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Methodical Investigation of filtering algorithms for human brain MRI

Siji T. Mathew* Nachamai M.**

Abstract : Retrieving useful information from the given data through a systematic and organized way can help to learn more about the data in a much better and clear way. Information is hidden in medical images. The medical images like Magnetic Resonance Images (MRI), Computed Tomography (CT), ultrasound, X-ray are suggested by the physicians depending upon the available symptoms of the disease. These medical images contain valuable information about a particular disease in hidden format. Identification of that potentially useful information is crucial in further treatments of a particular disease. In image mining the images are processed and extraction or mining of knowledge is done, to get original, valid, potentially useful, and understandable patterns from the available images. The obtained patterns are a good source for further research work. This research work uses brain Magnetic Resonance Images (MRI) of human beings. Different image filtering algorithms were used to retrieve noise free images.

Keywords : Brain MRI, salt and pepper, adaptive filter, median filter.

1. INTRODUCTION

The medical images are helpful in various stages of treatment. Doctors use Computed Tomography (CT), mammograms, X-rays, Magnetic Resonance Imaging (MRI), etc in various stages of diagnosing and treatment. Noise is the unwanted information contained in images. Noise included in digital images due to the errors in the acquisition stages of images. As a result, the pixel values in the image may not reflect the original intensities of the real location. The image enhancement or modification technique is known as filtering. Filters give a visual interpretation of images, and it is the pre-processing step in digital image processing. The filter can perform sharpening, smoothing, and edge enhancement depending on the filtering algorithm. Generally, there are two types of filters known as a linear filter and nonlinear filter. In linear filtering, a linear combination of values is applied to the pixel values of the original image. Linear filtering is easy to learn and compute. The nonlinear filters provide a smoothing effect to the image without blurring the edges [1]. The image filtering techniques are applied to improve image quality, increase visibility of available details, and hence help the physicians in diagnostic with accurate information deliverance. This paper list out various noise which are related to medical images, the application of filters and performance metrics.

2. DIFFERENT KINDS OF NOISE

Digital images are inclined to noise in its various development stages. Noise can cause image distortion and blurring. The noises may be acquired from a noise sources present in the surrounding area of image capturing devices, faulty memory location or may be induced due to the imprecision in the image capturing devices like cameras, magnetic fields, misaligned lenses, weak focal length, scattering and other unfavorable conditions present in the surrounding ambiance[2]. Gaussian, salt and pepper are the commonly seen noise in medical images. The medical images are processed and identification of noise is done using Matlab software.

* Dept. of Computer Science Christ University, Bangalore, India siji.mathew@res.christuniversity.in

** Dept. of Computer Science Christ University, Bangalore, India nachamai.m@christuniversity.in

2.1. Gaussian noise

Gaussian noise is called as electronic noise since it transpires from detectors or amplifiers. Gaussian noise is introduced from the imaging system due to the thermal vibration of atoms or due to hot objects radiation emission. This noise is uniformly distributed over the signal. The gray pixel values are generally affected by Gaussian noise. Each pixel in the noisy image is the sum of the true pixel value and a random Gaussian distributed noise value [3]. Mathematically, a Gaussian filter uses Gaussian function as convolution to modify the input signal.

2.2. SALT AND PEPPER NOISE

Salt and pepper or impulse noise or data drop noise is a type of noise which drops some pixel values in the images. The sudden and sharp disturbance in image signal may induce this noise. During data transmission, some pixel values corrupted as minimum or as maximum 255. Salt and pepper noise is seen as white and black pixels in images.

3. DIFFERENT KINDS OF FILTERS

Filtering enhances the input image in quality. The enhanced images are used in further stages of various image processing applications. The choice of filter is often determined by the nature of the task and the type and behavior of the data [4]. In this study human brain, MRI images were tested with a median filter, anisotropic filter, and wiener2 filter.

3.1. Median filtering

In median filter the signal is checked entry by entry and if any noise present that pixel is replaced with the median of its neighbouring pixels. Each pixel considers its own neighbouring pixel and this pattern is called as the "window". The entire signal entries were checked by the sliding window. The median filter removes the outlier without reducing the sharpness of the image [5]. The median filter performs poorly with Gaussian blur and with high levels of noise. The median filter is more effective to remove impulse noises like salt and pepper noise and speckle noise [6]. Figure1 shows the median filtered MRI image.

