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An Adaptive Weighted Filter Algorithm for Mixed Noise Image

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Abstract: Image de-noising by using the filter algorithm is a basic problem which we would meet during the image processing. But the traditional filters can't achieve good effects. So a new adaptive weighted filter which could deal with the mixed noise was proposed and the weight values can be adaptively adjusted according to the differences between the reference value and the objective value of all elements in the window based on the MTM (Modified Trimmed Mean) and grey relational analysis. It is shown that the new filter algorithm can preserve image detail information well and effectively remove the noise. Finally, Extensive simulations are carried out to evaluate the performance of the filter. Simulation experiments show that the new method exhibits better performance than other de-noising schemes obviously, both in the PSNR value, MSE value and the visual appearance.

Key words: Modified trimmed mean, adptive weighted filter, mixed noise, improved grey relational analysis, MSE, PSNR

INTRODUCTION

Image are often corrupted by mixed noise during transmission and acquisition due to a noisy sensor or channel transmission errors. Image de-noising by using the filter algorithm is a basic problem which we would meet during the image processing (Toprak and Guler, 2006; Fu *et al*., 2011; Gonzalez and Woods, 2003). The goal of noise removal is to suppress the noise while preserving the integrity of edge and detail information. In order to reduce the noise as much as possible, the image corrupted by mixed noise must be denoised. The mean filter and the median filter are two important algorithms for noise-reduction. If a desired signal with sharp edges is corrupted by mixed noise, as in some noisy image data, linear filters designed to remove the noise will also smooth out signal edges. In addition, noise components cannot be suppressed sufficiently by linear filtering because linear algorithm typically implemented uniformly across an image (Gonzalez and Woods, 2003).In such cases, some form of adaptive filtering would be preferable. So, we propose an adaptive apprpach to the removal of mixed noise based on the MTM and grey relational analysis. This algorithm can adjust the coefficient adaptively according the difference between the current pixel value and the remaining ordered pixel values inside a neighborhood window centered about the current pixel. Extensive simulations indicate that the proposed algorithm effectively improved the image contaminated by signal to noise ratio and better protect the image edge information.

FOUNDATION OF THE FILTER

Mean filter: The idea of mean filtering (Chan *et al*., 2005; Zhou *et al.,* 2007) is simply to replace each pixel value in an image with the mean (`average') value of its neighbors, including itself. This has the effect of eliminating pixel values which are unrepresentative of their surroundings. That is to say, a mean filter computes the average value of all pixels in the filtering window to replace the central pixel value in the window and noise is reduced at a certain extent. Mean filtering is usually thought of as a convolution filter. Like other convolutions it is based around a kernel, which represents the shape and size of the neighborhood to be sampled when calculating the mean. Often a 3×3 square kernel is used, as shown in Fig. 1, although, larger kernels (e.g., 5×5 squares) can be used for more severe smoothing. (Note that a small kernel can be applied more than once in order to produce a similar but not identical effect as a single pass with a large kernel.)

The traditional mean filter doesn't take the differences between pixels within the window into account, but only simply takes the mean of pixels within the window. Therefore, it makes the degradation of image detail while de-noising and it is not effective for the impulse noise.

Median filter: The Median Filter (MF) (Luo, 2006), which, as its name implies, uses the median value of all the pixels

$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$

Fig. 1: 3×3 averaging kernel often used in mean filtering

in the filtering window as a substitute for the central pixel value, is quite popular and provides excellent noise-reduction capability and certain adaptability.

Median filter is an effective method to remove impulse noise, but the de-noising effect of standard median filter can be greatly affected by the size of filtering windows and the intensity of noise. Gauss noise can be removed by mean filter, but meanwhile the degradation of image details often caused unfortunately. In view of these of two kind of noises, the scholars successively proposed some improved image filtering algorithm (Toprak and Guler, 2006; Lin and Yu, 2004; Guo *et al*., 2005; Huang *et al*., 2010; Jin *et al*., 2008). However, most of these filtering algorithms were designed only for a particular type of noise and performed poor in suppressing mixed noise.

Therefore, in order to solve this problem, this study proposed a new adaptive weighted filter based on Modified Trimmed Mean and grey relational analysis and tried to combine the advantage of the mean filter and median filter to remove the mixed noise.

MTM (Modified Trimmed Mean) filter: The MTM filter was first proposed by Lee and Kassam (Lee and Kassam, 1985). The filter is designed to remedy the problem of edge blurring resulted by a mean filtering (Plataniotis and Venetsanopoulos, 2000; Gonzalez and Woods, 2003). The idea is to perform the averaging operation on some selected samples inside a window.

