ORIGINAL ARTICLE

Visual Perception Method for Medical Image De-noising

Jamal Kamil Alrudaini[1], Dunya Muhee Hayder[2], Abdulnaser Khalid Hamzah[1], Ali Abdilkadhum Ruhaina[1]

[1] Department of Computer Engineering Techniques, Al-Nisour University College, 10036, Baghdad, Iraq
[2] Medical Physics Department, Madent Al-Elm University College, 10036 Baghdad, Iraq

ABSTRACT

Introduction: MRI images suffer from malformations while poorly maintained or poor storage. These defects can lead to the disappearance of certain details from the images that are most important in diagnosis. A proper filter for noise removal is very important. Median filter is used for filtering for filtering for filtering and missing pixel value prediction. In this work, decreasing the filtering area by detecting the noise location is considered. The filter stage is applied only to the projected area which is considered noise damaged. The experimental results in this work show the filter's advantage in smoothing texture and preservation of detail while processing noise removal. **Methods:** : The novel filter structure suggests predicting of the lost portions of the image and suggest a proper restoration in these portions. The filter algorithm depends on the visual function of the human eye. The human visual system for noise detection is simulated by using Beta distribution supported by Monte Carlo estimation. The predictive processing method depends on the testing of local image samples due to its Beta distribution. The number of problem pixels will be substituted for the estimated value using a nonlinear filter. **Results:** Predictability analysis improved the nonlinear filter results compared by using traditional nonlinear filters alone. **Conclusion:** Test results show filter progress in the subjective and objective quality. A proposed filter structure is improved the using of the traditional filters. PSNR is used for objective quality measure and improving the output images quality can be detected subjectively.

Keywords: Medical Image Processing, Monte Carlo Simulation, MRI , Beta distribution

Corresponding Author:
Jamal Kamil Alrudaini, Ph.D.
Email: jamal.k.eng@nuc.edu.iq
Tel: +964-7901333563

INTRODUCTION

Creating detailed medical organs images and human tissues is a very important task in medical testing procedures among this the Magnetic Resonance Imaging (MRI). MRI scans have a radio waves provide a strong magnetic field that use in medical image scanning. Imaging and Medical Surveillance has been aided in MRI since its inception by doctors and investigators. Advances in MRI are making a difference in medical science.

The development of magnetic resonance imaging (MRI) was the result of the continuing human need that led him to the technological advances we have reached today. With the advancement of time and the accumulation of knowledge, people began to search for other additional means to investigate and discover invisible things. Human need led to the development of X-ray imaging (x-ray), which is the first method that made it possible to look into the inside of a living human body.

However, there were several drawbacks to an X-ray: The inability to see soft tissue, in addition to rays that would cause cancer, prompted researchers to search for other additional methods that allow looking inside the human body. Magnetic resonance imaging (MRI) is an advanced methods allowing to look into the inside of the living human body, and one of the advantages of this method is that it does not use rays that can cause harm (as happens in x-ray imaging), so it can be used safely in examining women. Pregnant women, too(1). The Continuing increasing demands for MRI scans within health systems and institutions have led to concerns about noise efficacy and diagnostic clarity.

The magnetic resonance imaging method (MRI) is one of the most useful methods of radiography. MRI does not cause any kind of pain when a person performs it. It also works to diagnose all diseases very accurately, such as the presence of any disease or problem in the liver or heart. It is also a very safe diagnostic method, as it is safe for children and pregnant women. MRI is also known to be free of ionizing radiation. In addition to that, it works on diagnosing many diseases, including heart disease, cancer, and deformities of bones, joints, muscles, and blood vessels.

The principal sources of the noise in magnetic resonance imaging can be subdivided into two types. The first type is due to the hardware such as the effect of the materials used inside the equipment its self. The other type is the physiological effects due to the body motion or radiation paths.

If a person follows the instructions for an MRI scan, he will not suffer any harm from it. There is some side effects when exposed to MRI should be considered. Magnetic resonance waves cause the human body to overheat, if it is exposed to it for a very long time. Also, mmagnetic resonance waves may also cause allergic reactions in some people. These waves also cause fever and some deformities to people who carry metal pieces with them when exposed to them. Examples of such metal parts are pacemakers, screws, abutments, and plates.