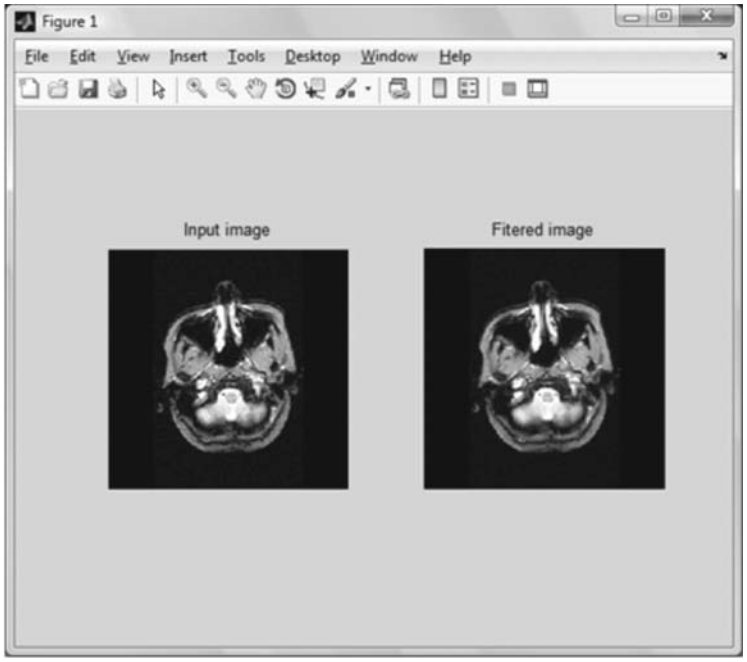


Fig. 1. Median filtered image.

Original image was not clear and after removing the noise an improved quality image is received. The filter remove noise and gave a clarity image.

3.2. Anisotropic filter

Perona and Malik introduced anisotropic algorithm for image pre-processing [7]. An anisotropic filter preserves the edges of the initial image. The smoothening technique is used in the images during filtering steps. They work differently in each part of the input images. Yang, Burger et.al suggested an improved Anisotropic filtering algorithm in 1987 [8]. It reduces noise in higher region of the images. Anisotropic filter uses Partial Differential Equations (PDE) to find and remove the noise in the image. The PDE function to obtain a de noised image is given in equation (1)

$$U = \text{div}\,(g\,(\nabla|Y|)\,\nabla Y) \quad ...(1)$$

Where U denotes the de noised image and Y denotes the noisy image g is the diffusion control function for smoothing the image, "the gradient operator and div is a linear differential operator which act as the divergence operator in the equation. Figure2 shows the anisotropic filtered image.

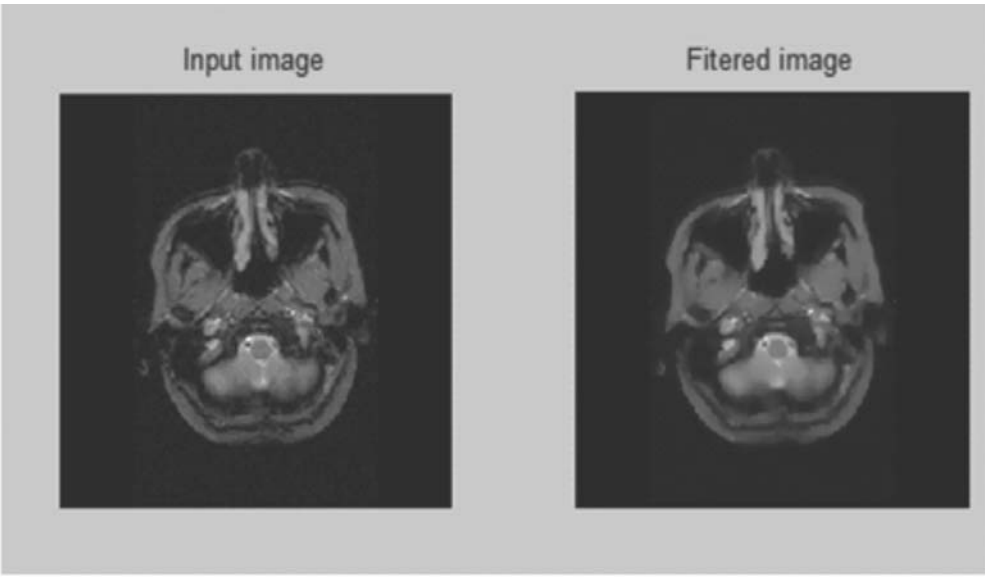


Fig. 2. Anisotropic filter applied MRI images

Anisotropic filters are able to remove the unwanted noise from input images.

3.3. Adaptive filtering : wiener 2

Wiener2 is a linear lowpass-filter used in to filter grayscale image. Wiener2 handle the blurring and additive noise present in the input images. In an adaptive Wiener method, wiener2 calculate the local mean and variance for every pixel of the image [9].

