Low-light Image Enhancement Technology Based on Multi-scale Gradient Domain Guided Filtering

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Abstract: The enhancement of current digital images is not limited to the single function of highlighting the high-frequency information of the image, it should also suppress noise to a certain extent. It therefore requires a lot of user interaction and is sensitive to noise, such as active contour-based image segmentation methods. This causes great trouble for further applications such as image classification, segmentation, and recognition. This also happens to be a key technology for intelligent interfaces when studying human-computer interaction. In recent years, many edge detection methods based on new theories and technologies have appeared, such as edge detection methods based on multi-resolution analysis and wavelet transform, fuzzy theory, mathematical morphology, artificial neural network and other theories. However, the commonly used multi-scale method has a large amount of calculation, which is to perform linear convolution of the image with a Gaussian function with adjustable width. When performing multi-scale smoothing, it is easy to blur important details of the image. With the development of computer vision technology, image understanding, image recognition, target tracking and other artificial intelligence neighborhood research hotspots. Statistical model can better describe the characteristics of natural images and has attracted extensive attention of researchers. The intensity component of the original image is enhanced in multi-scale, so that the detail information and color fidelity of the image are enhanced; However, the enhancement of dark areas in the image is not obvious, and the image noise is easy to expand. This paper mainly focuses on a main research field of weak illumination image enhancement technology using mathematical morphology for guided filtering.

1. Introduction

Edge detection is an important content in image processing. On the one hand, the edge of the image often corresponds to the important features of the object in the physical world where the image is generated, such as the boundary of geometry [1]. At present, the digital image enhancement is not limited to the single function of highlighting the high-frequency information of the image, but it should also suppress noise to a certain extent. Stretch or compress the dynamic range of the image according to the specific situation, or truly restore the image color [2]. The edge-based method is to extract the edges of different areas by detecting them, allowing users to draw curves around the edges of foreground objects, and then optimize the curves by segments. Therefore, it needs a lot of user interaction and is sensitive to noise, such as image segmentation method based on active contour [3]. This brings great trouble to further applications such as image classification, segmentation and recognition. From the aspect of image recognition human-computer interaction, it basically gives the machine system the ability to distinguish different targets, that is, people's ability to observe the essential characteristics of physical objects [4]. This also happens to be a key technology for intelligent interfaces when studying human-computer interaction. In recent years, many edge detection methods based on new theories and technologies have appeared, such as edge detection methods based on multi-resolution analysis and wavelet transform, fuzzy theory, mathematical morphology, artificial neural network and other theories [5].

The edge of the image is the boundary line between the target and the background to be

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extracted, and is the main basis for image analysis such as image segmentation, image enhancement, and pattern recognition. The edge of a two-dimensional image is a collection of gray-scale mutation points, which appear as high frequencies in the frequency domain. However, the commonly used multi-scale method has a large amount of calculation, which is to perform linear convolution of the image with a Gaussian function with adjustable width. When performing multi-scale smoothing, it is easy to blur important details of the image [6]. Therefore, how to restore or enhance the image based on the influence of the above factors has become the hot and difficult point of the current digital image processing technology. And with the development of computer vision technology, image understanding, image recognition, target tracking and other artificial intelligence neighborhood research hotspots [7]. It is widely used in security monitoring, aerospace military, smart home and so on. With the gradual deepening of the theory and application of various branches of mathematics, the prospect extraction technology combining the theories and methods of many cross fields has emerged. Statistical model can well describe the features of natural images, which has attracted wide attention of researchers [8]. The intensity component of the original image is enhanced by multi-scale, so that the detail information and color fidelity of the image are enhanced. However, the enhancement of dark areas of the image is not obvious, and the image noise is easy to expand [9].

2. Overview of image enhancement methods

2.1. Spatial domain image enhancement

Spatial domain intensity generally includes gray scale transformation, histogram transformation, histogram equalization and so on. Guided filter optimizes the binary segmentation results. Guided image filter is an edge-preserving filter, which can realize the functions of image edge smoothing, detail enhancement, image fusion and denoising [10]. It effectively promotes the stability and reliability of face recognition in the dynamic environment, and can minimize the interference of factors such as changing light, changing different angles W and shadow ornaments on the face, thus achieving good recognition results. Because wavelet can concentrate the signal energy on the wavelet coefficients, the amplitude of wavelet coefficients at the edge of the image with concentrated energy is relatively large. However, the amplitude of wavelet coefficients of noise with energy dispersion is relatively small. A simple way to solve this problem is to threshold the gradient signal. However, the traditional gradient operator will "blur" the pixels on the edge with small gradient values, even if the grayscale difference of the pixels between the two sides of the edge is large. Because the global processing method does not consider the local characteristics and adjusts the global pixels uniformly, the calculation is simple but the actual filtering effect is poor. The commonly used local window linear filtering can be based on regional information such as local contrast and edge intensity, or use the mode of partial differential equation for filtering, which has good results.

