academicJournals

Vol. 6(9), pp. 177-182, October, 2013
DOI: 10.5897/AJMCSR11.124
ISSN 2006-9731 ©2013 Academic Journals
http://www.academicjournals.org/AJMCSR

African Journal of Mathematics and Computer Science Research

Full Length Research Paper

Hybrid filters for medical image reconstruction

S. Vijaya Kumar

Department of IT, RGM College of Engineering and Technology, Nadyal-518501, India.

Accepted 2 September, 2011

The most significant feature of diagnostic medical images is to reduce Gaussian noise, and salt and pepper noise which is commonly found in medical images and make better image quality. In recent years, technological development has significantly improved analyzing medical imaging. This paper proposes different hybrid filtering techniques for the removal of Gaussian noise, and salt and pepper noise. The filters are treated in terms of a finite set of certain estimation and neighborhood building operations. A set of such operations is suggested on the base of the analysis of a wide variety of nonlinear filters described in the literature.

Key words: Gaussian noise, salt and pepper noise, hybrid filter.

INTRODUCTION

In the early development of image processing, linear filters were the primary tools for Image enhancement and restoration. Their mathematical simplicity and the existence of some desirable properties made them easy to design and implement. Moreover, linear filters offered satisfactory performance in many applications. However, they have poor performance in the presence of non additive noise and in situations where system nonlinearities or Gaussian statistics are encountered (Ioannis and Anastasias, 1990). In image processing applications, linear filters tend to blur the edges and do not remove Gaussian and mixed Gaussian impulse noise effectively. Previously, a number of schemes have been proposed for Gaussian mitigation. Inherently noise removal from image introduces blurring in many cases. An adaptive standard recursive low pass filter was designed by Klaus and Rolf (1992), who considered the three local image features edge, spot and flats as adaptive regions with Gaussian noise. Median filter has been introduced by Turkey (1974). It is a special case of non-linear filters used for smoothing signals. Median filter now is broadly used in reducing noise and smoothing the images. Hakan et al. (2002) have used topological median filter to improve conventional median filter. The better performance of the topological median filters over conventional median filters is in maintaining edge sharpness. Yanchun et al. (2006) proposed an algorithm for image denoising based on average filter with maximization and minimization for the smoothness of the region, unidirectional median filter for edge region and median filter for the indefinite region. It was discovered that when the image is corrupted by both Gaussian and impulse noises, neither average filter nor median filter algorithm will obtain a result good enough to filter the noises because of their algorithm. An improved adaptive median filtering method for denoising impulse noise reduction was carried out by Mamta and Rajni (2009). An adaptive median filter (AMF) is the best filter to remove salt, and pepper noise of image sensing was shown by Salem et al. (2010). The Computer tomography images were denoised using curvelet and wavelet transforms by Sivakumar (2007). The objective of this study is to develop new hybrid filtering techniques and investigate their performance on medical images.

Types of noises

Noise may be of different types. The characteristics of noise depend on its source. The filter or the operator

E-mail: svksr105@yahoo.co.in.

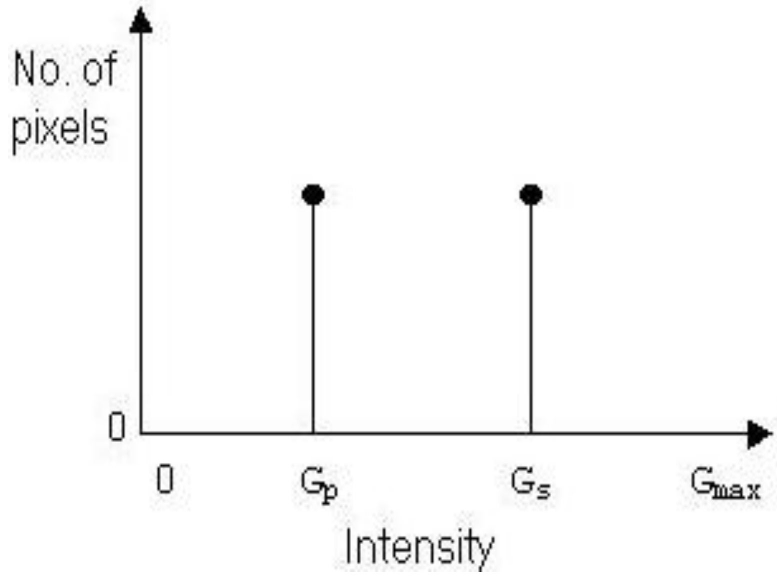

Figure 1. A histogram for salt-and-pepper noise.