Lee *et al*., used the median filter to estimate the m value. A data sample is selected if its value falls into the range of (m-q, m+q) where m is a value calculated from the data samples and q is a preselected threshold value. That is to say, the MTM filter selects the sample median from a window centered at a point and then averages only those samples inside the window close to the sample median.and caculated by Eq. 1:

$$\text{out}_i = \text{average}\{(x_i) | m_i - q \le x_i \le m_i + q, i \in W_i\}$$

Although, the MTM filter works well for some images, it cannot preserve the details. This is because the median filter is not a detail preserving filter.

Improved image grey relation analysis: GRA (Grey relational analysis) was initiated by Professor Ju-long Deng (1990). It has advantage of simplification and accuracy over dealing with the multiple attitude decision making problems.

GRA uses the grey relational coefficient to describe the trend relationship between an objective reference series at a given point in a system Suppose $x_0 \in X$ is the reference series and x_i ($i = 1, 2, ..., n$)$\in X$ are the objective series, the grey relational coefficient γ ($x_0(k)$, x_i $(k)) \in \Gamma$ between the reference series x_0 and the objective series x_i ($i = 1, 2, ..., n$) at point $k \in \{1, 2, ..., m\}$ was defined by Deng as follows:

$$\gamma(x_0(k), x_i(k)) = \frac{\Delta_{min} + \zeta\Delta_{max}}{\Delta_{0,i}(k) + \zeta\Delta_{max}} \tag{2}$$

where, $\Delta_{0,i}$ $(k) = |x_0\,(k) - x_i\,(k)|$ is the difference of the absolute value between x_0 (k) an x_i (k), $\Delta_{min} = \min_{\forall j} \min_{\forall k} |x_0\,(k) - x_j\,(k)|$ is the smallest value of $\Delta_{0,j} \forall_j \in \{1, 2, ..., n\}$; $\Delta_{max} = \max_{\forall j} \max_{\forall k} |x_0\,(k) - x_j\,(k)|$ is the largest value of $\Delta_{0,j}$ $\forall_j \in \{1, 2, ..., n\}$ and ζ is the distinguishing coefficient, $\zeta \in [0, 1]$, expressed as the contrast between the background and the object to be tested.

The grey relational grade Γ (x_0 (k), x_i (k)) between an objective series x_i ($i = 1, 2,..., n$) and the reference series $x_0 \in X$ was defined by Deng as follows:

$$\Gamma(x_0, x_i) = \frac{1}{n}\sum_{k=1}^{n} \gamma(x_0(k), r_i(k)) \tag{3}$$

Traditional Tang has some correlation incompleteness: (a) γ (x_0, x_i) is not unique, symmetry and comparability, (b) Identifying different factors will have a different correlation. So, an improved gray relational analysis was put forward here and the equation as follows:

$$\gamma(x_0(k), r_i(k)) = \frac{1}{\frac{x_0(k) + \omega|x_0(k) - x_i(k)|}{x_0(k)}} = \frac{x_0(k)}{x_0(k) + \omega|x_0(k) - x_i(k)|} \tag{4}$$

Through a lot of experiments: $\omega \in [3, 7]$

ADAPTIVE FILTER ALGORITHM

Suppose there is a 3×3 window sliding through each pixel in the image and let MTM pixel is the center of the window for each sliding and the coefficient of the proposed method can be varied adaptively based on degree of the grey relational analysis. The proposed method can be described as follows:

- Establish the referential sequence and comparative sequence

  View pixel of 3×3 matrix as a data series. Define MTM as a reference sequence

  Objective sequence:

X_k = x (i-1, j-1), x (i-1, j), ..., x (i,j),...,x (I+1, j+1)($1 \le k \le 9$)

- Calculate the reference sequence and comparative sequence correlation between the various points
- Compute the grey relational grades between the reference series x_0 and each of the objective series $x_1, x_2, x_3, ..., x_n$, respectively by Eq. 4
- **Determine the pixel value after filtering:** We use the equation 5 to calculate the pixel value, where the grey relational degree w_k ($1 \le k \le 9$) as the weighted coefficient:

$$(i,j) = w_1 x_{(i-1,j-1)} + w_2 x_{(i-1,j)} + \cdots w_9 x_{(i+1,j+1)} \quad (5)$$

Where:

$$yw_k = \frac{r_{0,i}^{(k)}}{\sum_{k=1}^{n} r_{0,i}^{(k)}}$$

EXPERIMENTAL RESULTS AND ANALYSIS

In this section we compare the proposed filter and other filters under three well defined criteria: The visual quality of the de-nosing image, the peak signal to nation ratio and the mean square error, that is, the Euclidean difference between the de-noising image and the original image.

