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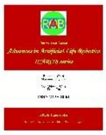

Research Article

A Research on Image Defogging Algorithm based on Image Enhancement

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ABSTRACT

In order to solve the problem of low contrast image and loss of image details in the foggy weather, the image defogging technique is used to remove the noise in the image and improve the image contrast, so as to recover a clear and fog-free image. In this paper, we mainly introduce three image defogging algorithms: global histogram equalisation, local histogram equalisation and the Retinex algorithm. The advantages and shortcomings of each algorithm are summarised through the study of the principles of each algorithm and the comparative analysis of the experimental result.

1. Introduction

In recent years, with the development of computer vision and image processing technology, the research and application of outdoor vision systems is growing rapidly, thus making image processing widely used in more scientific and engineering fields. These outdoor vision systems need to take outdoor scenery images as input and accurately detect the characteristics of the input images through computer vision, image processing and other processing techniques. In order to ensure that the vision system works properly around the clock, it must be able to adapt to all types of weather conditions in order to improve the reliability of the system. Foggy weather conditions are one of the most serious effects on vision of all weather conditions. The visibility of outdoor images is greatly degraded due to the presence of fog, haze, smog etc [1]. Therefore, it is of great practical importance to study how to effectively deal with image degradation obtained under weather conditions such as dust and fog, in order to recover atmospheric degraded images and enhance the information of scenic details.

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

There are three algorithms are mainly applied in this article: the global histogram equalization algorithm, the

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local histogram equalization and the 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 histogram equalisation algorithm is one of the more widely used global enhancement methods, mainly for enhancing the contrast of images with reduced dynamic range of grey values and for improving the dark or light areas of the whole image. The global histogram equalisation algorithm is simple and efficient to implement, and works well for single depth-of-field images, but for images with variable scene depth, it is difficult to reflect the changes in local depth of field in the image, and therefore, the contrast enhancement is less effective.

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*

Since global histogram equalisation is for the whole image, local image regions are ignored and the details of the local image become blurred due to the increase in overall brightness. Local histogram equalisation is proposed, i.e. an image is divided into multiple regions and then histogram equalisation is performed on multiple regions. This method can improve the contrast and detail of local regions, but it has the problem of local block effect and large computational effort.

3. Retinex Algorithm

Retinex theory is a theory of image enhancement based on scientific experiments and scientific analysis of the human visual system. The basic principle model of the algorithm was first proposed by Land in 1971 as a theory of colour and a method of image enhancement based on the constancy of colour [3]. Retinex theory is based on the idea that the colour of an object is determined by its ability to reflect long (R), medium (G) and short (B) wavelengths of light, rather than by the absolute value of the intensity of the reflected light; The colour of the object is not affected by the non-homogeneity of the light and is consistent, i.e. Retinex theory is based on colour sense consistency. The algorithm balances the three metrics of image dynamic range compression, image enhancement and image colour constancy, allowing for adaptive enhancement of foggy images. The Retinex enhancement process is therefore carried out by applying the Retinex algorithm to each of the R, G and B layers of the RGB image and then integrating them into the new image.

The main steps are as followed. According to the image formation model, the image can be seen as consisting of an incident image and a reflected image, where the incident light shines on the reflecting object and is reflected by the reflecting object to form the reflected light into the human eye. The final image formed can be expressed by the following equation.

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

(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. $I'(x,y)$is the logarithm of $I(x,y)$.

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

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:

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

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

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

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).

$$R(x,y) = \exp\big(G(x,y)\big) \quad (5)$$

The contrast enhancement of R(x,y) is performed to obtain the final result image.

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

$$R_i(x,y) = \log I_i(x,y) - \log[I_i(x,y) * F(x,y)] \quad (6)$$

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).

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

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

$$\iint F(x,y)dxdy = 1 \quad (8)$$

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]. And it has the advantage of maintaining both high image fidelity and compression of the dynamic range of the image. MSR also enables colour enhancement, colour constancy, local dynamic range compression, global dynamic range compression and can also be used for X-ray image enhancement. The specific formula of MSR is as followed:

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

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 ∈ (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.

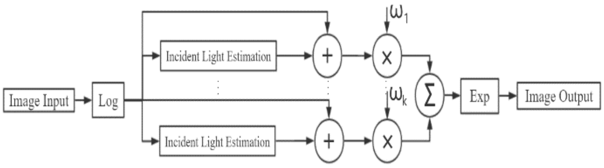

Fig.1 MSR algorithm flow chart

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.

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.

Fig.2 Three algorithm processing results

5. Conclusion

This article introduces the traditional image enhancement algorithm of global and local histogram equalization and the Retinex algorithm. Global enhancement is the dynamic adjustment of pixel values based on the statistical information of the whole image, with the aim of improving the overall contrast of the image. It should be noted that this method processes pixels independently of the location of the region and only reshapes the pixel distribution based on the image's grey scale information; in fact, the degree of scene degradation is closely related to the depth of field, so globalised enhancement is more limited when dealing with fogged images. Local enhancement highlights texture details in certain local areas of the image, eliminates block effects, suppresses over-enhancement and has some advantages over other algorithms in terms of image detail retention.

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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