which best reduces the effect of noise also depends on the source. Many image-processing packages contain operators to artificially add noise to an image. Deliberately corrupting an image with noise allows us to test the resistance of an image-processing operator to noise and assess the performance of various noise filters. The following are the various type of noise:

(a) Salt noise,
(b) Pepper noise,
(c) Gaussian noise,
(d) Salt and pepper noise,
(e) Random noise.

Salt noise

Salt noise appears as a set of white pixels. The intensity value of the white color is the highest of all colors.

Pepper noise

Pepper noise appears of a set of black pixels. The intensity value of the black is the lowest of all colors.

Gaussian noise

Gaussian noise also called Normal noise models are used frequently in practice (Peng and Lucke, 1995). The PDF of Gaussian Random Variable Z is given by:

$$p(z) = \frac{1}{\sqrt{2\pi\sigma}} \quad e^{-}(z-\mu)_{2/2\sigma 2} \qquad (1)$$

Salt and pepper noise

A common form of noise is data dropout noise. It is also called intensity spikes, speckle, impulse noise, shot and spike or salt and pepper noise. This noise is named for the salt and pepper appearance an image takes on after being degraded by this type of noise. Salt-and-pepper noise takes on two gray levels, Gp and Gs. Figure 1 shows a histogram for salt-and-pepper noise. Salt and pepper noise is caused by errors in the data transmission. The corrupted pixels are either set to the maximum value or have single bits flipped over. The maximum value causes a foggy appearance in the image. In some cases, single pixels are set alternatively to zero or to the maximum value, giving the image a `salt and pepper' like appearance. Unaffected pixels always remain unchanged. The noise is usually quantified by the percentage of pixels, which are corrupted. The following filters have been implemented in this paper.

Basic definitions

In this section, we present some of the general definitions of digital image processing which will be used in the paper.

Definition 1

A digital image is two dimensional function f(x, y), where x, y are spatial coordinates and f(x, y) is the intensity value at location (x, y) (Gonzalez and Woods, 1992). The intensity values for gray level images are in the range [0 255], while for binary images are in the range [0 1].

Definition 2

A Neighborhood of the pixel p ε X is a subset of X which contains an open set and contains the p, and is denoted by N (p).

Definition 3

The four neighbors of the point p at location (x, y) are its four horizontal and four vertical neighbors, point p and is denoted by N_4(p). 5 is the central pixel p(x, y) and 2, 4, 6, and 8 denotes the 4-neighbours of a point p(x, y).

1	4	7
2	5	8
3	6	9

Definition 4

The 8-neighbours of a point p(x, y) consist of its 4-neighbours together with its four diagonal neighbors. The point ‘p’and its 8-neighbours are denoted by N8(p). 5 is the central pixel p(x, y) and 1, 2, 3, 4, 6, 7, 8, 9 denotes the 8-neighbours is denoted by N8(p).

1	4	7
2	5	8
3	6	9

Definition 5

The LT neighbors of a point p(x, y) consist of the neighbors (x-1, y-1) and (x+1, y+1). The point p and its Lt neighbors are denoted by L_3 (p). 5 is the central pixel and the 1, 9 are the LT neighbors.

1	4	7
2	5	8
3	6	9

Definition 5

RT neighbors of a point p(x, y) consist of the neighbors (x-1, y+1) and (x+1, y-1). The point p and its RT neighbors are denoted by R_3 (p). 5 is the central pixel and the 3, 7 are the RT neighbors.

