

Hybrid Filters for Medical Image Enhancement

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Abstract-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 by topological approach. 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.

Keywords: Digital topological neighborhood, brain tumor image, Gaussian noise, salt and pepper noise

1. 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. 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 is designed by Klaus Rank and Rolf Unbehauen [6] considered the three local image features edge, spot and flats as adaptive regions with Gaussian noise. Median filter has been introduced by Tukey [12] in 1970. 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.*, [3] 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.*, [13] 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 are more sophisticated, can destroy some relevant image details. Thus it is essential to develop noise filters which can preserve the features that are of

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 Juneja *et al.*, [7]. An adaptive median filter (AMF) is the best filter to remove salt and pepper noise of image sensing was shown by Salem Saleh Al-amri *et al.*, [10]. The Computer Tomography images were denoised using curvelet and wavelet transforms by Sivakumar [11]. The objective of this study is to develop new hybrid filtering techniques and investigate their performance on medical images.

This work is organized as follows: Section 2 discusses types of noises involved in medical imaging. In Section 3 basic definitions are introduced. Section 4 discusses the various existing filtering techniques for de-noising the medical images. Section 5 deals with proposed hybrid filtering techniques for de-noising the Gaussian noise and salt and pepper noise in the medical images. In Section 6 experimental results and Section 7 puts forward the conclusion drawn by this paper.

2. TYPES OF NOISES

2.1 Salt and pepper noise

Salt and pepper noise is a form of noise typically seen on images. It represents itself as randomly occurring white and black pixels. A "spike" or impulse noise drives the intensity values of random pixels to either their maximum or minimum values. The resulting black and white flecks in the image resemble salt and pepper. This type of noise is also caused by errors in data transmission.

2.2 Speckle noise

Speckle noise affects all inherent characteristics of coherent imaging, including medical ultra sound imaging. It is caused by coherent processing of backscattered signals from multiple distributed targets.

Speckle noise is caused by signals from elementary scatterers. In medical literature, speckle noise is referred to as 'texture' and may possibly contain useful diagnostic information. For visual interpretation, smoothing the texture may be less desirable. Physicians generally have a preference for the original noisy images, more willingly, than the smoothed versions because the filter, even if they interest to the physician. Several different methods are used to eliminate speckle noise, based upon different mathematical models of the phenomenon. In our work,

we recommend hybrid filtering techniques for removing speckle noise in ultrasound images. The speckle noise model has the following form (denotes multiplication). For each image pixel with intensity value f_{ij} ($1 \leq i \leq m, 1 \leq j \leq n$ for an $m \times n$ image), the corresponding pixel of the noisy image g_{ij} is given by,

$$g_{i,j} = f_{i,j} + n_{i,j} \quad (2.1)$$
 where, each noise value n is drawn from uniform distribution with mean 0 and variance 2 .

2.3 Gaussian noise

Gaussian noise is statistical noise that has a probability density function (abbreviated pdf) of the normal distribution (also known as Gaussian distribution). In other words, the values that the noise can take on are Gaussian-distributed. Gaussian noise is properly defined as the noise with a Gaussian amplitude distribution. Noise is modeled as additive white Gaussian noise (AWGN), where all the image pixels deviate from their original values following the Gaussian curve. That is, for each image pixel with intensity value f_{ij} ($1 \leq i \leq m, 1 \leq j \leq n$ for an $m \times n$ image), the corresponding pixel of the noisy image g_{ij} is given by,

$$g_{i,j} = f_{i,j} + n_{i,j} \quad (2.2)$$

where, each noise value n is drawn from a zero – mean Gaussian distribution.

3. BASIC DEFINITIONS

This section presents some general definitions and digital topological results, which will be used along the development of this paper.

Definition 3.1: [9] A digital image is a function $f: \mathbb{Z}_x \times \mathbb{Z}_y \rightarrow [0, 1, \dots, N-1]$ in which $N-1$ is a positive whole number belonging to the natural interval $[1, 256]$. The functional value of ‘ f ’ at any point $p(x,y)$ is called the intensity or gray level of the image at that point and it is denoted by $f(p)$.

Definition 3.2: [9] A neighborhood of a point $p \in X$ is a subset of X which contains an open set containing p . It is denoted by $N(p)$.

Definition 3.3: [9] The 4-neighbours of a point $p(x,y)$ are its four horizontal and vertical neighbours $(x \pm 1, y)$ and $(x, y \pm 1)$. The point ‘ p ’ and its 4-neighbours is denoted by $N_4(p)$.

