A Research on Image Dehazing Technology for Image Enhancement

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Abstract

Image defogging is to study the method of image enhancement in foggy weather with low definition and lighter color. Image defogging technology aims to improve image contrast and scene clarity, and has broad application prospects in the fields of target recognition, traffic navigation, and remote sensing. Three defogging algorithms in image defogging technology are introduced based on the current research status: global histogram equalization, local histogram equalization, and Retinex algorithm. This article introduces the main steps of the three algorithms and discusses the advantages and disadvantages of each algorithm. Finally, the processing results of these three algorithms are compared and comprehensively evaluated.

Keywords: digital image processing, image enhancement, foggy degraded image, dehazing algorithm

1. Introduction

In recent years, with the development of computer vision systems in the fields of military, transportation, and security monitoring, as well as the impact of haze on people's real lives in previous years, image defogging has become an important research direction of computer vision and is currently widely used in the satellite remote sensing system, aerial photography system, target recognition system and outdoor monitoring system, etc. The visibility of outdoor images is greatly degraded due to the presence of fog[1], the color of the image is gray and white, the contrast is reduced, the object characteristics are difficult to recognize, the visual effect is deteriorated, and the image is very low in viewability. This will seriously affect the post-processing of the image, so image dehazing is required.

The enhancement processing of foggy degraded images is a frontier subject of interdisciplinary, involving research in many fields such as computer vision and digital image processing. In recent years, due to the influence of severe weather such as heavy fog on the video surveillance system, the research of foggy image processing has attracted more and more scholars' attention and has become a research hotspot in the field of image processing. How to choose an algorithm that has better dehazing effect and is easy to apply in practice is the primary task of the current image dehazing work.

2. Algorithm Introduction

Three algorithms are mainly applied in this article: global histogram equalization algorithm, local histogram equalization and Retinex algorithm. Next, the relevant content of the three algorithms will be introduced.

Image enhancement is one of the most important issues in low-level image processing. Mainly, enhancement methods can be classified into two classes: global and local methods[2].

2.1. Global histogram equalization algorithm

The global histogram equalization algorithm performs global processing on the histogram of an image to realize the contrast enhancement of the entire image. The global histogram equalization method is simple and easy to implement, and the processing speed is fast. The disadvantage is that the contrast enhancement effect is not obvious, and the depth of the scene in the same image is diverse, and the degree of degradation is also different. So this method of global histogram equalization does not work well.

The global histogram equalization, the central idea is to change the grayscale histogram of the original image from a relatively concentrated grayscale interval to a uniform distribution in the entire grayscale range. Histogram equalization is to non-linearly stretch the image, redistribute image pixel values, so that the number of pixels in a certain gray scale range is approximately the same, and finally change the histogram distribution of a given image to a uniformly distributed histogram distribution.

2.2. Local histogram equalization algorithm

In order to ensure that the local area of interest obtains the required enhancement effect, it is necessary to perform local histogram equalization. The local histogram equalization algorithm disperses the histogram equalization operation to all local areas of the image, and adaptively enhances the local information of the image through the superposition of the local operations, so that the contrast of each area of the image can be greatly improved. But this method is computationally intensive.

3. Retinex Algorithm

Retinex is a commonly used image enhancement method based on scientific experiments and scientific analysis. It was proposed by Edwin H. land[3].The basic theory of Retinex theory is that the color of an object is determined by its ability to reflect long wave (red), medium wave (green) and short wave (blue) light. Color uniformity is the basis of color uniformity. Different from the traditional linear and nonlinear methods, Retinex can achieve a balance in dynamic range compression, edge enhancement and color constancy. Therefore, Retinex can enhance various types of images adaptively.

The main steps are as followed:

According to the image formation model, an image can be expressed as:

$$\mathrm{I}(x, y) = \mathrm{S}(x, y) \cdot \mathrm{R}(x, y) \tag{1}$$

(x, y) is the coordinates of the pixels in the image, "S" represents the incident light, "R" represents the reflection characteristics of the object, "I" is the reflected light, which is captured by the camera as an image.

Take the logarithm to separate the incident light component S and the reflected light component R. $\mathrm{I}'(x, y)$is the logarithm of $\mathrm{I}(x, y)$.

$$\begin{aligned}\mathrm{I}'(x, y) &= \log[\mathrm{S}(x, y) \cdot \mathrm{R}(x, y)] \\ &= \log(\mathrm{S}(x, y)) + \log(\mathrm{R}(x, y))\end{aligned} \tag{2}$$

Convolve the original image with a Gaussian template, which is equivalent to low-pass filtering the original image to obtain a low-pass filtered image D(x,y), where F(x,y) represents Gaussian filtering function:

$$\mathrm{D}(x, y) = \mathrm{I}'(x, y) \cdot \mathrm{F}(x, y) \tag{3}$$

Subtract the low-pass filtered image from the original image to obtain the high-frequency enhanced image G(x,y).

$$\mathrm{G}(x, y) = \mathrm{I}'(x, y) - \mathrm{D}(x, y) \tag{4}$$

In the previous steps, the incident light component S and the reflected light component R are separated, so the antilog of the resultant high-frequency enhanced image G(x,y) must be taken to obtain the enhanced image R(x,y).

$$\mathrm{R}(x, y) = \exp(\mathrm{G}(x, y)) \tag{5}$$

The contrast enhancement of R(x,y) is performed to obtain the final result image. System circuit module design In the circuit design, this design adopts a voltage stabilizing module, temperature and humidity data acquisition module and voice module. These modules greatly improve the function of the device.