Subjective evaluation criteria: The 256×256 lena image is selected as testing image. Tests are performed on image corrupted by mixed noise and compare images with different degrees, different combinations of noise pollution. Different level of Gaussian noise and impulse noise is superimposed to the original image. See from the experiment, a variety of filtering methods can be carried out at different levels of image noise filtering. The human eye is the only one able to decide if the quality of the image has been improved by the de-nosing method.

In the Fig. 1(a) original image, (b) noisy image, (c) de-nosing image with mean filter algorithm, (d) De-nosing image with median filter algorithm, (e) De-nosing image with MTM algorithm, (f) De-nosing image with proposed algorithm.

As can be seen from Fig. 1 that median filter can be better to filter out impulse noise, the mean filter can better filter out Gaussian noise, the reference algorithm can effectively filter out mixed noise and better protect the image details. In the mixed noise case, the proposed algorithm in the noise power and place are better. In short, the proposed algorithm is superior to other algorithms on the visual effect aspect and can get clearer edge when effectively de-noise.

Objective evaluation criteria: Filtering effect of the objective evaluation of the fidelity criteria are MSE mean square error and PSNR. These numerical measurements are the most objective, since they do not rely on any visual interpretation. They are defined as follows [6] [7]:

$$MSE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(S_{ij} - Y_{ij})^2 \quad (6)$$

$$PSNR = 10\lg\frac{255^2}{MSE} \quad (7)$$

where, M, N is the size of the image S_{ij} and Y_{ij} are the original image and restored image, respectively. We can see from the Eq. 6 and 7, if the PSNR is larger, the filtering is more close to the original image, the result is better. Similarly, if the smaller of the MSE, it is clearly seen that our method is better than other filters.

We numerically compare the performances of the four algorithms as applied to the image. Table 1 display PSNR and the mean square error for de-nosing experiments given in the study. Where, is the Gaussian noise variance, p is the salt and pepper noise intensity.

It can be seen from Table 1 the proposed filter has higher PSNR and lower MSE value than the other estimated filters at the various densities. Therefore, we can conclude that the proposed filer has the best filtering performance among these filters. And also we can be seen from Table 1, when the noise variance is larger, the proposed algorithm can get higher PSNR and can hold better de-nosing effect.

The trends of PSNR and MSE gain of our proposed method with the image corrupted by the mixed noise, which Gaussian noise variance is 0.02 and the salt and

Fig. 2(a-f): Performance comparisons of various filters, (a) Original image, (b) Noisy image, (c) Image after mean filter, (d) Image after median filter, (e) Image after MTM filter and (f) image after proposed filter

pepper noise intensity is 0.02, is illustrated as Fig. 2. It can be seen from the Fig. 2 that the trends of PSNR and MSE gain of our proposed method are better than that of the mean filter, median filter and the modified trimmed mean filter for window size 3×3. For the window size 3×3, the PSNR in our proposed scheme is low/high when the noise level is low/high. The PSNR gain improves marginally in our scheme over the mean filter, median filter and the modified trimmed mean algorithm. From Table 1 and Fig. 2, it is evident that, for using window size 3×3, the MSE gains for our proposed method are better or comparable than that of the mean filter, median filter and the modified trimmed mean algorithm.

From the above results, we conclude that our proposed scheme has better performance for all images at all noise levels than the mean filter, median filter and the modified trimmed mean algorithm for window size 3×3. We have shown graphically the results for Lena image. We have obtained similar results for all three images, that is, Lena, Barbara and Goldhill; because of their repetitive nature, we have omitted the graphical representation of the results for other two images-Barbara and Goldhill.

