A New Self-adaptive Weighted Filter for Removing Noise in Infrared Images

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Abstract —**Aimed at the infrared images with mixed noise, this paper proposes a new adaptive weighted mixed filtering algorithm. The new algorithm first judges the type of the noise according to the difference values of pixel's neighborhood region. Then removes the gauss noise by self-adaptive weighted mean filter and removes the impulse noise by self-adaptive weighted median filter. The result of computer simulation on infrared images indicates that the new algorithm is superior to traditional mean filtering algorithm and traditional median filtering algorithm. The new algorithm can not only remove mixed noise effectively, but also reserve image details.**

Keywords- infrared image; self-adaptive weighted filter

I. INTRODUCTION

Currently infrared image is widely applied in the military and civilian field. Due to the limited of sensitivity and resolution of infrared detector, and the effect of radiation from goal and background, infrared images usually have a lot of noise and bad contrast degree [1]. So noise removing is a key step in infrared target recognition and infrared image processing.

Traditionally, there are two kinds of method to remove noise. One is linear filter, such as, mean filter, wiener filter. This filter can effectually remove gauss noise, but is ineffective in removing impulse noise and can engender the loss of image details. The other is nonlinear filter, such as, median filter, statistical filer. This filter can remove impulse noise effectively, but is ineffective to gauss noise [2]. Using the linear filter or the nonlinear filter singly can't remove the mixed noise.

This paper proposes a new self-adaptive weighted filtering algorithm to remove the mixed noise in infrared images. The new algorithm first judges the type of the noise according to the difference value of pixel's neighborhood region. Then removes the gauss noise by self-adaptive weighted mean filter and removes the impulse noise by self-adaptive weighted median filter. The new algorithm can not only remove mixed noise effectively, but also reserve image details.

II. THE CLASSIFICATION OF NOISE POINTS

The classification of noise points is accord to the difference values of pixel's neighborhood region. The image edge gray has continuity in one or several directions in the neighborhood region. But the noise points gray are discontinuous in most directions. It means if a pixel is edge pixel, it has the maximum difference value between this pixel and neighborhood region pixels in one or several directions. If a pixel is noise point, it has the maximum difference value in most directions. So the type of the noise can be judged [3].

The size of the filter window is 3x3. $f(i, j)$ is the center pixel of the filter window. h_i is the difference between the center pixel and eight neighborhood region pixels. Set a threshold T1. Judge the type of the noise according to the number of pixel points (N) which satisfy h_i>T1. Where N is the number of detail points in neighborhood region. Set another threshold T2. If N=0, the center pixel point is gauss noise point. Remove this noise by using self-adaptive weighted mean filter. If N>T2, the center pixel point is impulse noise. Median filter is used to remove this noise. The remains are detail points. In order to reserve image details, self-adaptive weighted median filter is used to remove the remainder noise points [3].

The selection of threshold T1 is related to the image detail characteristics and is independent on the degree of noise pollution. The threshold T1 should be large if the image has abundant detail information. Otherwise, if the image has a lot of smooth region, the threshold T1 should be valued smaller appropriately. The larger the T1 is, the smoother the output image after filter is and the fuzzier the output image is. If the value of T1 is smaller, the image can be made clearer in details, but the ability will recede in restraining gauss noise. The appropriate value of T1 is 40 to 90. It determined by experiment.

The threshold T2 is used to distinguish the detail points and noise points. If the image contains a lot of detail points, the threshold T2 should be larger. The threshold T2 should be valued smaller if there are less detail points in the image.

III. SELF-ADAPTIVE WEIGHTED MEAN FILTER

The standard mean filter algorithm is widely used for gauss noise elimination. Its principle is: Firstly, a filter window is used to move over the image. Then, the value of the central point pixel is replaced with the average value of the neighbor pixels in the filter window.

$$g(x,y)=\frac{1}{M}\sum_{(x,y)\in s} f(x,y) \tag{1}$$

In the formula (1), s is the neighborhood pixels. M is the number of the pixels in the filter window. $f(x, y)$ is the source image. $g(x, y)$ is the output image after filtering. The standard mean filter has good capability in gauss noise suppression. But much image detail will lost, which causes image blur.

In order to preserve details, this paper proposes the self-adaptive weighted mean filter algorithm to remove the gauss noise. The difference between the new algorithm and standard mean filter algorithm is: Adaptive weighted values are assigned to pixels in the filter window. The chosen of the weighted values should satisfy these formulas: The closer the grey value of certain pixel point in the filter window to the average value of all pixels in the filter window, the larger the weighted value is; vice versa, the smaller the weighted value is [4]. Therefore, this paper proposes the following function of the weighted value:

$$y=\frac{1}{1+d^2} \tag{2}$$

In the formula (2), d is the difference value between the value of certain pixel point and the average value of all pixels in the filter window. Let the size of the filter window is (2n+1)x(2n+1) for the pixel point $f(i, j)$.

The calculation process of the weighted values is described as follows:

$$ave=\frac{1}{(2n+1)^2}\sum_{p=-n}^{n}\sum_{q=-n}^{n} f(i+p,j+q) \tag{3}$$

$$total=\sum_{p=-n}^{n}\sum_{q=-n}^{n}\frac{1}{1+[f(i+p,j+q)-ave]^2} \tag{4}$$

$$w(i+p,j+q)=\frac{1}{\{1+[f(i+p,j+q)-ave]^2\}\times total} \tag{5}$$

The output after filtering is:

$$g(i,j)=\sum_{p=-n}^{n}\sum_{q=-n}^{n} f(i+p,j+q)\times w(i+p,j+q) \tag{6}$$

IV. SELF-ADAPTIVE WEIGHTED MEDIAN FILTER

The standard median filter algorithm is widely used for impulse noise elimination due to good smoothing performance for impulse noise. Its principle is: The pixels values of the filter window are arranged from small to large. The value of middle sequence number is considered as the filter output [5]. The math formula is given:

$$g(x,y)=median\{f(x-p,y-q),(p,q)\in S\} \tag{7}$$

In the formula (7), S is the size of filter window. $f(x, y)$ is the source image. $g(x, y)$ is the output image after filtering. The median filter can remove the impulse noise effectively, but can't preserve image details.

