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An overview of image enhancement dehazing algorithms

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Abstract. This dissertation is an overview of Image dehazing algorithm that is utilized to process hazy images through certain technologies to remove the image haze occlusion and interference, improve the visual effect of image. For example, the contrast, color and detail and other aspects. The research method is literature review. The image enhancement algorithms mainly include histogram equilibrium, homomorphic filtering, wavelet transformation and Retinex method. The of these algorithms will be discussed detailly in the following sections of the article. The conclusion is that due to the error of the parameter information in the image with fog, the current defogging algorithm is still unable to achieve perfect results.

Keywords: image enhancement, dehazing algorithms, histogram equilibrium, homomorphic filtering

1. Introduction

Images captured in hazy weather are under the influence of aerosols in the air and mass reduction, this is due to the light scattering by particles in the process of air and absorption, lead to the surface of the target scene reflected light attenuation, and atmospheric environment light scattering by aerosols and blended into the imaging optical path, the phenomenon such as fuzzy, contrast, color degradation decline [1].

Image dehazing algorithm is to process foggy images through certain technologies to remove the image haze occlusion and interference, optimize the contrast, color and detail and other aspects. It mainly includes image enhancement and image restoration.

Image enhancement is referring to by some image processing methods of degradation of some image characteristics, such as edge, outline, contrast and so on, in order to improve the visual effect of image, improve image clarity, or some "useful", in the outstanding image compression other "useless" information, the image is converted to a more suitable for people or in the form of computer analysis.

The aim of image enhancement is to make the processed image more suitable for the human eye`s sensory characteristics or machine recognition. In medical imaging, remote sensing imaging. Image enhancement technology has a wide range of applications in the field of character photography [2].

The image enhancement algorithms include histogram equilibrium, homomorphic filtering, wavelet transformation and Retinex method, which will be discussed detailly in the following sections. There are also some other algorithms such as Histogram equalization (AHE) and Restricted Contrast Adaptive Histogram Equalization (CLAHE).

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2. Histogram equilibrium

The "central idea" of histogram equalization processing is to change the gray histogram of the original image from a relatively concentrated gray range to a uniform distribution in the whole gray range. Histogram equalization is to carry out nonlinear stretching of the image and redistribute image pixel values so that the number of pixels in a certain gray range is roughly the same. Histogram equalization finally changes the histogram distribution of a given image into a "uniform" histogram distribution.

Considering the pixels of an image have a tendency of entirely occupation of the possible gray level and have an evenly distribution, then this image has a high degree of contrast and a large dynamic range [3]. The HE algorithm uses the cumulative distribution function (CDF) to map the specified input gray level to the output gray level, to obtain a output gray level that has approximately uniform probability density function, in order to optimize the image contrast and dynamic range [4].

2.1. Local equalization and global equalization

There are two methods of HE algorithm: local equalization and global equalization.

Firstly, the global method is to equalize the whole image to enlarge the gray area with more information and improve the image`s visual effect. It is relatively simple, but the effect of local details is vague, and it is suitable for simple scene foggy images [4].

Then the local method is to disperse the equalization algorithm to the local area of the image, and then obtain the required enhancement effect through local operation. It is suitable for image processing on hazy days with complex depth information changes and low contrast, but it will increase the impact of noise on the image [4].

2.2. Standard histogram equalization algorithm

It is assumed that I $\in$ I(I, j) is the image of gray level L, and I(I, j) is the gray level of the coordinate position (I, j), also I(I, j) $\in$ [0, L-1]

The probability density function of the gray level of image I is defined as:

$$p(k) = \frac{nk}{N}, (k = 0,1\ldots, L - 1) \tag{a}$$

Where in (a), N is the total number of pixel points, nk is the number of pixel points with gray level of K.

The cumulative distribution function of gray level of image I is defined as:

$$c(k) = \sum_{i=0}^{k} p(i), (k = 0,1,\cdots, L-1) \tag{b}$$

The standard histogram equalization algorithm project the initial image to enhanced image of nearly uniform grayscale distribution through the cumulative distribution function This mapping can be represented by:

$$f(k) = (L-1) \times C(k) \tag{c}$$

3. Homomorphic filtering

Homomorphic filtering algorithm combines gray scale transformation and frequency filtering to process image mainly through compression of brightness range and contrast enhancement [5].

In the process of image collection, noise and image are often combined by multiplication, which is the luminance-imaging model [6]:

$$F(x,y) = i(x,y) \cdot r(x,y) \tag{d}$$

In formula (d), F(x, y) represents the generated image; I (x, y) is illuminance component; R (x, y) represents the reflection component.

