IMAGE ENHANCEMENT ALGORITHMS

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Image enhancement is a process of improving image quality and enhancing image features by applying different methods and techniques. This article will introduce some common image enhancement methods and their principle formulas, and describe the final effects they produce.

Introduction

Image enhancement has wide applications in fields such as computer vision, image processing, and computer graphics. Image enhancement improves image visualization and analysis by improving aspects such as image contrast, clarity, color saturation, and detail. Image enhancement is widely used in many fields, including computer vision, medical imaging, remote sensing images, security surveillance, and digital art. It can improve the visual quality of images, enhance image features and information, and make images more suitable for subsequent analysis, processing and applications. The following are some common image enhancement methods and how they work.

I. Histogram equalization

Histogram equalization redistributes the pixel values of the image so that the histogram of the image is evenly distributed throughout the entire grayscale range, thereby enhancing the contrast of the image.The following is its principle formula:

$$J(x, y) = (L - 1) * CDF(I(x, y))$$

Let the original image be I, the equalized image be J, and the gray level of the image be L (usually 256). Among them, CDF represents the cumulative distribution function, which calculates the cumulative probability of the occurrence of pixels at each gray level.

Histogram equalization can enhance the contrast of the image and make the details in the image more obvious. Dark areas will become lighter, and bright areas will become darker, resulting in a more even distribution of brightness throughout the image.

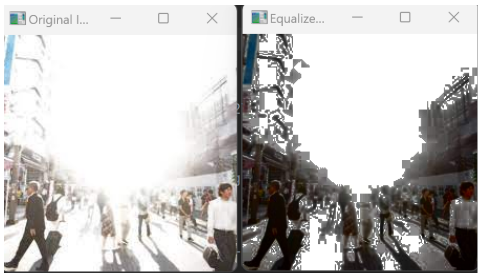

Figure 1 – Histogram equalization

The above figure is a comparison picture of pictures after histogram equalization. It should be noted that histogram equalization is a global operation and does not consider the local structure of the image. In some images, histogram equalization may introduce noise or enhance it. Therefore, before applying histogram equalization, you may want to consider using other image enhancement techniques or performing local contrast enhancement to process image details in specific areas.

In general, histogram equalization is a commonly used image enhancement technique that enhances the contrast and visual effects of an image by redistributing its pixel values. It is widely used in fields such as computer vision, image processing, and computer graphics.

II. Gaussian filter

Gaussian Filtering is a commonly used image processing technique used to smooth images, reduce noise, and extract image features. It is based on the concept of Gaussian function and is implemented by performing a convolution operation on the image.

The Gaussian function is a commonly used mathematical function, also known as the normal distribution function. It has the shape of a bell curve, with a peak value and a standard deviation parameter. Gaussian functions are widely used in image processing to blur images and reduce noise.

Gaussian filtering is very common in real-time image processing, such as real-time object detection and tracking in the field of computer vision. Due to the linear and local nature of Gaussian filtering, the filtering operation can be accelerated by using fast convolution algorithms such as Gaussian pyramid.

The following is its principle formula:

$$J(x, y) = G * I(x, y)$$

Among them, let the original image be I, the Gaussian filter be G, and the filtered image be J. * represents the convolution operation, and G represents the Gaussian filter template.

Gaussian filtering can smooth the image and remove noise and small details, making the image clearer. It reduces high-frequency components in the image by blurring the pixels in the image.

The following is a comparison picture of pictures after Gaussian filter:

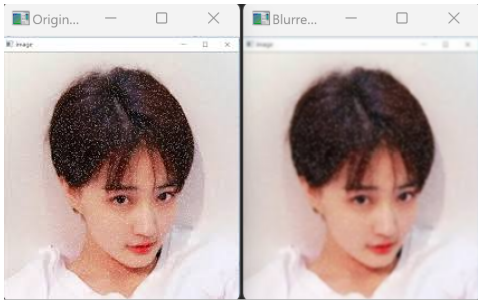

Figure 2 – Gaussian filter

It should be noted that the selection of Gaussian filter should be adjusted according to the specific application requirements. Smaller filter sizes preserve more detail, but may not reduce noise enough. Larger filter sizes smooth the image more strongly, but may result in loss of detail. Therefore, for some images, it may be necessary to select different filters or parameters according to specific needs, or to combine other image processing techniques to achieve better results.

III. Sharpening (Laplacian sharpening)

Laplacian sharpening is widely used in image processing and computer vision, and is often used to enhance the edges, details, and texture of images. It can make images clearer and more distinct, improving the visual quality and recognition performance of images.

By enhancing the high-frequency components in the image, the edges and details of the image are more prominent. The following is its principle formula:

$$J(x, y) = I(x, y) + k * L(x, y)$$

Among them, let the original image be I, the Laplacian filter be L, and the filtered image be J. k is the gain factor, and $L(x, y)$ represents the result of filtering the image by the Laplacian filter.

Laplacian sharpening enhances edges and details in an image, making them stand out more. It does this by adding high-frequency components to the image, making edges sharper and details clearer.

The following is a comparison picture of pictures after Laplacian filter:

Figure 3 – Laplacian filter

No matter which type of image you choose, you can enhance the sharpening effect by adjusting the parameters of the Laplacian filter or combining it with other image enhancement techniques. Please note that when performing image processing, it should be taken to maintain the naturalness and authenticity of the image and avoid excessive enhancement or distortion.

IV. Wavelet transform

Wavelet transform analyzes the frequency and spatial information of the image by converting the image into the wavelet domain, and enhances or suppresses the wavelet coefficients of different frequencies according to requirements.

Wavelet transform can capture the multi-scale details and structure of the image. By enhancing or suppressing the wavelet coefficients of different frequencies, the image details can be enhanced or removed.

The following is a comparison picture of pictures after Wavelet transform:

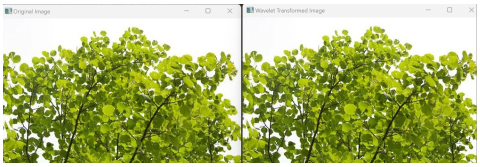

Figure 4 – Wavelet transform

Note that the effect of the wavelet transform also depends on the chosen wavelet function and transform parameters. You can try using different wavelet functions (such as haar, db2, db4, etc.) and adjust the transformation parameters to get the best results. Different wavelet functions and scale parameters are suitable for different types of signals and images. In addition, when displaying the wavelet transformed image, the contrast and brightness can be appropriately adjusted to enhance the visualization of the effect.

V. Conclusion

Image enhancement is the process of improving image quality and performance by applying various methods and techniques. This study introduces some common image enhancement techniques and models. The end effects that they produce are described. The methods are analyzed and it is shown under what conditions they are most effective.

References

1. Xiaolin Chen, Research on Image Quality Evaluation Technology Based on Visual Features/ Shang Hai, 2012, Page 12-13.
2. Yanmei Li, Related Technology and Application Research of Image Enhancement /Chen Du, 2013,Page 15-20.