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An Improved Infrared Image Contrast Enhancement Method

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Abstract. Aiming at the characteristics of infrared image, such as concentrated gray level distribution, low contrast and poor resolution, the paper proposes an improved infrared image enhancement algorithm. Firstly, the original image is filtered by adaptive median filtering method, then platform histogram equalization and gamma transformation are performed on the filtered image to improve the overall contrast of the image. At the same time, the filtered image is performed by Laplacian sharpening to get the edge information of the image. Finally, we obtained an enhanced infrared image by weighted combination of gamma transformation and Laplacian sharpening. Experiment shows that target contrast and average brightness are enhanced by the proposed algorithm, furthermore, the overall information is preserved and the edge information of the image is obtained, which improves the visual effect.

1. Introduction

Infrared image is an image of thermal radiation distribution. The variation of pixel brightness in the image reflects the change of radiant energy intensity of target and scene[1]. Since the temperature difference between the target and the background in the scene is relatively small, infrared images have the characteristics of high background and low contrast, and its signal-to-noise ratio is also lower than that of visible light. In order to be able to identify the target from the infrared image accurately, the infrared image must be enhanced[2]. Histogram equalization is a commonly used image enhancement method. It redistributes image histogram data through image histogram statistics [3], and changes the gray value of each point in the image by a certain correspondence to achieve image enhancement. The gray level adjustment strategy [4] is: in the histogram, the interval between the number of pixels and the densely distributed gray levels becomes larger, so that the contrast is improved; the number of pixels is small, and the interval between grayscales with less distributed distribution becomes smaller, even 0 (the gray level is combined), reducing the contrast. However, Histogram equalization may cause the background and noise to occupy more gray levels, while the target has less gray level, which is equivalent to improve the background and noise contrast, but reduce the contrast of target. Therefore, conventional histogram equalization enhancement algorithm is not suitable for infrared image enhancement.

In order to overcome the shortcomings of the histogram equalization algorithm, domestic and foreign scholars have proposed a variety of histogram-based infrared image enhancement algorithms[5], with platform histogram equalization algorithm (PE), histogram projection (HP) [6], brightness Algorithms such as double histogram equalization (BBHE) and binary sub-image histogram equalization (DSIHE) [7] are maintained. Among them, the platform histogram algorithm is the most widely used algorithm, although this algorithm can increase the contrast, the effect is not soft enough, it is relatively blunt, for some blurred infrared images, the contrast effect is poor, and in some cases, the image quality is degraded. In order to compensate for the lack of platform histogram equalization,

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this paper performs gamma transformation on the image of the platform histogram equalization, and combines the Laplacian sharpening to improve the enhancement effect of the infrared image, and obtain the overall information of the image, which improves the visual effect and is convenient for subsequent operations.

2. Traditional Image Enhancement Method

2.1. Platform Histogram Enhancement

Platform histogram enhancement is an improved algorithm based on histogram equalization algorithm in which threshold T is designed to transform the original histogram. The histogram equalization mainly enhances the background and noise, while the platform histogram mainly enhances the target, suppresses the background and noise, and improves the visual effect of the infrared image, but there is a problem that the layering is not strong and the overall brightness of the image is low.

2.2. Gamma Transformation

The gamma transform is a common nonlinear transform whose basic expression is equation.1:

$$y=cx^{\gamma} \tag{1}$$

Where c and γ are positive numbers, γ indicates the gray value of the input image, *y* indicates the gray value of the output image [8]. Fractional gray region is mapped into a wider region by gamma transform. The gamma transform maps a portion of the grayscale region into a wider region. When r=1, the gamma transformation is linear; when r<1, the transformation function curve is above the proportional function. At this point, the low gray level is expanded, and the high gray level is compressed to make the image brighter. This is very similar to the logarithmic transformation; when r>1, the transformation function curve is below the proportional function. At this time, the high gray level is expanded and the low gray level is compressed to darken the image. The gamma transform is applied to make the image too bright or too dark.

2.3. Laplacian Sharpening

Laplacian sharpening can be used to enhance the edge of image by Laplacian operators [9]. Laplacian is a differential operator that enhances the gray-spotted region of the image, reduces the slowly changing regions of the grayscale, and highlights the details and edges of the image to make the image clearer. The Laplacian operator is a second-order differential operator in n-dimensional Euclidean space. It is discrete and defined as equation.2. Laplace operation is a linear combination of partial derivative operations, and is an isotropic linear operation with rotational invariance. For discrete digital images f(i,j), the Laplacian is shown in equation.3:

$$\nabla^2 f=\frac{\partial^2 f}{\partial x^2}+\frac{\partial^2 f}{\partial y^2} \tag{2}$$

$$\nabla^2 f=f(x+1,y)+f(x-1,y)+f(x,y+1)+f(x,y-1)-4f(x,y) \tag{3}$$

3. Improved Image Enhancement Method

In this paper, the infrared image is enhanced by the combination method. Firstly, the original image is filtered by adaptive median filtering method, the particle noise and salt and pepper noise are removed, the image is smoothed, and the filtered histogram is used to perform platform histogram equalization. And gamma transformation to improve the overall contrast of the image; at the same time, the filtered image is subjected to Laplacian sharpening to obtain the edge information of the image, and finally the weighted combination of the gamma transformed image and the sharpened image is performed. The flow chart is shown in Figure.1.