1	4	7
2	5	8
3	6	9

5 is the central pixel $p(x,y)$ and 2,4,6, and 8 denptes the The 4-neighbours of a point $p(x,y)$.

Definition 3.4: [9] The 8-neighbours of a point $p(x,y)$ consist of its 4-neighbours together with its four diagonal neighbours $(x \pm 1, y \pm 1)$ and $(x - 1, y \pm 1)$. The point ‘ p ’ and its 8-neighbours is denoted by $N_8(p)$.

1	4	7
2	5	8
3	6	9

5 is the central pixel $p(x,y)$ and 1,2 3,4,6,7,8,9 denotes the 8-neighbours is denoted by $N_8(p)$.

Definition 3.5: The cross neighbours of a point $p(x,y)$ consists of the neighbours $(x+1,y \pm 1)$ and $(x -1,y \pm 1)$.

The point ‘ p ’ and its cross neighbours is denoted by $C_4(p)$.

1	4	7
2	5	8
3	6	9

5 is the central pixel $p(x,y)$ and 1,7,3,9 denotes the The cross neighbours of a point $p(x,y)$.

Definition 3.6: The LT neighbours of a point $p(x,y)$ consists of the neighbours $(x-1,Y-1)$ and $(X+1,Y+1)$. The point ‘ p ’ and its LT neighbours is denoted by $L_3(p)$.

1	4	7
2	5	8
3	6	9

5 is the central pixel $p(x,y)$ and 1,9 denotes the LT neighbours of a point $p(x,y)$.

Definition 3.7: The RT neighbours of a point $p(x,y)$ consists of the neighbours $(x-1,Y+1)$ and $(x+1,Y-1)$. The point ‘ p ’ and its RT neighbours is denoted by $R_3(p)$.

1	4	7
2	5	8
3	6	9

5 is the central pixel $p(x,y)$ and 3,7 denotes the RT neighbours of a point $p(x,y)$.

Definition 3.8: The sigma neighbours of a point $p(x,y)$ consist of the neighbours $(x-1,y),(x+1,y),(x,y-1),(x-1,y-1)$

The point ‘ p ’ and denoted by $S(p)$.

1	4	7
2	5	8
3	6	9

5 is the central pixel $p(x,y)$ and 2,3,4,6 denotes the sigma neighbours of a point $p(x,y)$.

4.SOMEEXISTING 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

$$g(p) = Y(f(p)) \quad (4.1)$$

where Y 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.

4.1. Median filter (MF)

The best-known order-statistic filter in digital image processing is the median filter. It is a useful tool for reducing salt-and- pepper noise in an image. The median filter [12] plays a key role in image processing and vision.

In median filter, the pixel value of a point p is replaced by the median of pixel value of 8-neighborhood of a point ‘ p ’. The operation of this filter can be expressed as:

$$g(p) = \text{median} \{f(p), \text{where } p \in N_8(p)\} \quad (4.2)$$

The median filter is popular because of its demonstrated ability to reduce random impulsive noise without blurring edges as much as a comparable linear lowpass filter. However, it often fails to perform well as linear filters in providing sufficient smoothing of nonimpulsive noise components such as additive Gaussian noise. One of the main disadvantages of the

basic median filter is that it is location-invariant in nature, and thus also tends to alter the pixels not disturbed by noise.

4.2. Hybrid median filter (HMF)

Hybrid Median filter [4] is of nonlinear class that easily removes impulse noise while preserving edges. 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

$$g(p) = \text{median} \left\{ \begin{array}{l} \text{median}\{f(p), p \in N_4(p)\}, \\ \text{median}\{f(p), p \in C_4(p)\}, \\ f(p) \end{array} \right\} \dots\dots\dots(4.3)$$

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 neighbours of a point 'p' and pixel value of 'p'.

5. PROPOSED HYBRID FILTERING TECHNIQUES

In this section, we will provide the definition of proposed hybrid filters.

5.1. Hybrid cross median filter (H1F)

The hybrid cross median filter is a nonlinear filtering technique for image enhancement. It is proposed for Gaussian noise and 'salt and pepper' noise removal from the medical image. It is expressed as:

$$g(p) = \max \left\{ \begin{array}{l} \text{median}\{f(p), p \in L_3(p)\}, \\ \text{median}\{f(p), p \in R_3(p)\}, \\ f(p) \end{array} \right\} \dots\dots\dots(5.1)$$

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

5.2. Hybrid min filter (H2F)

Hybrid min filter plays a significant role in image processing and vision. Hybrid min filter is not a usual min filter. Min filter [1] 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 Ng(p). H2F 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. It is expressed as:

$$g(p) = \min \left\{ \begin{array}{l} \text{median}\{f(p), p \in L_3(p)\}, \\ \text{median}\{f(p), p \in R_3(p)\}, \\ f(p) \end{array} \right\} \dots\dots\dots(5.2)$$