Mean is calculated using the following equation (2)

$$\mu = \frac{1}{NM}\sum_{n1,\, n2 \in \eta} \alpha(n_{1,}\, n_{2,}) \quad ...(2)$$

And variance using equation (3) $$\sigma^2 = \frac{1}{NM}\sum_{n1,\, n2 \in \eta} \alpha^2(n_{1,}\, n_{2,}) - \mu^2 \quad ...(3)$$

where η is the N X M local neighbourhood of each pixel in the image A.

The wiener2 creates a pixel wise Wiener filter using the equation (4),

$$b(n_1, n_2) = \mu + \frac{\sigma^2 - v^2}{\sigma^2}(a(n_{1,}\, n_{2,}) - \mu) \quad ...(4)$$

where v^2 is the noise variance, μ is the mean and σ^2 is the variance. If the noise variance is not given, wiener2 uses the average of all the local estimated variances [10].

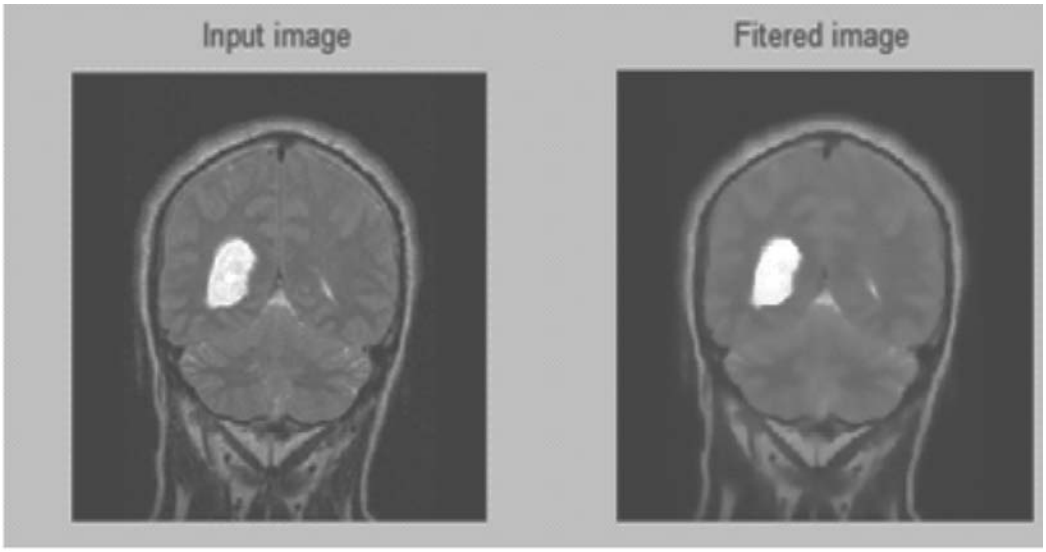


Fig. 3. Wiener2 filtered image

Wiener2 preserve the edges and smooth the input image. Wiener2 filters are able to remove the unwanted noise from input images. An MRI image contains printed text about patient name, doctor name, date of taken, equipment description etc in it. The patient's basic information which was present in the original images are filtered out with the help of wiener2 algorithm.

4. PERFORMANCE EVALUATION METRICS

The performance analysis of the filtering algorithms was calculated using Mean Square Error and Peak Signal to Noise Ratio. Mean Square Error (MSE) and Peak Signal to Noise Ratio(PSNR) gives the performance value for each image input. They are widely used as performance analysis matrices for medical MRI image filters [11].

4.1. Mean Square Error (MSE)

The original image and compressed images are taken for the study and MSE represents the cumulative squared error between these images.

Let $x = \{x_i | i = 1, 2, \cdots, N\}$ and $y = \{y_i | i = 1, 2, \cdots, N\}$ are two images,

where N is the number of pixels, x_i and y_i are the values of the i^{th} samples in x and y, respectively. The calculation of MSE is done using equation (5)

