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A Comparative Analysis of Filters on Brain MRI Images

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Abstract— ***Medical imaging and bio-medical have special place for the image processing field in modern science. With the advent of developing imaging modalities like magnetic resonance imaging, computerized tomography (CT), mammography, and ultra sonography (USG) it is now possible to look inside the internal structure of sick body. It provides a convenient way to diagnose, monitor and track the abnormality in the ailing body. In this paper results and effects of various filter technique applied to tumor-bearing MRI images of brain have been presented. Performance evaluation of various image enhancement/noise removal techniques for MRI images as aimed at identifying tumor is given.***

Keywords— Magnetic resonance images, image enhancement, noise removal.

I. INTRODUCTION

The impact of digital image processing is increasing by the day for its use in the medical and research areas. For example, brain tumors are nonthreatening and can be detected before having a chance to grow or spread. Approximately 40 per cent of all, detected at primary stage, are successfully treated with surgery and, in some cases using radiation [1].
Magnetic Resonance Imaging (MRI) has become a widely used method of high quality medical imaging, especially brain imaging where MRI's soft tissue contrast and non-invasiveness is a clear advantage. MRI provides a matchless view inside the human body. The level of details that we can see is extraordinary on being compared with any other imaging modality. Proper, reliable and fast detection of brain cancer is of major technical and economic importance for the doctors. Common practices based on specialized techniques are slow, and possess a degree of subjectivity which is hard to quantify [2].
The aim of de-noising technique is removal of noises from an image and thus becomes the first step in image processing. The technology for removal of noise should be applied carefully; otherwise noise removal introduces artifacts which cause blurring of the image [3].
In this paper, we provide a quantitative evaluation of the performance of different de-noising techniques for MRI images. In particular, we benchmark various image enhancement techniques, namely the median filter [14], Gaussian filter [14], Max filter [12], Min filter [12], and Arithmetic Mean filter [8]. Results of above mentioned filters, when applied on MRI images are noted in line with [4].

II. RELATED STUDY

In general, any kind of magnetic resonance image analysis starts with an image enhancement process. The choice of enhancement technique has a direct impact on the final result, since the image quality has great impact on subsequent analysis. In the literature, however, relatively little attention has been given to this pre-processing step. In the following, we briefly discuss various filtering techniques that we evaluated in our study.

1). Median Filtering:

Median filtering [5][6] is similar to using an averaging filter, where each pixel is set to an average of the pixel values in the neighbourhood of the corresponding input pixels. However with median filtering, the value of an output pixel is determined by the median of the neighbourhood pixels, rather than the mean. It is much less sensitive than the two extreme values. Median filtering is therefore better able to remove this outlier without reducing the sharpness of the image.

2).Gaussian filter:

A smoothing filter, defined by a Gaussian kernel [7], shows lower blurring effects compared to simpler averaging filters. The key point is that this filter corrects not only the spectral coefficient of interest, but all the amplitude spectrum coefficients within the filter window too.

3).Arithmetic means filters:

Let sxy represent the coordinate set in rectangular window of sub image of an image over a size of M*N with a centre at point (x,y).The arithmetic mean filter [8] compute the average value of the noisy image g(x,y) over an area defined as sxy. The arithmetic filter applied over the region of pixel defined by S_{xy} i.e.

$$F^\wedge(x, y) = \frac{1}{mn} \sum_{(s, t) \in S_{xy}} g(s, t).$$

4).Max filter:

Max filter [5] is useful for finding the brightest points in an image. Also, because pepper noise has very low values, it is reduced by this filter as a result of the max selection process in the sub image S_{xy}. Median filtering when used for far order statistic does give better output in that case max filter is given by

$$F^\wedge(x, y) = \max_{(S, t) \in S_{xy}} \{g(s, t)\}.$$

5). Min filter:

The min filters [5] are used for finding the darkest point in an image.

