frequency is bad, vice versa. When σ takes smaller value, Gaussian mould is relatively smaller, performance of Gaussian function is relatively stiff, the produced estimation of incident component is relatively rugged after convolution, the expression is low-frequency color and fidelity effect is worse. Therefore, single scale Retinex based on σ parameter can not guarantee detail restoration and color fidelity at the same time.

MSR algorithm based on wavelet integration

Image integration algorithm based on wavelet transformation: As for wavelet decomposition by N layers of 2-D image, it can obtain $3N + 1$ different sub carrier, of which it contains $3N$ high-frequency coefficient and 1 low-frequency coefficient. Except that data of low-frequency coefficient is positive value, other data of high-frequency data is distributed between 0. In the high-frequency coefficient, coefficient with bigger absolute value is used for grey discontinuous, which is the obvious characteristic corresponds to original image (such as virgin, line and regional boundary etc). Image integration method based on wavelet transformation is to make wavelet decomposition for multiple-source images. And then it makes integration process for wavelet coefficient of different sub carrier, then makes wavelet reverse transformation, then it can obtain image after integration. The framework of algorithm is indicated by diagram 1.
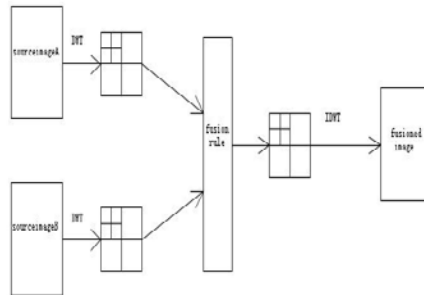

Diagram 1 Algorithm framework of image integration based on wavelet transformation
In the following, we will use one simple example to describe effect of image wavelet integration:

(a)A Source image A   (b) Source image B   (c) Integration image
Diagram 2 Presentation diagram on integration effect of image wavelet

The above image (a) is gray image; (b) is RGB image. The detailed integration plan is as follows: respectively make integration for gray image between (a) and gray of 3 colors channel, of which the integration rule of low frequency and high frequency all adopt average method, (c) is the RGB image after gray image superposition after 3 integrations. (C) not only has color but also details strengthens, which has merits of (a) and (b).

Formulation of integration rule: Make wavelet coefficient integration for reflecting image of 3 scales, respectively make proper integration rule as for low-frequency part and high-frequency part, of which, the coefficient with larger absolute corresponds to the gray mutation place, that corresponds to the obvious characteristics of original image, in order to better stress these obvious characteristics, this paper adopts strategy with larger absolute to make integration. Suppose H_1, H_2, H_3 is high-frequency wavelet coefficient waiting for integration, the integration formula is as follows:

$$H(i, j) = m \times H_{\max}(i, j)$$

$$if\{H_{\max}(i, j) = \max\{abs(H_1(i, j)), \cdots abs(H_3(i, j))\}\} \tag{2}$$

$H(i, j)$ indicates high-frequency wavelet coefficient waiting for integration, m is adjustment coefficient. If it takes m bigger than 1，high-frequency coefficient will be enlarged that means details will become much more obvious, but at the same time, if image has noise, it will also enlarge noise. Under normal condition, it takes m equals to 1.1, this will not only keeps details but also not enlarge noise.。

In the following, we will make research on integration method of low-frequency coefficient in key point. Suppose L_1，L_2，L_3 is low-frequency wavelet coefficient waiting for integration. As for low-frequency coefficient, this paper adopts integration rule based on partial energy, because the low-frequency part of image includes most information such as background, color domain etc, that is to say that energy of image is mainly concentrated on the low-frequency part. It can use partial energy to evaluate energy of pixel point, the definition is as follows: $E = \dfrac{1}{M \times N} \displaystyle\sum_{i=1}^{M} \sum_{j=1}^{N} f(i, j)^2$, of which, E is partial energy, $f(i, j)$ is the gray value of pixel point, M, N is the side length of partial region. The detailed method is as follows: get the coefficient matrix corresponds to low-frequency parameter, and then get new partial energy matrix. The more of these matrixes corresponds to the same position, which indicates this position contains larger energy, regard new partial energy as weight calculation of weight factor and low-frequency coefficient matrix, and then it gets low-frequency coefficient matrix after integration, which can better keep the low-frequency information of original image. We can set one weight bigger than 1 for matrix for coefficient matrix (this paper takes 1.2), which further stresses color domain and background of image. Finally, it makes reconstruction on wavelet of low-frequency part and high-frequency part, and then gets the integration result.

