

# Improved Retinex Image Enhancement Algorithm

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## Abstract

Retinex method mainly consists of two steps: estimation and normalization of illumination. How to extract the background illumination accurately is a key problem. The backgrounds of picture sequence in video's adjacent frames are usually similar and closely related. More accurate illumination information can be extracted when this characteristics of video's picture sequence is considered. In the paper, we propose an improved Retinex algorithm. Filter the images using the Gauss masks of different scale and parameter for each frame image, and all these filtering results are fused together by minimum method. In the paper, the scale of Gauss filters are set as 5, 9, 13, 25, and their variance set as 0.3, 0.5, 0.7 and 1.0 respectively. 6 adjacent frame images are selected, and the uniform and optical background image for these 6 images can be extracted by maximum method. This method makes use of the similarity and relationship among the adjacent frame images in videos. Enhance the images using Retinex method with this optical background image as their uniform illumination information. Experiment shows that more accurate backgrounds are acquired and more excellent enhancement performance are achieved.

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## 1. Introduction

As a result of the environmental condition, especially the illumination, most of digital images or video image sequence from gathering equipment, are too bright or dark, and have the imbalanced background, thus the images lose the partial detail information, and the images' quality reduce, which seriously affect the application of images and videos in the transportation, the public security, the punishment detect and so on. How to use the images with the imbalanced background which seriously damaged by the illumination, and how to restore or enrich the detail as well as to balance the background, are important.

American physicist Edwin Land thought that, in the visual information conduction process, humanity's visual system has carried on some kind of processing to the information, has removed the light source intensity and non-uniform irradiation and so on uncertain factors, only been retained. These intrinsic information describing object substantive characteristics will be transferred to cerebral cortex, and the human vision come into being after a more complex information processing. Based on such understanding, in 1977 Edwin Land proposed for the first time the Retinex color theory. According to the Retinex theory, through calculating the relative light and shade relations among picture's various elements, and making the adjustment to each element in the image, present element color can be determined, which is called as the traditional global Retinex algorithm.

Literature [1] proposed the model of how the human vision system adjusts the object color and brightness apperceived - Retinex algorithm. It may achieves the balance in the gradation dynamirange compression, the edge enhancement and the color constancy, thus may be used to the automatic enhancement for different kind of images. But the algorithm is based on the experimental data, and has no unitive mathematical model. Many different improved Retinex algorithms appeared, such as SSR (SingleScale Retinex) algorithm [2-3], MSR (Multiscale Retinex) algorithm [4-6], McCannps Retinex algorithm [7-9] and so on, and obtained widespread application. In essence, all these classics Retinex algorithm is to smooth original image through Gauss model with certain parameters and to extract image's background as far as possible accurate through some suitable ways. In this article, considering the relevance of video's adjacent frame images, we propose an improved multiscale global Retinex algorithm.

## 2. Retinex Theory

The Retinex theory motivated by Land [1] is based on the physical imaging model, in which an image  $I(x,y)$  is regarded as the product  $I(x,y) = R(x,y) \cdot L(x,y)$  where  $R(x,y)$  is the reflectance and  $L(x,y)$  is the illumination at each pixel  $(x,y)$ . Here, the nature of  $L(x,y)$  is determined by the illumination source, whereas  $R(x,y)$  is determined by the characteristics of the imaged objects. Therefore, the illumination normalization can be achieved by estimating the illumination  $L$  and then dividing the image  $I$  by it. However, it is impossible to estimate  $L$  from  $I$ , unless something else is known about either  $L$  or  $R$ . Hence, various assumptions and simplifications about  $L$ , or  $R$ , or both are proposed to solve this problem [2]. A common assumption is that edges in the scene are edges in the reflectance, while illumination spatially changes slowly in the scene. Thus, in most Retinex methods, the reflectance  $R$  is estimated as the ratio of the image  $I$  and its smooth version which serves as the estimate of the illumination  $L$ , and many smoothing filters to estimate the illumination have been proposed.