$$F^\wedge(x, y) = \min \{g(s, t)\} \ (s, t) \in S_{xy}.$$

6).Mean filter:

Mean filter [3, 9] is the optimal filter for removing grain noise in an image. It is a linear filter that applies mask over each pixel in the signal. Each of the components of the pixels coming under the mask are averaged together to form a single pixel that is why the filter is otherwise known as average filter and is given by:

$$F^\wedge(x, y) = \text{median} \{g(s, t)\} \ (s, t) \in S_{xy}.$$

Image noise:

Noise in images [9] is caused by the random fluctuations in brightness or colour information. It represents unwanted information which degrades the image quality. It is defined as a process which affects the acquired image quality that is not a part of the original image content. Digital image noise [10] may occur due to various sources. During acquisition process, digital images convert optical signals into electrical one and then to digital signals. Due to these processes noise is introduced in digital images. Owing to natural phenomena at conversion process each stage experiences a fluctuation that adds a random value to the intensity of a pixel in a resulting image. In general image noise is regarded as an undesirable by-product of image release. The types of Noise are following:-

- Amplifier noise (Gaussian noise)
- Salt-and-pepper noise
- Shot noise (Poisson noise)
- Speckle noise

Image Processing provide function imnoise to corrupt an image with noise. The function has the basic syntax

g=imnoise (f, type, parameters)

Where 'f' is the input MRI image, type is defined which type of noise is applied on image and parameters are related to the type of image. 'Imnoise' is the function in Matlab used to add noise in an image [7]. Performance of de-noising is measured using quantitative measures such as peak signal-to-noise ratio (PSNR) [12]. PSNR [3] is the ratio of maximum possible power in the image to the noise quantity in the image. Mathematically represented as:

$$PSNR = 10.\log10 \left(\frac{MAX}{MSE}\right) = 20.\log10 \left(\frac{MAX}{\sqrt{MSE}}\right)$$

Where MAX is the maximum possible pixel value in the image, MSE is the mean-square error in the image. The unit of SNR is 'db.' (Decibel). If both images are identical then PSNR values becomes infinity because in such cases MSE will become zero.

(A). Gaussian noise:

Gaussian noise [10] is statistical in nature. Its probability density function equals to that of normal distribution, which is otherwise called as Gaussian distribution. In this type of noise, values of the noise are being Gaussian-distributed. A special case of Gaussian noise is white Gaussian noise, in which the values always are statistically independent and often said as white noise which describes the correlation of noise. Gaussian noise is sometimes equated to be of white Gaussian noise, but it may not necessarily the case. For application purpose, Gaussian noise is also used as additive white noise to produce additive white Gaussian noise. It is commonly defined as the noise with a Gaussian amplitude distribution, which state that no correlation between time and spectral density of noise. The syntax of adding the gaussain noise to an image is:

g = imnoise (f,"gaussain", m, var)

This add gaussain noise of mean m and variance var to image f. the default value for mean noise is '0' and for var is '0.01'[7].

(B). Salt and pepper noise

In salt and pepper noise [10] [11] model, there are only two possible values 'a and b'. The probability of getting each of them is less than 0.1 (else, the noise would greatly dominate the image). For 8 bit/pixel image, the intensity value for pepper noise typically found nearer to 0 and for salt noise it is near to 255. Salt and pepper noise is a generalized form of noise typically seen in images. In image criteria the noise itself represents as randomly occurring white and black pixels.

An effective noise reduction algorithm for this type of noise involves the usage of a median filter. Salt and pepper noise occurs in images under situations where quick transients, such as faulty switching take place. This type of noise can be caused by malfunctioning of analog-to-digital converter in cameras, bit errors in transmission, etc. The syntax of adding the noise to an image is given by:

g= imnoise (f, "salt& pepper", d)

Over the image 'f' it adds salt & pepper noise with the noise density'd'. The default value of noise density is '0.05' [7].