Linear filter is usually used to deal with the image which combines noise and image in a linear way, and the filter result of multiplicative noise is not good. The processing method of homomorphic filter is to transform multiplicative noise into additive noise by nonlinear logarithmic transformation, and finally restore original signal by exponential inverse transformation. The process is shown in Figure 1:

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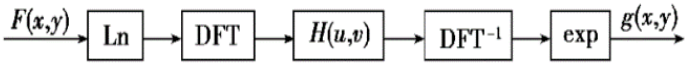

Figure 1. Homomorphic Filtering flowchat.

In figure 1, Ln represents logarithm transform, DFT represents the Fourier transform, H(u, v) is the homomorphic filter function, DFT-1 represents inverse Fourier transform, and exp represents the exponent [7].

4. Wavelet Transformation

4.1. Background

Wavelet transform is another landmark signal processing method after Fourier transform, which has been widely used in many fields such as image processing, quantum physics, data compression and signal analysis.

The wavelet transform is to change the trigonometric function of the Fourier transform into a wavelet function. Wavelet is a waveform with a small area, limited length and zero mean value, unlike trigonometric functions, which are infinitely extended at both ends of the image. Therefore, when the signal is decomposed, the position information is available.

Under haze weather conditions, the atmosphere is cloudy, the degree of light attenuation is large, resulting in cloudy vision, distant scenery blurred. The foggy image enhancement method based on wavelet transform uses the multi-resolution analysis ability of wavelet transform to decompose foggy image to low frequency sub-band image and high frequency sub-band image, then designs processing methods of different parts according to their characteristics.

The low frequency part contains most of the noise of the foggy image, while the high frequency component corresponds to the detail part of the graph [8].

4.2. Basic idea

The basic idea of this method is using a family of functions to represent or approximate a signal, this kind of family is called the wavelet function system.

The wavelet function system is represented by $\psi(x)$ and $\Phi(x)$ represents scale function, and is defined as: [9]

$$f(x) = \sum_{k} c_{j_0}(k)\varphi_{j_{0,k}}(x) + \sum_{j=j_0}^{\infty}\sum_{k} d_j(k)\psi_{j,k}(x)$$

In the formula, j0 is any initial scale, Cj 0 (k) is the number of scale system, DJ (k) is the wavelet coefficient.

The steps of wavelet transform image enhancement [10]:

(1) According to the initial hazy figure.

(2) The wavelet decomposition of the initial figure is carried out to get the component of low and high frequency of the image.

5. Algorithm based on retinex

The theory of Retinex was put forward in 1963, which simulates Human Visual System (HVS) based on the principle of retinal imaging [11].

When judging the true color of an image, the human visual system is almost immune to the interference of light, in another word, visual constancy. Retinex algorithm was proposed based on visual constancy. Visual form constancy is the ability to recognize that a shape or object remains the same despite changes in size, position, direction, orientation and distance. For example, an object is still the same whether it is seen from the top, side or underneath.

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This algorithm has the advantage of color consistency and can ensure the color of the image is not disturbed by the outside bad factors, so it is often used to enhance the low-quality color image, and has achieved satisfactory results.

Retinex algorithm includes single-scale algorithm, multi-scale algorithm.

Single-scale Retinex algorithm gets reflection graph by estimating the ambient brightness without correcting the scene. This method is simple to implement but prone to halo phenomenon.

Multi-scale Retinex algorithm achieves the dynamic compression and color invariance, resulting in better visual effect, but the algorithm is also prone to halo generation [12].

Retinex algorithm can improve image color constancy, improve image contrast, and effectively display the details of dark areas in the image, but the processed image is easy to produce edge blur and color distortion.

6. Conclusion

This dissertation concludes the mainly used dehazing algorithms of image enhancement. The hazy image can be regarded as the low-frequency noise introduced into the clear image, the gray level of the image is concentrated in a certain area, the contrast of the image is low, and the visual effect is blurred. The main purpose of image dehazing is to remove the noise (fog) in the image, improve the contrast of the image, so as to restore a clear fog free image. Image enhancement is a traditional method of dehazing and is simple to implement and has obvious visual effect, which has been widely used in various fields, such as remote sensing, video surveillance, navigation and so on. Analysis and comparison of various algorithms, Retinex algorithm has a large development space, it has the value of further research and discussion.

Although various defogging algorithms have been developed to a certain extent, due to the error of the parameter information in the image with fog, the current defogging algorithm is still unable to achieve perfect results. Therefore, the field of image defogging still has great development prospects.

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