Researchers such as Jobson proposed the single-scale Retinex (SSR) algorithm[4,5]. The specific formula is as follows:

$$\mathrm{R_i}(x, y) = \log \mathrm{I_i}(x, y) - \log[\mathrm{I_i}(x, y) * \mathrm{F}(x, y)] \tag{6}$$

In the formula, Ri(x,y) is the output of Retinex in the "i" color spectrum, Ii(x,y) is the image distribution, that is, the brightness value at the position (x,y). * represents the convolution operation, F(x,y) is a wraparound function that is defined by equation (7).

$$\mathrm{F}(x, y) = \mathrm{K} \cdot e^{\frac{-(x^2+y^2)}{\sigma^2}} \tag{7}$$

Among them, σ is the wrapping scale, K is the normalization constant. The wrapping function satisfies:

$$\iint \mathrm{F}(x, y)\,dxdy = 1 \tag{8}$$

The stronger the dynamic compression capability of SSR is, the better the details of the dark part of the image can be enhanced, but the color distortion of the output image is more serious.

MSR is developed on the basis of SSR algorithm[6]. The specific formula of MSR is as followed:

$$R_i(x,y) = \sum_{k=1}^{K} w_k \{\log I_i(x,y) - \log[I_i(x,y) * F(x,y)]\},$$
$$i = 1, \ldots, N \qquad (9)$$

Among them, i represents the i-th color channel, and (x,y) represents the coordinates of the pixel in the image. N is the number of color channels in the image. N=1 represents a grayscale image, N=3 represents a color image, $i \in (R,G,B)$. $I_i(x,y)$ represents the i-th color channel in the input image, $R_i(x,y)$ represents the output result of the MSR of the i-th channel. $F(x,y)$ is a Gaussian function, k represents the number of Gaussian surround functions or the number of surround scales, w_k represents the weight related to the Gaussian function, $\sum_{k=1}^{K} w_k = 1$, in general, MSR takes three scales of high, medium and low, K=3. As shown in the Fig.1, it is the flow chart of MSR algorithm.

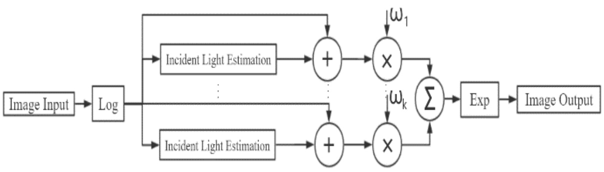

Fig.1 MSR algorithm flow chart

4. Result

The software used for image processing in this project is MATLAB (R2015a), based on Windows 10. As shown in Fig.2, it shows the results after three dehazing algorithms.

Fig.2 Three algorithm processing results

As shown in the figure, the first image in the first line is the original image, the second picture is the result of processing using the global histogram method, the first image in the second line is the local histogram method, and the last image is the MSR algorithm.

5. Conclusion

This article introduces the traditional image enhancement algorithm of global and local histogram equalization and the Retinex algorithm. Regardless of the specific reasons for image degradation, only from the perspective of image processing, based on improving the contrast of the image, the commonly used method is histogram equalization, and its algorithm is simple and easy to implement. It can be seen from the experimental results that the histogram equalization algorithm greatly reduces the influence of impurities on the image contrast enhancement, so this method can achieve better clarity when processing foggy scenes. However, this method is only suitable for degraded images with a single depth of field. For degraded images with complex depth of field, a certain degree of blocky response will appear while the image is sharpened, especially the detailed information of the distant scene in the image appears blurred.

The enhanced image processed by the MSR algorithm can obtain a satisfactory enhancement effect by using the MSR algorithm. The contrast of the image is significantly improved, the detailed information of the image is fully enhanced, and the detailed features of the scene can be fully displayed and suppressed. noise. Although the MSR algorithm is a better image defogging algorithm, it still has some shortcomings.

This method regards the intensity of the image as the spatial coordinate vector of the RGB three colors, and performs arithmetic processing on it. In the synthesis of the three colors, errors are likely to occur and cause the distortion of the image.

Although it can be enhanced to a certain extent for dense fog weather, the overall effect cannot achieve the enhancement effect of general foggy weather. Since heavy fog has a greater impact on image clarity, once a foggy degraded image with multiple depths of field is formed, the algorithm does not have adaptability and does not take into account the local characteristics of the image, so local areas with different depths of field cannot be effectively enhanced.

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