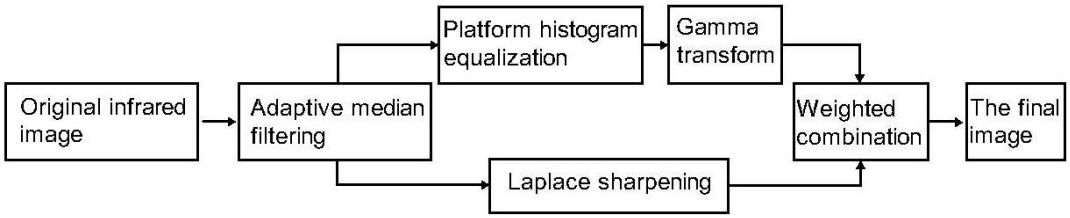


Figure 1. Flow chart of the proposed algorithm.

Steps:

(1) Infrared images are performed by adaptive median filtering.

(2) The platform threshold *T* is determined by the equation.4 according to the method of averaging.

$$T = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} f(x,y) \tag{4}$$

Where f(x,y) is the original image, *M* and *N* are the sizes of the image.

(3) If the value corresponding to some gray levels in the original histogram is larger than the threshold *T*, the value at this point is set to *T*. If the value there is not larger than *T*, then the value at that point remains the same. which is:

$$P_T(k)=\begin{cases} P_r(k) & P_r(k)\le T \\ T & P_r(k)>T \end{cases} \tag{5}$$

Where *k* is the gray level of the image, $0\le k\le 255$, $P_T(k)$ is the platform histogram, $P_r(k)$ is the original histogram, and *T* is the platform threshold.

(4) Accumulate the platform histogram according to equation. 6 and obtain a cumulative function.

$$F_T(k) = \sum_{i=0}^{k} P_T(i) \tag{6}$$

(5) Redistribute the gradation of the image by the cumulative histogram according to equation.7, and an equalized image is obtained.

$$R_T(k) = \left\lfloor \frac{255F_T(k)}{F_T(255)} \right\rfloor \tag{7}$$

(6) According to equation.1, the image is performed by gamma transformation to an image y_1 is obtained. Infrared image has poor contrast and is blurred, and the average brightness of the image needs to be enhanced, that is, the selection range of *r* is [1.5, 3].

(7) Perform a Laplacian sharpening process on the filtered image and obtain an image y_2.

(8) Weight the images obtained by (6) and (7) as shown in equation.8.

$$y=y_1*p+y_2*(1-p) \tag{8}$$

where *p* is a weighting coefficient, and it's value ranges from [0, 1].

The main purpose of the method is to increase the contrast of the image. If *p* is too small, the image brightness information cannot be enhanced enough, the brightness information of edge is too large, and the edge of combined image target is rigid and the visual effect is not good; On the contrary, if *p* is large, the brightness information is excessively increased, the edge highlighting effect of the edge is not obvious, and the brightness information of the combined image is unevenly distributed. The available value range is [0.65, 0.8].

4. Experimental Results and Analysis

According to the proposed algorithm, Simulation is performed on the MATAB platform, and the experiment results are shown in Figure. 2.



(a)Original image (b)Platform histogram equalization (c)Gamma transformation (d)the proposed Algorithm



(e)Original image (f)Platform histogram equalization (g)Gamma transformation (h)Algorithm of this paper

Figure 2. Image comparison of different enhancement methods.

It is shown from Figure.2 that the results of platform histogram equalization are significantly improved compared with the original image, but the overall image enhancement effect is not strong; the results of gamma transformation show that the image is dark overall and the enhancement effect in dark areas is not obvious. The overall contrast is poor; the proposed algorithm show that the overall brightness of the image is improved, the dynamic range of the gray level is properly stretched, and edge information is enhanced obviously. The image is rich in layering and the target is prominent. Visual effect is better.

To demonstrate the effectiveness of the proposed algorithm further, the image quality is evaluated quantitatively based on the contrast and ambiguity index. The contrast of the image is calculated as equation.9:

$$C=\sum_{\delta}\delta(i,j)^2 P_{\delta}(i,j) \tag{9}$$

Where $\delta(i,j)=|i-j|$ is the difference in gray values between adjacent pixels, $P_{\delta}(i,j)$ indicates a difference in gradation between adjacent pixels.

The ambiguity index of the image [10] is shown in equation.10:

$$F_B=\frac{1}{MN}\sum_i\sum_j \min[P(i,j),1-P(i,j)] \tag{10}$$

$P(i,j)=\sin\left[0.5\pi(1-I(i,j)/I_{max})\right]$, $I(i,j)$, I_{max} are the gray value and the maximum gray value at the location of (i,j) in the image, respectively. According to the definition of the ambiguity index, the sharpness of image increases as the ambiguity index decreases. Comparison of contrast and ambiguity index is given in Table 1.

Table 1. Comparison of contrast and ambiguity index of image enhancement algorithm.

		Original image	Platform histogram equalization	Gamma transform	Algorithm of this paper
Figure.(a)	Contrast C	45.6462	58.6956	46.0935	72.7478
	Fuzzy factor	0.3347	0.2137	0.1338	0.1444
Figure.(e)	Contrast C	42.2623	70.0770	56.5376	76.2024
	Fuzzy factor	0.3290	0.1771	0.2069	0.1421

It can be seen from Table 1 that the proposed algorithm increases the contrast, the ambiguity index decreases, the image becomes clearer, and the visual effect is better.

5. Conclusion

The proposed algorithm is suitable for infrared images with low blur and contrast. The sharpness and contrast of the image not only are improved, but also the edge information is preserved, thus visual effect of the image is better, make the image highly recognizable and richly layered, and play a good auxiliary role in the segmentation and recognition of infrared images.

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