SALT-AND-PEPPER NOISE ELIMINATION IN MEDICAL IMAGE BASED ON MEDIAN FILTER METHOD

ANISHA BHATIA

Vivekananda education society's institute of technology, Mumbai
Email: anisha_bhatiya@yahoo.com

Abstract— Removing salt-and-pepper noise in medical images plays a very important role for the pre-processing of medical images. An adaptive median filter is implemented, and the effectiveness on denoising is evaluated by PSNR, MSE, UQI and SSIM noise to original image. Analyze the influence of the filter window size and the density of noise on the quality of denoised image also. Simulation results based on Matlab show that this method can eliminate the salt-and-pepper noise in ultrasound medical image and preserve the edges and detail information of the objects. This method has been used in the virtual endoscope system, and the filtering performance is very satisfactory.

Keywords— Salt-and-pepper noise, Adaptive median filter, Peak Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE), Universal Quality Index (UQI) and Structural Similarity Index Mean (SSIM).

I. INTRODUCTION

Virtual Endoscope (VE) is an application of virtual reality in modem medicine, and it is noninvasive, untouched and free of risks [1, 2]. The structures of a VE system consist of data acquisition and preprocessing, segment of tissues, 3D construction, path planning and real-time rendering. Generally, the medical image data of VE system are acquired by advanced imaging equipments such as CT, MRI and Ultrasound. Due to the random disturbance of electron devices, the influence of ambient environment, and human factors during the imaging process, the acquired medical images are often corrupted by noise and distortion. This will decrease the accuracy of tissue segmentation and feature extraction, thus influence the quality of 3D construction and the accurate analysis. Therefore, the first step for medical image preprocessing is to filter data. The goals of filtering action are smoothing image, canceling noise while preserving the integrity of edge and detail information, and enhancing the image features. A plentiful statistical analysis shows that salt-and pepper noise (impulse noise) is one of the common noise sources. Aiming at this kind of noise, many filtering algorithms have been proposed in the literatures [3-9]. Median filter is used widely to remove salt-and-pepper noise in practice.

II. ADAPTIVE MEDIAN FILTER

2.1. Median filter

Median filter is a nonlinear spatial filter based on order-statistics theory which is particularly effective in restraining salt-and-pepper noise. It replaces the value of a pixel by the median of the gray levels in the neighborhood of that pixel.

Let *Sxy* represent an *mxn* sub-image of the input noisy image, g . It is centered at coordinates *(x,y)* . *f(x,y)* represents the filter response at those co-ordinates. Then the 2-dimensional median filter is given by the expression

$$f(x,y) = \text{median}\{g(s,t)\}$$
$$(s,t) \in Sxy$$

2.2. Adaptive median filter

Traditional median filter doesn't take into consideration for how image characteristics vary from one location to another. It replaces every point in the image by the median of the corresponding neighborhood. In practice, adaptive filter that is capable of adapting their behavior depending on the characteristics of the image in the area being filtered can produce more effective output image for some input noisy images. An adaptive median filter whose behavior changed based on statistical characteristics of the image inside the filter region defined by the *m* x *n* rectangular windows *Sxy* is specified in theory [10]. Same as median filter, adaptive median filter also works in a rectangular window area S*xy*. Unlike median filter, however, the adaptive median filter changes the size of S*xy* during filter operation, depending on various conditions. The output of the filter is a single value used to replace the value of the pixel at *(x, y).*

Consider the following notation:

Zmin = minimum intensity value in Sxy

Zmax = maximum intensity value in Sxy

Zmed = median of the intensity values in Sxy

Zxy = intensity value at coordinates (x, y)

Smax = maximum allowed size of Sxy

The adaptive median filtering algorithm consists of two parts, denoted level A and level B:

Level A: If Z min < Zmed < Zmax, go to level B
Else increase the window size
If window size < Smax, repeat level *A*
Else output Zmed

Level *B:* If *Z* min < *Zxy* < *Z*max, Output *Zxy*
Else output Z med

Observing the algorithm, the purpose of level *A* is to determine if the median filter output, Zmed , is an impulse (black or white) or not. If the condition Zmin < Zmed < Zmax is true, then Z med cannot be an impulse according to the noise theory. In this case, go to level *B* and test if the point in the center of the window, Z*xy*, is itself an impulse.
If the condition Z min < Z*xy* < Zmax is true, then Z*xy* cannot be an impulse. In this case, the algorithm outputs the unchanged pixel value, Z*xy*. By not changing these "intermediate-level" points, distortion is reduced in the image. If the condition Zmin < *Zxy* < *Z*max is false, then either Z*xy* = Zmin or Z*xy* = Zmax. In either case, the value of the pixel is an extreme value and the algorithm outputs the median value Zmed, which we know from level *A* is not a noise impulse.

III. STIMULATION RESULTS AND ANALYZING

3.1. Stimulation results

The choice of the maximum allowed size of S*xy*, Smax directly influences the denoised image quality. In order to determine the relationship between Smax and the spatial density of salt-and pepper noise, and to validate the adaptability of traditional median filter and adaptive median filter to preprocess medical image data for virtual endoscope system, many computer simulations have been performed on Ultrasound medical image with different noise density such as 5%, 10%, 20%, and 30%. Algorithms are programmed based on MATLAB.