1	4	7
2	5	8
3	6	9

Definition 6

The sigma neighbors of the point p(x, y) consist of the neighbors (x-1, y), (x+1, y), (x, y-1) and (x-1, y-1) and sigma neighbors denoted by S_5(p). 5 is the central pixel and the 2, 3, 4, 6 are the sigma neighbors.

1	4	7
2	5	8
3	6	9

Some existing filtering techniques

In this section, we provide the definitions of some existing filters. The image processing function in a spatial domain can be expressed as

$$g(p) = T(f(p)) \qquad (2)$$

Where T is the transformation function, f(p) is the pixel value (intensity value or gray level value) of the point p(x, y) of input image, and g(p) is the pixel value of the corresponding point of the processed image.

Minimum filter

The minimum filter selects the smallest value within an ordered window of pixel values. An n x n window is overlaid on the upper-left corner of the image and the minimum is determined. This value is then put onto the output image in the position corresponding to the center location of the window. The window is slid one position to the right of the image and the process is repeated. As the end of a row is reached, the window is moved back to the left side of the image and filtering is thus done for the whole image. Salt noise appears as a set of white pixels. The intensity value of the white color is the highest of all colors. Since the minimum filter replaces the center pixel value by the smallest value of its neighborhood, this filter removes salt noise. This filter tends to darken the image. Minimum filter thus works well for the suppression of the salt noise. The transfer function of this filter is:

$$T(x, y) = \min (f (x_i, y_i)) \qquad (3)$$

Where x_i, y_i are the x and y co-ordinates of the neighboring pixels. f(x_i, y_i) is the intensity value of the neighbors. The value of ‘i’ varies from 1 to the size of the mask. For a 3 x 3 mask, the value varies from 1 to 9.

Maximum filter

The maximum filter selects the largest value within an ordered window of pixel values. Pepper noise appears of a set of black pixels. The intensity value of the black is the lowest of all colors. Since the maximum filter replaces the center pixel value by the largest value of its neighborhood, this filter removes pepper noise. This filter tends to brighten the image for the same reason. Maximum filter helps in eliminating the pepper noise. The transfer function of this filter is:

$$T(x, y) = \max (f(x_i, y_i)) \quad (4)$$

where x_i, y_i are the x and y co-ordinates of the neighboring pixels. $f(x_i, y_i)$ is the intensity value of the neighbors. The value of 'i' varies from 1 to the size of the mask. For a 3 x 3 mask, the value varies from 1 to 9.

Median filter

Median filter reduces noise similar to the mean filter. The median filter considers each pixel in the image in turn and looks at its nearby neighbors to decide whether or not it is representative of its surroundings. Instead of simply replacing the pixel value with the mean of neighboring pixel values, it replaces it with the median of those values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. If the neighborhood under consideration contains an even number of pixels, the average of the two middle pixel values is used.

Median filter controls the pepper and Gaussian noises. The median filter is reputed to be edge preserving. The transfer function used here is

$$g(p) = median\{f(p), where\ p \in N8(p)\} \quad (5)$$

PROPOSED HYBRID FILTERING TECHNIQUES

Hybrid median filter (HMF)

Hybrid median filter is of nonlinear class that easily removes impulse noise while preserving edges (Hu and de Haan, 2006). The hybrid median filter plays a key role in image processing and vision. In comparison with basic version of the median filter, hybrid one has better corner preserving characteristics. This filter is defined as:

$$g(p) = median\begin{Bmatrix} median\{f(p), p \in N4(p)\}, \\ median\{f(p), p \in C4(p)\}, \\ f(p) \end{Bmatrix} \quad (6)$$

A hybrid median filter preserves edges much better than a median filter. In hybrid median filter, the pixel value of a point p is replaced by the median of median pixel value of 4-neighborhood of a point 'p', median pixel value of cross neighbors of a point 'p' and pixel value of 'p'.