Retinex theory mainly compensate for the impact of images affected by illumination. Based on Retinex image formation model:

$$S(x,y) = R(x,y) \cdot L(x,y) \quad (1)$$

An image is pixel-by-pixel product of the ambient illumination and the scene reflectance. As the ambient illumination is independent of object itself, only the scene reflectance reflects the inhesion characteristic of object itself. Illumination is a kind of low-frequency image information which is slow changing, and reflectance contains the most high-frequency detailed image information. The Retinex theory deal with the problem of separating the two quantities: first estimating the illumination and then obtaining the reflectance by division. From the mathematical point of viewbased on logarithmic domain, complex multiplication can be converted to a simple addition operation. So the first step taken by most Retinex Algorithms is the conversion of the given image into Logarithmic domain. As shown in formula 2:

$$\log S = \log R + \log L \quad (2)$$

Therefore, as shown in formula 3, the logarithm of the reflectance can be obtained by the logarithm of the image subtract the logarithm of the illumination.

$$\log R = \log S - \log L \quad (3)$$

Then the reflectance can be obtained by taken its index form, as shown in formula 4. The reflectance is inherent properties of object itself.

$$R = \exp(\log S - \log L) \quad (4)$$

As the illumination compared with the reflectance is low frequency component, so the Retinex Algorithm uses the low-pass filter to estimate the illumination .However, as Gaussian filter used in the filtering process will inevitably lose some high-frequency components, image will lose some of the details and edges, resulting in image distortion.

### 3. Nucleation Rate Prediction Using Bp Neural Network

Retinex method mainly consists of two steps: estimation and normalization of illumination. As mentioned above, illumination  $L$  is estimated as a smooth version of input image  $I$ . Once the estimation is completed, illumination is normalized by taking the difference between the logarithms of the input image and the estimated illumination. Smoothing should especially be carried out among pixels which have homogeneous illumination because illumination discontinuities such as cast shadow violate the assumption that the illumination slowly varies. This robustness requirement implies that the estimated illumination must be discontinuous at locations where the input image  $I$  has strong discontinuities of intensity. However, these methods lack inadaptability which can preserve discontinuities efficiently. As a result, they still cannot completely remove cast shadows, and they ultimately cannot avoid the damage in the detail information of images.

The classic Retinex algorithms seem different, but in fact they are very alike. In all these methods, illumination is extracted by smoothing the original image through some kinds of Gauss mask, and complicated calculation is carried out in order to make the illumination information accurate as far as possible. How to extract illumination accurately is the hot and crux in this region. The backgrounds of picture sequence in video's adjacent frames are usually similar and closely related. More accurate illumination information can be extracted as the characteristics of video's picture sequence are considered.

In this paper, we propose a novel Retinex method applying the method of information fusion, which extract illumination by fusing the adjacent frame images' illumination. Our method is mainly based on the point that the backgrounds of picture sequence in video's adjacent frames are usually similar and closely related. The improved global Retinex algorithm for video pictures is shown as follows:

Step 1: Extract the backgrounds for each frame image using multi-scale Gauss masks.

Filtering the images using the Gauss masks of different scale and parameter, background illumination information of different position and illumination power are extracted. For each frame image, all these filtering results are fused together by minimum method, then more accurate and entire background information are extracted. This method is fit for videos in complicate environments. In the paper, the scale of Gauss filters are set as 5, 9, 13, 25, and their variance set as 0.3, 0.5, 0.7 and 1.0 respectively.

Step 2: Fuse the illumination of some adjacent frame images by maximum method.

In the paper, 6 adjacent frame images are selected, and the uniform and optical background image for these images can be extracted by maximum method. This method makes use of the similarity and relationship among the adjacent frame images in videos.

Step 3: Enhancement using Retinex method.

Step1: Transform the input image  $S$  into the logarithms domain, namely:

$$s = \log S$$

Step2: Transform the background image into the logarithms domain, namely:

$$l = \log L$$

Step3: Compute the reflectance :

$$r = \log R = \log S + \log L = s - l$$

Step4: Take the index transform, and the enhanced images are obtained.

$$R = \exp(r)$$

#### 4. Experiment results and analysis



Figure 1 Adjacent 6 frames of images in the video



Figure 2 Enhanced image of the second frame image

Certain transportation monitor video's 6 pictures are collected, and used as experiment data, as figure 2 shown. In this case, the detail information of the car's top cap is that we need to analyze. Because of illumination's influence, the detail of car's top cap can't be recognized by naked eyes. Adopting our method, the result in figure 3 is obtained. We can see the double-row shelf of the car's coping very clearly, and there are no goods on the shelf from the figure 3. More abundant detail information are acquired in the dark region.

## 5. Conclusion

In global Retinex methods, illumination is extracted by smoothing the original image through some kinds of Gauss mask, and how to extract illumination accurately is a key problem. Based on the point that the backgrounds of picture sequence in video's adjacent frames are usually similar and closely related, we propose an improved Retinex algorithm. In the method, the illumination of some adjacent frame images are fused by maximum method, and used as these adjacent frame images' uniform illumination. Experiment shows that more accurate back grounds are acquired and more excellent enhancement performance are achieved.

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