2.2. Frequency domain image sharpening

Spatial image processing is intuitive, and the image is understood as a two-dimensional function value. The image processing in frequency domain is to filter and transform the image in frequency domain. The global contrast of the image is enhanced, and the dynamic range of the image is compressed. Moreover, the analysis framework of deep learning is based on the formation of visual object organization. The main principle is to filter the input image through a guide image, and the output image can fully obtain the edge features of the guide image while retaining the overall features of the input image. The most essential feature should be robust to noise, and be free from the influence of environment and conditions, such as lighting conditions and acquisition equipment for extracting image features. The traditional enhancement algorithm takes the reflection component directly as the enhanced image, but the local area of such an image will appear inhomogeneity, and the noise in the dark area may also be highlighted. Here the "blurred" edge is modeled as a sloped edge, and the pixel grayscale difference between the two sides of the edge is called the "edge

height". For sloped edges, since the output of the traditional gradient operator is the slope of the edge. Fourier transform and inverse Fourier transform are the basis of frequency domain processing. The process is to represent spatial information in frequency domain and spectrum, and the inverse process is the step of image restoration.

3. Feature extraction and classification

3.1. Feature extraction

In recent years, experts and scholars at home and abroad have done a lot of work on feature extraction and its application in image analysis, pattern recognition, artificial intelligence and computer vision. In-depth research has been done in the above fields, and some achievements have been obtained, some of which can have basic practical value. For digital images, the basic principles of multi-scale edge detection and continuous images are basically the same, but there are some differences in some specific processing techniques. The pixel corresponding to the component is also equal to zero or very close to zero, but the corresponding pixel is enlarged and much larger than zero after processing by the enhancement algorithm. Then the displayed image will have different degrees of distortion at the corresponding pixel points, as shown in Figures 1 and 2.

Figure 1 Original image

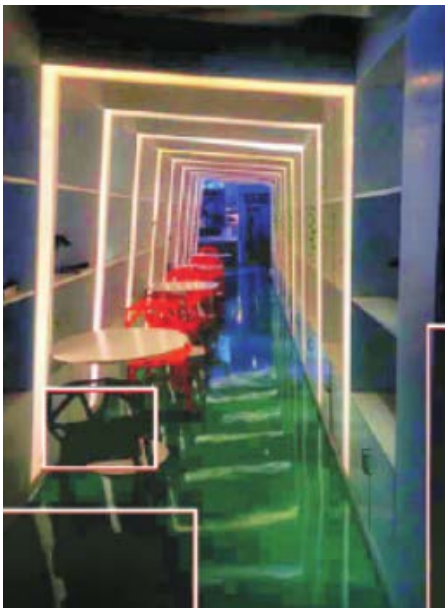

Figure 2 Uncorrected image

However, if the structural elements are too small, the gradient operator will produce a small output result on the slope edge, although it has high spatial resolution. These two components are closely related in airspace. However, they can be separated in the frequency domain, and the illumination component is the low-frequency component in the frequency domain of the signal, that is, the flat area or the background brightness of the image. After guided filtering, most of the noise is suppressed and the foreground edge is well preserved. At the same time, within a limited number of times, the more filtering times, the more obvious the details are. Scholars need to work harder to study, and have more profound discoveries and attainments in image feature extraction methods.

3.2. Feature classification

The process of classifying objects in an image into specific categories is called image recognition. To classify, the first step is to have a class. Because there is no purely objective criterion, many classifications are basically subjective, and all the classifications are complicated. If the modulus value of a point is originally a local maximum value, but its modulus value becomes close to 0 after several transformations, the point is considered to be a noise point, not an edge point. If a correction method is added to the luminance component on the basis of this algorithm, the color distortion phenomenon will disappear. As shown in Figures 3 and 4.

Figure 3 Algorithm enhanced image

Figure 4 Image after the algorithm correction

If the slope is not large, the threshold method cannot be used to distinguish the edge of the slope from noise or quantization error. And the output of the ideal gradient operator should be equal to the edge height of the input, not the edge slope. Therefore, the general Gaussian low-pass filter gets the effect of blurring the whole image, and the bilateral filtering is based on this. The similarity index of pixel gray value is added for convolution operation. Ordinary vertices are connected by edges, and their weights are determined by the boundary smoothing term. It is obviously difficult to calculate gravity and supporting force from the information we can see. In reality, we need to rely on our experience.

4. Conclusions

This paper proposes an image method to extract different illumination invariant characteristics in different situations. Firstly, the input image is transformed into gradient domain, and a set of optimal relative gradient difference information can be theoretically deduced to obtain the characteristics of constant illumination. While improving the edge detection algorithm, it can extract the boundary line between the target and the background more clearly, which is suitable for image analysis such as target recognition, image segmentation and feature extraction. On the hardware, the quality and direction of incident light are strict, the precision of optical system is also high, and the accuracy control of equipment parameters is strict. In order to further discuss fractional differentiation, the ability of guiding filter to keep the principal component of image or two-dimensional signal is stronger. When extracting the foreground area of the image with noise and uneven gray level, it can suppress noise, keep accurate edge information, and extract complete and true edges. A luminance component correction model based on luminance magnification factor histogram is designed to suppress color distortion or distortion in enhanced images. Doing so has a very important role in the subsequent image representation and feature extraction, especially the robustness to changing lighting.

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