Hybrid cross median filter (H_1F)

The hybrid cross median filter is a nonlinear filtering technique for image enhancement (Ioannis and Anastasias, 1990). It is proposed for Gaussian noise removal from the medical image. It is expressed as:

$$g(p) = median\begin{Bmatrix} median\{f(p), p \in L3(p)\}, \\ median\{f(p), p \in R3(p)\}, \\ f(p) \end{Bmatrix} \quad (7)$$

In hybrid cross median filter, the pixel value of a point p is replaced by the median of median pixel value of LT neighbors of a point 'p', median pixel value of RT neighbors of a point 'p' and pixel value of 'p'.

Hybrid min filter (H_2F)

Hybrid min filter plays a significant role in image processing and vision. Hybrid min filter is not a usual min filter. Min filter recognizes the darkest pixels gray value and retains it by performing min operation. In min filter, each output pixel value can be calculated by selecting minimum gray level value of $N_8(p)$. H_2F filter is used for removing the salt noise from the image. Salt noise has very high values in images. It is also proposed for Gaussian noise removal from the medical image (Gnanambal and Marudhachalam, 2011). It is expressed as:

$$g(p) = min\begin{Bmatrix} median\{f(p), p \in L3(p)\}, \\ median\{f(p), p \in R3(p)\}, \\ f(p) \end{Bmatrix} \quad (8)$$

In hybrid min filter, the pixel value of a point p is replaced by the minimum of median pixel value of LT neighbors of a point 'p', median pixel value of RT neighbors of a point 'p' and pixel value of 'p'.

Hybrid max filter (H_3F)

Hybrid max filter is not a usual max filter. Hybrid max filter plays a key role in image processing and vision. The brightest pixel gray level values are identified by max filter. In max filter, each output pixel value can be calculated by selecting maximum gray level value of $N_8(p)$. H_3F filter is used for removing the pepper noise from the image. It is also proposed for Gaussian noise removal from the medical image. It is expressed as:

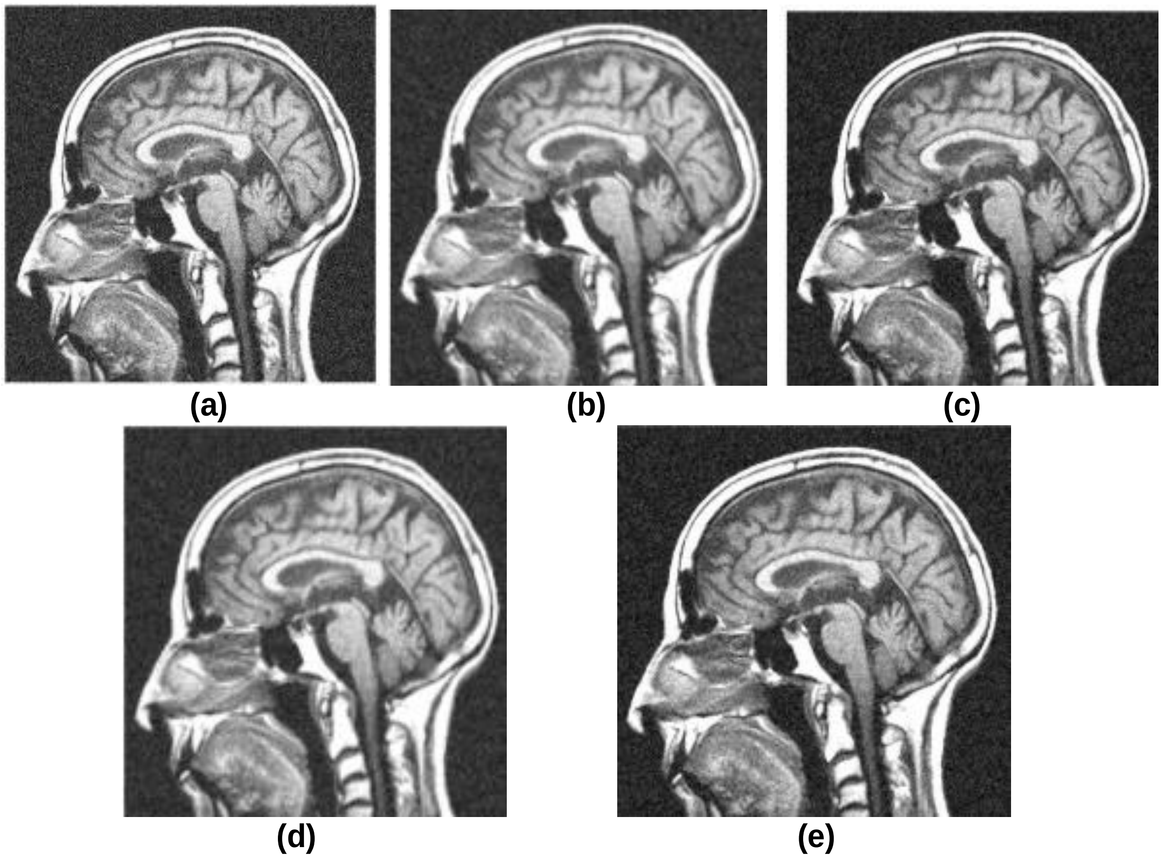

Figure 2. (a) Original image with Gaussian noise, (b) Median filtered image, (c) Hybrid max filtered image, (d) Hybrid sigma filter image, (e) Hybrid min filtered image.

$$g(p) = max\begin{Bmatrix} median\{f(p), p \in L3(p)\}, \\ median\{f(p), p \in R3(p)\}, \\ f(p) \end{Bmatrix} \quad (9)$$

In hybrid max filter, the pixel value of a point p is replaced by the maximum of median pixel value of LT neighbors of a point ‘p’, median pixel value of RT neighbors of a point ‘p’ and pixel value of ‘p’.

Hybrid sigma filter (H_4F)

In hybrid sigma filter, the pixel value of a point p is replaced by the median of median value of n8, median value of the sigma neighbors of a point ‘p’ and pixel value of ‘p’.Basically, this filter works well for the medical images. It is expressed as:

$$(p) = median\begin{Bmatrix} median\{f(p), p \in N8(p)\}, \\ median\{f(p), p \in S5(p)\}, \\ f(p) \end{Bmatrix} \quad (10)$$

Proposed enhancement technique

The following steps are performed in the proposed method:

1. Read the original image,
2. Convert the image from RGB to Gray,
3. Apply the adaptive histogram equalization method on original image,
4. Apply the hybrid filter (H_1F, H_2F, H_3F, H_4F),
5. Display the resultant enhanced image.

RESULTS AND DISCUSSION

The proposed hybrid filtering techniques have been implemented using MATLAB 7.0.2. The performance of various hybrid filtering techniques is analyzed and discussed. The measurement of medical image enhancement is difficult and there is no unique algorithm available to measure enhancement of medical image and here we have introduced the hybrid filter for removal of noise from the medical images. The proposed method is simple and easy to implement as shown in Figures 2 and 3.