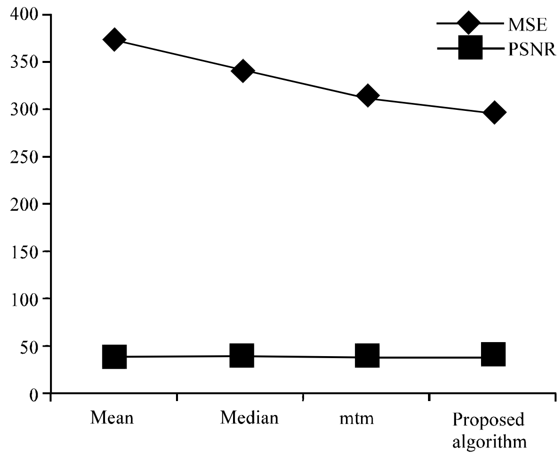

Fig. 3: PSNR and MSE gain versus noise level σ = 0.02 P = 0.02 of proposed algorithm, MTM, median and mean filter for window size 3×3

Table 1: PSNR and MSE of various filters

Filter type	Parameter	PSNR	MSE
Mean filter	σ = 0.02 P = 0.02	38.61	369.56
	σ = 0.02 P = 0.05	36.72	446.35
	σ = 0.10 P = 0.02	29.31	936.92
	σ = 0.10 P = 0.05	28.90	975.84
Median filter	σ = 0.02 P = 0.02	39.44	339.60
	σ = 0.02 P = 0.05	38.71	365.89
	σ = 0.10 P = 0.02	29.01	965.11
	σ = 0.10 P = 0.05	28.63	1002.21
MTM filter	σ = 0.02 P = 0.02	40.34	310.82
	σ = 0.02 P = 0.05	39.51	363.08
	σ = 0.10 P = 0.02	29.31	936.46
	σ = 0.10 P = 0.05	29.08	958.85
Adaptive MTM filter	σ = 0.02 P = 0.02	40.91	293.81
	σ = 0.02 P = 0.05	40.61	302.43
	σ = 0.10 P = 0.02	29.63	906.87
	σ = 0.10 P = 0.05	29.38	929.85

CONCLUSION

An effective filtering algorithm is proposed based on MTM filtering and the improved grey relational analysis. The new algorithm not only have better self-adaptive algorithm can be closer and closer to the target value, but also to effectively remove mixed noise with image noise, in addition, it can also be well protected image details, improve image de-noising effect and clarity. The experimental results show that compared with existing method and the algorithm not only can obtain clearer image edges but also can de-noise effectively

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REFERENCES

Chan, R.H., C.W. Ho and M. Nikolova, 2005. Salt and pepper noise removal by median type noise detectors and detail preserving regularization. IEEE Trans. Image Proc., 14: 1479-1485.

Deng, J.L., 1990. Grey System Theory Tutorial. Huazhong University Press, China, pp: 56-64.

Fu, S.J., C.M. Zhang and X.C. Tai, 2011. Image denoising and deblurring: Non-Convex regularization, inverse diffusion and shock filter. Sci. China Inform. Sci., 54: 1184-1198.

Gonzalez, R.C. and R.E. Woods, 2003. Digital Image Processing. 2nd Edn., Prentice Hall, USA., pp: 215-220.

Guo, S.M., C.S. Lee and C.Y. Hsu, 2005. An intelligent image agent based on soft-computing techniques for color image processing. Expert System Appl., 28: 483-494.

Huang, C.Y., Y.P. Zhang and H.Y. Huang, 2010. An adaptive filter approach for removal of mixed noise based on grey relevancy. Microelectron. Comput., 2: 126-128.

Jin, L.G., C.Q. Xiong and D.H. Li, 2008. Adaptive center-weighted median filter. J. Huazhong Univ. Sci. Technol. (Nat. Sci.), 8: 9-12.

Lee, Y.H. and S.A. Kassam, 1985. Generalized median filtering and related nonlinear filtering techniques. IEEE Trans. Acoust. Speech Signal Process., 33: 672-683.

Lin, T.C. and P.T. Yu, 2004. Partition fuzzy median filter based on fuzzy rules for image restoration. Fuzzy Sets Syst., 147: 75-97.

Luo, W., 2006. An efficient detail-preserving approach for removing impulse noise in images. IEEE Signal Process. Lett., 13: 413-416.

Plataniotis, K.N. and A.N. Venetsanopoulos, 2000. Color Image Processing and Applications. Springer, Berlin, Germany, pp: 107-109.

Toprak, A. and I. Guler, 2006. Suppression of impulse noise in medical images with the use of fuzzy adaptive median filter. J. Med. Syst., 30: 465-471.

Zhou, S.M., J.Q. Gan, L.D. Xu and R. John, 2007. Interactive image enhancement by fuzzy relaxation. Int. J. Autom. Comput., 4: 229-235.