Test analysis

In order to demonstrate practicability and effectiveness of algorithm, the used Matlab 2012a in operation system is WindowsXP, CPU is AMD 4-core and 3.0 GHz, make simulation test on common PC with memory of 4GB RAM. On making wavelet decomposition, it adopts wavelet basis as db1 wavelet, make decomposition for image by 2 layers. The adopted image size is 906×656. It makes process on weak light and degraded image in different scenes. The detailed result is indicated by the following diagram group.
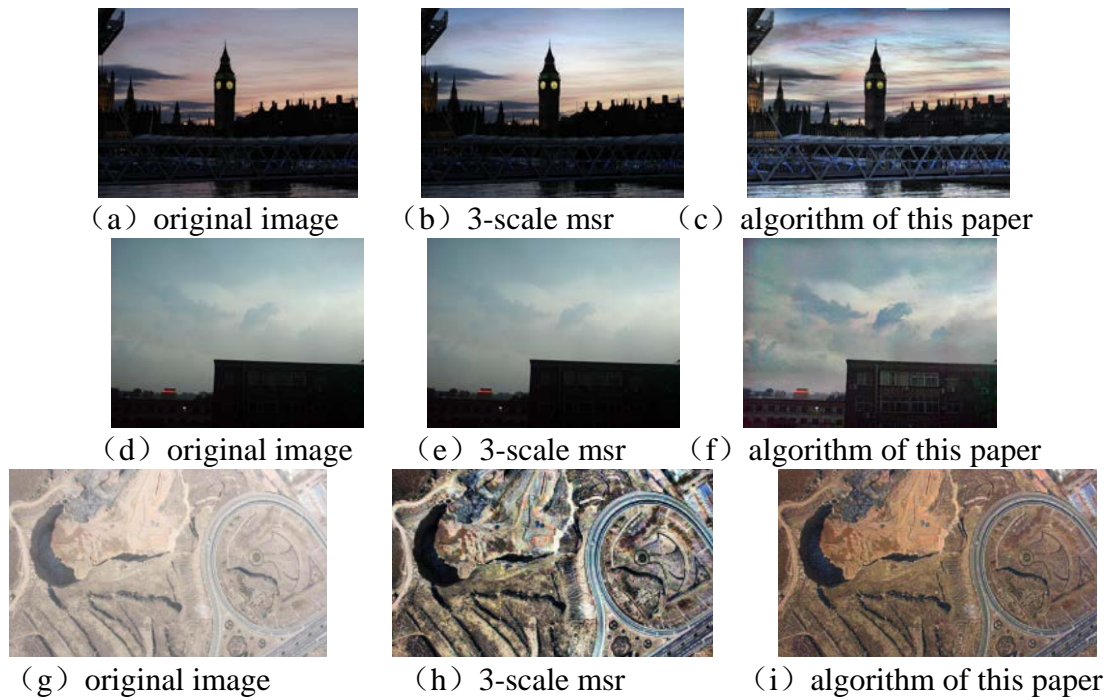
（a）original image   （b）3-scale msr   （c）algorithm of this paper

（d）original image   （e）3-scale msr   （f）algorithm of this paper

（g）original image   （h）3-scale msr   （i）algorithm of this paper

Diagram 3（a-i）Comparison on process result of different algorithm

Diagram 3 is composed of 3 groups of pictures, of which diagram 3, (a), (d) and (g) are original images. By comparing with 3 groups of images, we can see the process result of algorithm in this paper is indicated by diagram 3(c), (f) and (i), it is universally better than the traditional MSR algorithm in aspect of color fidelity, in addition, it is better than the traditional MSR algorithm in aspect of detail procession. For example, textural features of cloud in diagram 3(c) is indicated, while diagram 3(b) dose not indicate cloud details, the house under diagram 3(f) is much more clear than diagram 3(e), the ground texture of diagram 3(i) is much more gentle than diagram 3(h).

In the following, we will make judgment on restored image from angle of objective evaluation; it makes evaluation on image quality in diagram 3 from angle of without coefficient. According to 3 objective evaluation indexes such as average value, average gradient and virgin strength to make judgment. The result is indicted by the following table.

Table 1 Diagram average, average gradient and virgin strengthen in diagram 3

	Average value	Average gradient	Virgin strength
Diagram (a)	80.4704	2.3736	25.3303
Diagram (c)	96.8594	4.9462	51.6569
Diagram (d)	109.8728	5.8144	60.9941
Diagram (d)	112.5265	1.0582	11.2793
Diagram (e)	116.9254	1.1486	12.2363
Diagram (f)	121.2860	3.3189	34.1205
Diagram (g)	88.2241	7.7250	74.3873
Diagram (h)	96.0331	10.3776	108.5565
Diagram (i)	103.4807	13.4262	131.7412

From table 1, we can see the quality evaluation result of image after algorithm process in this paper is better than the traditional MSR algorithm. The value of original image is smaller, the corresponding image light and contrast ratio is worse. He quality evaluation data of degraded image after process of algorithm in this paper has universally enhanced than the traditional MSR algorithm, which indicates that process result of this paper has higher quality than that of after traditional MSR process.

Conclusions

When the traditional MSR algorithm makes restoration for degraded image, it can not simultaneously keep detail enforcement and color fidelity. This paper makes improvement on traditional 3-scale MSR algorithm and makes integration for reflecting image of 3 scales, so that it can improve MSR algorithm and stress advantage of Gaussian function with different scales. The basic idea for integration is as follows: firstly, make decomposition on image waiting for integration by 2 layers, and then take maximum absolute in high-frequency component to stress details of image, low-frequency component adjusts background and color based on method of partial energy, so that it can realize fidelity effect. Finally, through subjective observation and objective evaluation, it indicates that algorithm of this paper has better effect than traditional MSR algorithm in aspect of detail and fidelity.

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