Therefore, this paper proposes the self-adaptive weighted median filter algorithm. This algorithm is similar to the algorithm that mentioned in section 3 of this paper. Adaptive weighted values are assigned to pixels in the filter window. The pixels values in the filter window are arranged from small to large. Then get rid of the minimum and maximum in the sequence, leaving the seven middle pixel points. Larger weighted values will be assigned to the pixel points that are closer to the middle sequence number. Otherwise, smaller weighted values will be assigned to the pixel points. This algorithm can preserve image details effectively. The function of the weighted value is the same as formula (2).

The calculation process of the weighted values is described as follows:

$$mid = median\{f(i+p, j+q), (p,q) \in S\} \quad (8)$$

$$total = \sum_{p=-n}^{n} \sum_{q=-n}^{n} \frac{1}{1+[f(i+p, j+q) - mid]^2} \quad (9)$$

$$w(i+p, j+q) = \frac{1}{\{1+[f(i+p, j+q) - mid]^2\} \times total} \quad (10)$$

The output after filtering is:

$$g(i,j) = \sum_{p=-n}^{n} \sum_{q=-n}^{n} f(i+p, j+q) \times w(i+p, j+q) \quad (11)$$

V. SIMULATION EXPERIMENT AND RESULT ANALYSES

To verify the performance of the new algorithm in this paper, the algorithm in this paper is compared with the standard mean filter algorithm and standard median filter algorithm with the infrared image of 240x320 shown in Fig.1 as source image. The size of the filter window is 3x3. The promotion of signal-to-noise ratio (*R*), normalized mean square error (*NMSE*) and peak signal-to-noise ratio (*PSNR*) are adopted as objective evaluation standard for filtering performance [6].

$$R = 10\lg \frac{\frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} [y(i,j) - s(i,j)]^2}{\frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} [x(i,j) - s(i,j)]^2} \quad (12)$$

$$NMSE = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} [y(i,j) - s(i,j)]^2}{\sum_{i=1}^{M} \sum_{j=1}^{N} [s(i,j)]^2} \quad (13)$$

$$PSNR = -10\lg \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} [y(i,j) - s(i,j)]^2}{M \times N \times (L-1)^2} \quad (14)$$

In the formula (12), (13), (14), *M*, *N* is the size of the image. *L* is the gray level of the image. *s* is the source image. *x* is the image added noise. *y* is the output image after filtering.

If the value of R is negative, it means that the noise is suppressed after filtering. The smaller the value of *R* is, the better the filtering performance is. The smaller the value of *NMSE* is, the better the filtering performance is. The larger the value of *PSNR* is, the better the filtering performance is.

Table 1 tabulates the values of *R*, *NMSE*, *PSNR* for infrared image with gauss noise (0.02) and impulse noise (0.02) at different filter algorithm. Table 2 tabulates the values of *R*, *NMSE*, *PSNR* for infrared image with gauss noise (0.05) and impulse noise (0.05) at different filter algorithm.

Table 1 R, NMSE, PSNR for infrared image with gauss noise (0.02) and impulse noise (0.02) at different filter algorithm

	Image with noise	Mean filter algorithm	Median filter algorithm	Algorithm of this paper
R	-	-3.9995	-4.4067	-5.0464
NMSE	0.1508	0.0601	0.05467	0.04719
PSNR	12.4846	16.4842	16.8913	17.5311

Table 2 R, NMSE, PSNR for infrared image with gauss noise (0.05) and impulse noise (0.05) at different filter algorithm

	Image with noise	Mean filter algorithm	Median filter algorithm	Algorithm of this paper
R	-	-3.4337	-4.4895	-5.8232
NMSE	0.2891	0.1311	0.1028	0.0756
PSNR	9.6577	13.0916	14.1473	15.481

From Table 1 and Table 2, it can be seen that compared with standard mean filter algorithm and standard median filter algorithm, the new algorithm is superior to the traditional algorithm. And the performance of the new algorithm is the best. The value of *NMSE* is smaller and the value of *R* and *PSNR* is larger. The new algorithm can remove mixed noise effectively.

Fig.1 is the source infrared image. Fig.2 is the image with gauss noise (0.05) and impulse noise (0.05). Fig.3 to Fig.5 are the output images after standard mean filtering, standard median filtering and the self-adaptive weighted filtering.

Fig.1 source image

Fig.2 image with noise

Fig.3 mean filter

Fig.4 median filter

Fig.5 self-adaptive weighted filter

From Fig.1 to Fig.5, it can be seen that the new algorithm have the best filtering effect compared with the traditional filter algorithm. The new algorithm combines the good ability to get rid of mixed noise in infrared images and rather good ability to protect the detail information.

VI. CONCLUSION

In this paper, a new algorithm is proposed to remove both the gauss noise and impule noise in the infrared images. The new algorithm first classfiy the noise. Then removes the different noise by different filter. Through the computer simulation on infrared images, it indicates that the new algorithm is superior to traditional mean filtering algorithm and traditional median filtering algorithm. The new algorithm has good capability in mixed noise suppression, and can reserve image details. The new algorithm is simple and effective, and can improve the signal-to-noise ratio of the images. It is also easy to implement.

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