We select Peak signal-noise ratio (PSNR), *Mean Square Error (MSE), Universal Quality Index (UQI) and Structural Similarity Index Mean (SSIM)* as four objective evaluating parameters with the purpose of increasing the assessment objectivity for denoised image quality.
The parameters are defined as follows:

- Peak Signal-to-Noise Ratio (PSNR):
  PSNR = 20 log10 (255/RMSE)
  …..where Root Mean square error (MSE)

- Mean Square Error (MSE) :
  $MSE = \sqrt{1/MN \Sigma (Yij-Xij)^2}$
  i, j

- Structural similarity index mean (SSIM):

SSIM is designed to improve on traditional methods like peak signal-to-noise ratio (PSNR) and mean squared error (MSE), which have proved to be inconsistent with human eye perception [11]. The Structural Similarity (SSIM) index is a method for measuring the similarity between two images. The SSIM index can be viewed as a quality measure of one of the images being compared provided the other image is regarded as of perfect quality. It is an improved version of the universal image quality index [12].

The structural similarity index correlates with human visual system. Thus SSIM is used as a perceptual image quality evaluation metric. The SSIM is defined as function of luminance, contrast and structural components(s) [11].

- **Universal image quality index (UQI):**

The universal quality index is given by:

$$Q = 1/M \Sigma Qj$$

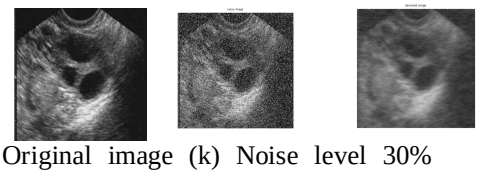
Where M is the steps and Qj is the local universal quality index [13].

Take an example for ultrasound medical image from a phthisic. The stimulation results and data are shown in below and Table respectively.

(a) Original image (b) Noise level 5% (c) Denoised Image

(d) Original image (e) Noise level 10% (f) Denoised Image

(g) Original image (h) Noise level 20% (i) Denoised Image



(j) Original image (k) Noise level 30% (l) Denoised Image

Performance Analysis:

PSNR:

NOISE LEVEL	VALUES
5	19.8656
10	18.3896
15	17.1772
20	16.5077

MSE:

NOISE LEVEL	VALUES
5	670.6862
10	942.1544
15	1.2456e + 003
20	1.453e + 003

UQI:

NOISE LEVEL	VALUES
5	0.9470
10	0.9462
15	0.9425
20	0.9401

SSIM:

NOISE LEVEL	VALUES
5	0.5390
10	0.5093
15	0.4765
20	0.4510

CONCLUSION

Median filter as the common method to filter salt-and pepper noise plays a very important role in medical image preprocessing. It can improve the image quality of 3D reconstruction, and this is significant in practice. The paper implements the median filter and a new adaptive median filter, analyzes the selection of filter window size and the influence of spatial density of salt-and-pepper noise to the denoised image, and obtains some useful conclusions.

REFERENCES

[1] L Hong, A Kaufman, "3D virtual colonoscopy", *IEEE symposium on Biomedical Visualization*, 1995, 1, pp. 26-32.

[2] W E Lorensen, F A Jolesz, "The Exploration of crosssectional data with a virtual endoscope ", *Interactive Technology and the New Health Paradigm*, 1995, pp. 221230.

[3] Yiiksel M E, Besdok E, "A Simple Neuro-Fuzzy Impulse Detector for Efficient Blur Reduction of Impulse Noise Removal Operators for Digital Images", *IEEE Transactions on Fuzzy Systems*, 2004,12(6), pp. 854-865.

[4] Abreu E, Lightstone M, Mitra S K, "A new efficient approach for the removal of impulse noise from highly corrupted images", *IEEE Transactions on Image Processing*, 1996,5(6), pp. 1012-1025.

[5] G.R. Arce, M P McLoughlin. "Theoretical analysis of the MAX/Median filter", *IEEE Trans. Acoust, Speech, Signal Processing*, 1987, 35(1), pp. 60-69.

[6] T Kasparis, N S Tannes , Q Chen, "Deta il-preserving adaptive conditional median filters", *Electron. Image, 1992*, 1(14), pp. 358-364

[7] Sun T, Neuvo Y, "Detail-preserving Median based Filters in Image Processing", *Pattern Recognition Letters, 1994*, 15(4), pp. 341-347.

[8] Restrepo A., Bovik A. C, "Adaptive Trimmed Mean Filters for Image Restoration", *IEEE Transactions on Acoustics, Speech and Signal Processing* ,1988,36(8), pp. 1326-1337.

[9] Nail Alajlan, Ed Jernigan, "An Effective Detail Preservating Filter for Impulsive Noise Removal", *ICIAR, Springer-Verlag Berlin Heideberg* , 2004, pp. 139-146.

[10] Rafael C. Gonzalez, Richard E. Woods, *Digital Image Processing, Second Edition*, Publishing House of Electronics Industry, Beijing, 2002.

[11] Bo Fu, Kecheng Yang, Wei Li, Fan Fan, A Salt & Pepper Noise Fast Filtering Algorithm for Grayscale Images Based on Neighborhood Correlation Detection [2010].

[12] V.Jayaraj, D.Ebenezer, K.Aiswarya, "High Density Salt and Pepper Noise Removal in Images using Improved Adaptive Statistics Estimation Filter" (IJCSNS International Journal of Computer Science and Network Security, vol 9, no. II) [November, 2009].

[13] Raymond H. Chan, Chung-Wa Ho, and Mila Nikolova, Salt and Pepper Noise Removal by Median type Noise Detectors and Detail-preserving Regularization (IEEE Transactions, vol. 14 issue 10, pp. 1479 - 1485) [2005].

★★★