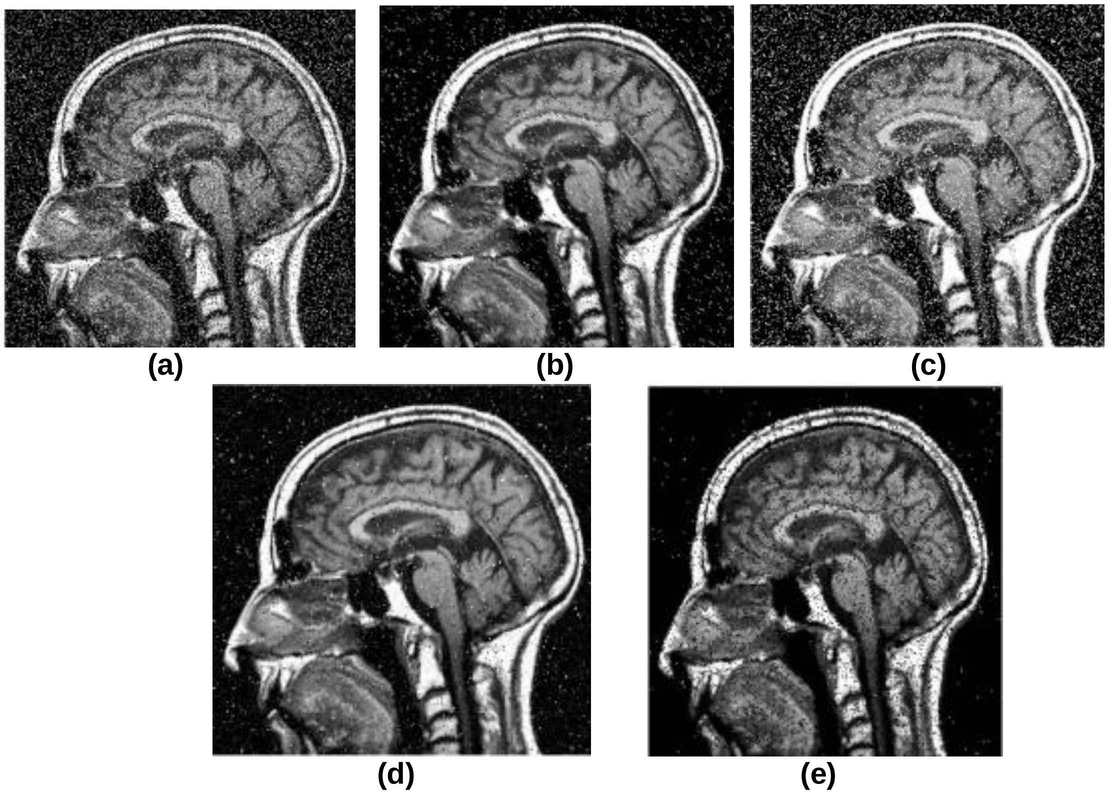

Figure 3. (a) Original image with salt and pepper noise, (b) Median filtered image, (c) Hybrid max filtered image, (d) Hybrid sigma filter image, (e) Hybrid min filtered image.

REFERENCES

Gnanambal I, Marudhachalam R (2011). New Hybrid Filtering Techniques for Removal of Gaussian Noise from Medical Images: ARPN. J. Eng. Appl. Sci. pp. 08-12.

Gonzalez R, Woods R (1992). Digital Image Processing. Adison - Wesley, New York.

Hakan GS, Richard AP, Benoit D (2002). Topological Median Filter: IEEE . Image Process. 11(2):89-104.

Hu H, de Haan G (2006). Classification-based hybrid filters for image processing: Proc. SPIE, Visual Communications and Image Processing. 6077, 607711.1-607711.10.

Ioannis P, Anastasias NV (1990). Nonlinear Digital Filters: Principles and Applications. NJ: Springer Publisher.

Klaus R, Rolf U (1992). An Adaptive Recursive 2-D Filter for Removal of Gaussian Noise in Images: IEEE Trans. Image Process 431-436.

Mamta J, Rajni M (2009). An Improved Adaptive Median Filtering Method for Impulse Noise Detection. Int. J. Recent Trends Eng. 1(1):274-278.

Peng S, Lucke L (1995). A hybrid filter for image enhancement:Proc. of International Conference on Image Processing (ICIP). 1:163-166.

Salem SA, Kalyankar NV, Khamitkar SD (2010). A Comparative Study of Removal Noise from Remote Sensing Image: Int. J. Comp. Sci. 7(1):32-36.

Sivakumar R (2007). Denoising of Computer Tomography images using curvelet transform: ARPN J. Eng. Appl. Sci. 2(1):21-26.

Turkey JW (1974). Nonlinear (nonsuperposable) methods for smoothing data: Proc. Congr. Rec. EASCOM '74. pp. 673-681.

Yanchun W, Dequn L, Heng M, Yan W (2006). An Algorithm for Image Denoising Based on Mixed Filter: Proceedings of the 6th World Congress on Intelligent Control and Automation. pp. 690-9693.