III. COMPARATIVE STUDY

Among various filters, each has different characteristics and Working of each one is different for different types of images. Since Datasets collected by image sensors are generally contaminated by noise, imperfect instruments, problems with the data acquisition process, and interfering natural phenomena can all degrade the data of interest [12].

Figure (1) represent the various filtering technique applied on brain MRI image. Various filtering technique which when applied on original image produce result which helps in enhancing an image and help for the comparative study among those that figure (2) represents the median filter applied on original image which is affected by Gaussain and salt & pepper noise .

As we can see from below results, noise in an image cause degradation in image quality, so the information associated with the image is damaged .to overcome that damage and to acquire maximum information with quality from the noised image, various filtering technique are used.

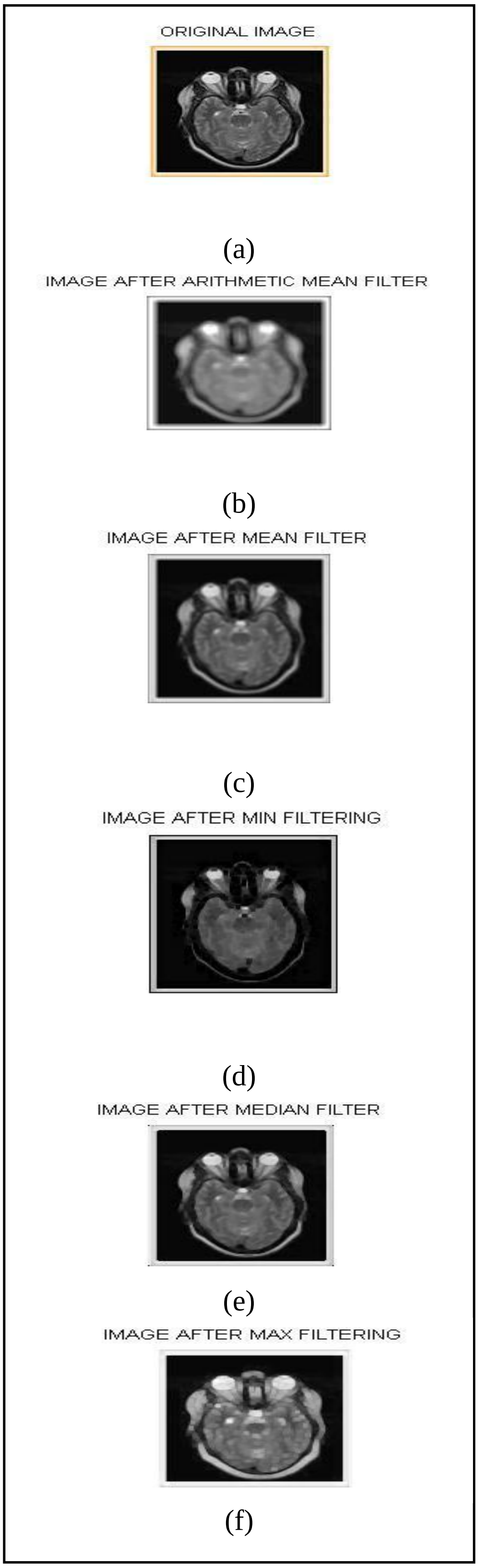
The various filtering technique are used to remove noise from the image. They raise the quality and enhance the image. There are some advantage and disadvantage among those techniques. The comparison is provided in the table below.