$$MSE(x, y) = \frac{1}{N}\sum_{i=1}^{N}(x_i - y_i)^2 \quad ...(5)$$

4.2. Peak Signal to Noise Ratio (PSNR)

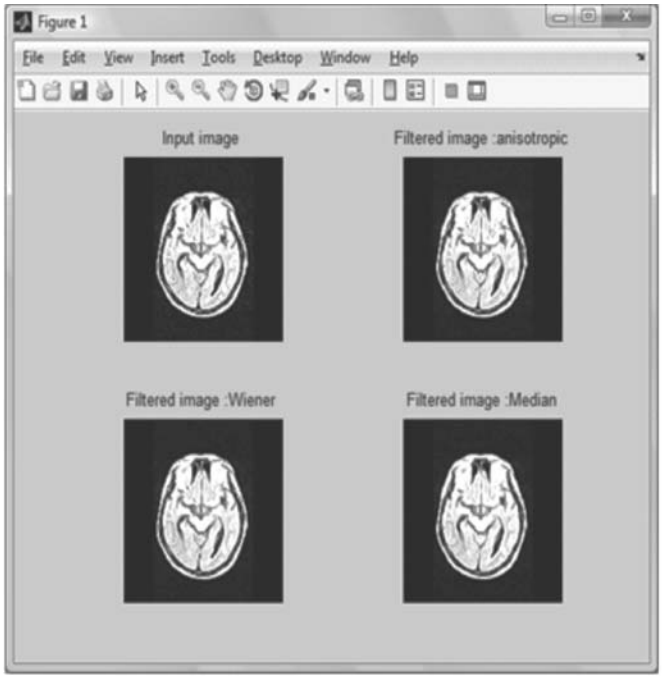
In PSNR calculation the size of the error relative to the peak value of the signal and the size of the error relative to the average squared value of the signal are calculated [9]. The PSNR is higher for the enhanced or transformed image and lower for weakly transformed image. The measure of input image's reliability is calculated. The similarity value between given original image and the transformed image is also calculated. MSE is the Mean Square Error calculated in equation (5) and R is the maximum fluctuation is represented with R for the input image data. PSNR value is calculated using equation (6).

$$PSNR = 10 \log_{10} \frac{R^2}{MSE} \quad ...(6)$$

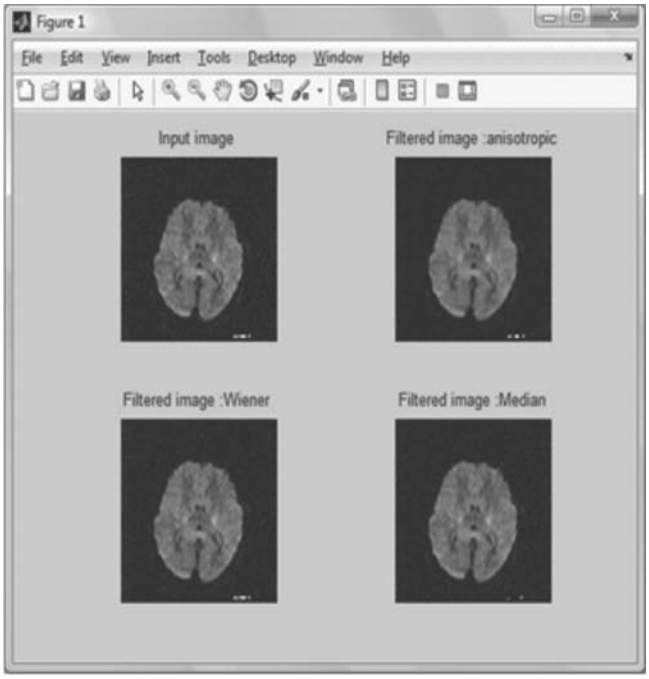
5. CONCLUSIONS

Patient 1 MRI image filtering

Patient 2MRI image filtering



Patient 3MRI image filtering



Patient 4MRI image filtering

Fig. 4. Study result for filtering algorithms

The MRI images of the patients are preprocessed using three different filters namely median filter, anisotropic filter and wiener2 filter. The performance analysis was done with the help of statistical parameters MSE and PSNR. A comparative study is done among the filters with the help of Matlab 2012. An original image contains noise as discussed in section 2. The filtering algorithms are useful to remove these unwanted noise and text fields. An input image in Dicom format was taken and read in Matlab. The filtering algorithms were coded and applied into this image. This work is a part from image segmentation and extraction. The resultant image with high accuracy is used as the input for next step of segmentation.

Figure 4 shows a comparative study of filtering algorithms. In the preprocessing, the filters were applied separately on the original images. From the filtered image, MSE and PSNR values were calculated in Matlab. The resulting values obtained after applying the filters are listed in Table I.

Table 1. Performance Analysis of filtering algorithms with MSE and PSNR values.

Algorithm used	*Performance Metrics*	
	MSE(dB)	***PSNR(dB)***
Median filtering	14.75	36.44
Anisotropic	13.24	36.91
Adaptive-wiener2	12.2	38.6

In general PSNR value indicates the reconstruction quality of digital images [11]. Figure 5 gives graphical comparison of the filtering algorithm. In this study three different filtering algorithms were studied in detail and applied in brain MRI images. PSNR value for adaptive wiener2 is 38.60 dB which more when compared with other two algorithms. Median algorithm gives a PSNR value of 36.44dB and anisotropic filter give 36.91 dB. So here for the given MRI images, Wiener2 filtering give noise removed brain MRI with all relevant information stored in it. These filtered images are used for further segmentation process.