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

5.3. Hybrid max filter (H3F)

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 [1] each output pixel value can be calculated by selecting maximum gray level value of Ng (p). H3F 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:

$$g(p) = \max \left\{ \begin{array}{l} \text{median}\{f(p), p \in L_3(p)\}, \\ \text{median}\{f(p), p \in R_3(p)\}, \\ f(p) \end{array} \right\} \dots\dots\dots(5.3)$$

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

5.4. Hybrid sigma filter H5F

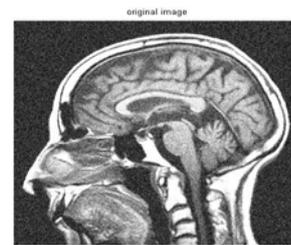
Hybrid sigma filter is not a usual sigma filter. Hybrid sigma filter plays a key role in image processing and vision. The brightest pixel gray level values are identified by sigma filter. In sigma filter [1] each output pixel value can be calculated by taking the average gray level value of S(p). H5F filter is used for removing the salt and pepper noise from the image. It is also proposed for Gaussian noise removal from the medical image. It is expressed as:

$$g(p) = \text{median}\{\text{median}(f(p), p \in N_8(p)), \text{medina}(f(p), p \in L(p)), f(p)\} \dots\dots\dots(5.4)$$

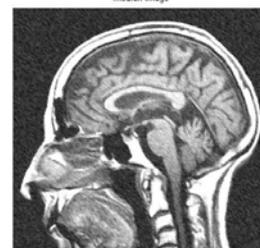
In hybrid sigma filter, the pixel value of a point p is replaced by the medina of median pixel value of LT neighbours of a point 'p', median pixel value of sigma neighbours of a point 'p' and pixel value of 'p'.

6. EXPERIMENTAL RESULTS, ANALYSIS AND DISCUSSIONS

The proposed hybrid filtering techniques have been implemented using MATLAB 7.0. 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.



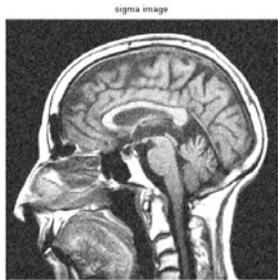
Origina image with Gaussian noise



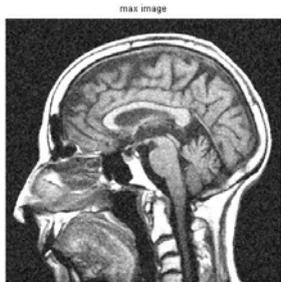
Median filtered image



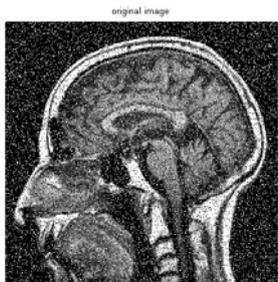
Hybrid max filterd image



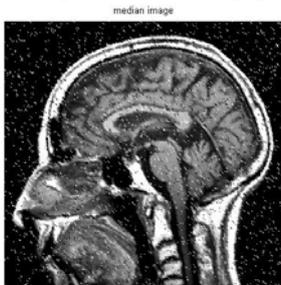
Hybrid sigma filter image



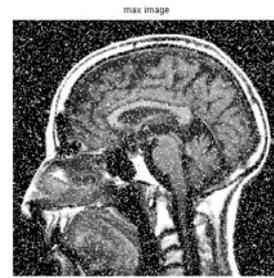
Hybrid min filterd image



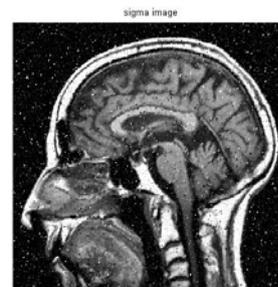
Original image with salt and peeper noise



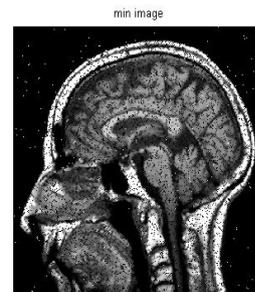
Median filtered image



Hybrid max filterd image



Hybrid sigma filter image



Hybrid min filterd image

7. CONCLUSIONS

In this work, we have introduced various hybrid filtering techniques for removal of Gaussian noise from medical images. The proposed method are simple and easy to implement.

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