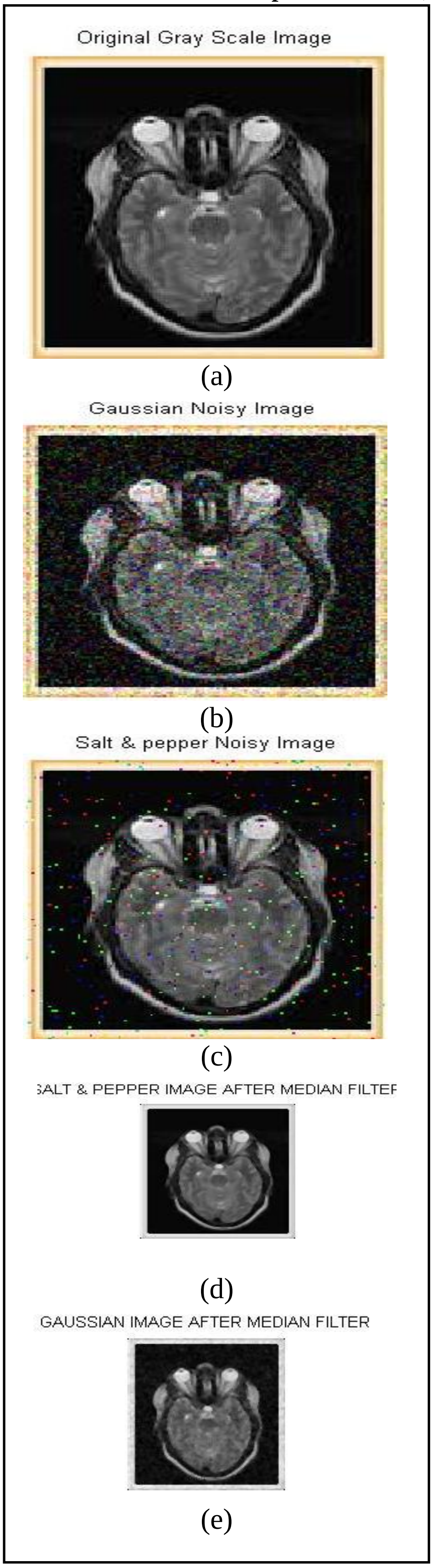
S.no	Filter name	Advantage	Disadvantage
1	Median Filter	Able to remove this outlier without reducing the sharpness of the image	Remove impulse noise. While smoothing the edges and boundary, it erases the detail whose size is about n/2.
2	Gaussian filter	It is used for peak detection.	It reduce details of an image
3	Max filter	Enhance brighten pixel of an image	It does not provide the detail of dark pixel
4	Min filter	Enhance dark pixel of an image	It does not provide the detail of brighten pixel.
5	Arithmetic mean filter	It better suited to calculated the noise region for sub images of an images	It time consuming to find region of an image and divide into sub images.
6	Mean filter	Removing grain noise from an image	Weak when noise is adaptive in nature.

IV. ANALYSIS

After applying various filter techniques, the difference in the MRI image is clearly observed. The max filters provide the suitable output. It enhances the brighten value of an image. Among various filtering techniques, Max filter gives better image.But after finding Gaussian and salt & pepper noise in Brain MRI images various filtering technique have been applied and it is found that median filter works better for the noisy image as a mean square value (MSV) of 285.82 for gaussain noise and 196.05 for salt & pepper noise and peak square noise ratio (PSNR) value for gaussain noise is 23.19 and for salt & pepper noise 26.12.

Noise Name	Mean Square Value (MSV)	Peak Square Noise Ratio (PSNR)
Gaussian Noise	285.82	23.19
Salt & Pepper Noise	196.05	26.12





V. CONCLUSION

In this work we have taken MRI images of brain. Different filtering techniques have been subsequently applied for enhancement of MRI images. It is observed that the arithmetic mean filter, mean filter and min filter provide a poor choice for enhancing MRI images. The Max filter is shown to have a slightly better brightened value in an image as compared to the others. However, after finding noise to an image, median filtering is applied. The results are analysed and evaluated through mean square value and Peak square noise ratio [5] [14].

Through this work we have observed that the choice of filter for enhancing the MRI image depends on the type of the filtering technique, which is used. It is remarkable that it saves the processing time. The results we have achieved are useful and helpful for medical practitioners to analyse the MRI image [5].

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