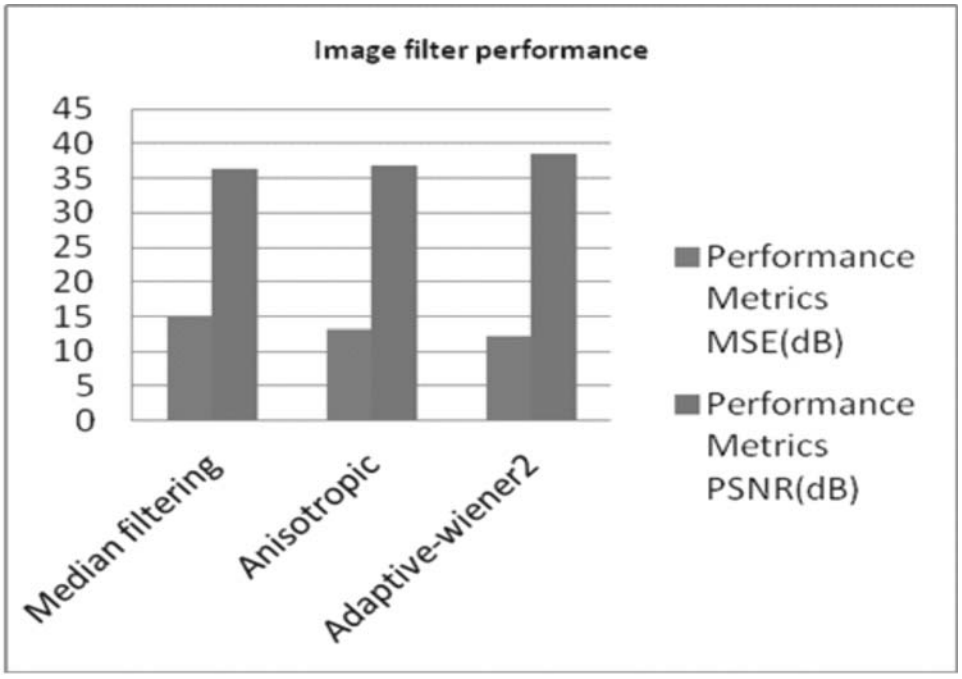


Fig. 5. Performance evaluation using MSE and PSNR

6. REFERENCES

1. A.K. Jain," Fundamentals of Digital Image Processing", Englewood Cliffs, NJ: Prentice Hall, 1989.
2. A. Boyat and B. K. Joshi, "Image denoising using wavelet transform and median filtering," 2013 Nirma University International Conference on Engineering (NUiCONE), Ahmedabad, 2013, pp. 1-6.
3. Gonzalez R. C., & Woods R. E. "Digital Image Processing," second ed., Prentice Hall,Englewood, Cliffs, NJ, 2002.
4. Nadir Mustafa, Jiang Ping Li, Saeed Ahmed Khan and Mohaned Giess, "Medical Image De-Noising Schemes using Wavelet Transform with Fixed form Thresholding" International Journal of Advanced Computer Science and Applications, 2015.

5. Kwan H.K. and cai Y., “median Filtering Using Fuzzy concept”, 36th Midwest symposium on circuits and systems, Detroit, MI, vol. 2, pp. 824-827, August 1993.

6. G.R. Arce, “ Nonlinear Signal Processing: A Statistical Approach”, Wiley:New Jersey, USA, 2005.

7. Pietro Perona and Jitendra Malik ,Scale-space and edge detection using anisotropic diffusion, Proceedings of IEEE Computer Society Workshop on Computer Vision,. pp. 16–22,1987.

8. Yang, G.Z., Burger, P., Firmin, D.N. , Underwood, S.R. , Structure adaptive anisotropic filtering, Image and Vision Computing, No. 14, 135-145,1996.

9. Lim, Jae S., Two-Dimensional Signal and Image Processing, Englewood Cliffs, NJ, Prentice Hall, 1990, p. 548, equations 9.26, 9.27, and 9.29.

10. http://in.mathworks.com/help/vision/ref/psnr.html?refresh=true accessed on 05/3/2016

11. Ahmet M., Paul S., “Image quality measures and their performance”, IEEE Transactions on communications, 43:2959-2965, 1995.

12. Huynh-Thu, Q.; Ghanbari, M, “Scope of validity of PSNR in image/video quality assessment”. Electronics Letters 44 (13): 800,2008.