Many filters had been proposed to recover the noisy or defected images in MRI images. Among these are nonlinear filters with spatial prediction(2, 3). Nonlinear digital filters in two dimensions are tested for restoration of color image in this work(4). Nonlinear noise predictor is designed for impulsive noise detection according to Monte Carlo Simulation with respect to the Beta distribution of image data. Stability of the filter is considered in reconstruction structure(5, 6). The filter structure consisting of Monte Carlo simulation and Beta distribution phenomena has been improved for good detection of the noise location(7).The filter stage is a median filter which used for prediction of the lost data because of the impulse noise. Data comparison in the experimental results improved this novel structure

MATERIALS AND METHODS

Samples

Magnetic resonance waves are issued by a computed tomography device and are only used for medical purposes, as this device works to photograph body parts in the form of clips. These waves are depending on the magnetic properties of the body. It is also known that the human body contains millions of hydrogen ions, when exposed to magnetic resonance waves, they are transformed into a large magnet that emits many signals from the body, which leads to converting them into an image that appears on the computer(8). There are several parts of the body organs can be imaged with an MRI, including the uterus, spinal cord, breast, gallbladder, blood vessels, brain and ovaries (Figure 1).

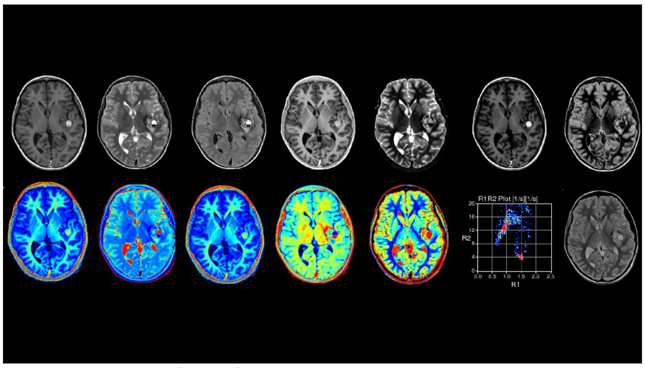

Figure 1: Samples of MRI images

For a good improvement of the filter design standard test images are used in the experimental results which are normally included in previous works for easy comparison. The test images are Lena, Peppers, Boats and Baboon. Artificial impulse noise is applied with amplitude of (0-255) in different noise percentage to check the filter output in high and low noise levels. Then the filter is applied to MRI test images for subjective quality check.

Reduction of noise becomes especially very important when the calculation of the peak signal to noise ratio (PSNR) is low in the image signal. Standard signal correction methods usually assume a uniform standard deviation obtained from the signal with noise within the image and an evaluation of a single correction parameter for the entire image. This method is very important when a big data treatment and large scale of data is used(9, 10). In medium ranges of information volume, a systematic approach is followed through a thorough study of all database information based on the assumption of a heterogeneous noise distribution of the general structure and evaluation of correction factors for each pixel separately. More detailed investigations are required (11).

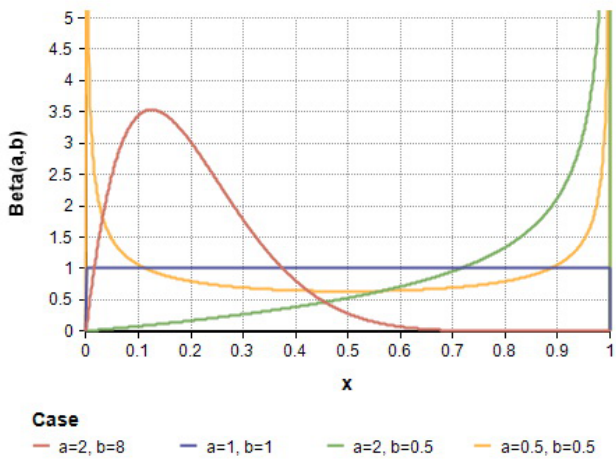

Figure 2: Probability distribution of Beta according to the (α and β parameters variation for samples (x).

Visual Perception Tracking Simulation

Visual perception is represented by Gamma and Beta distribution. Variability of beta has a very flexible representation method used across a fixed range. Uncertainty in probability occurrence of events is determined by beta distribution in this work. Undesirable data prediction is explained according to the data nature and its behaviour which be assumed as Beta distributed. Data distribution shows a various shape variations due to alpha α and beta β parameters (Figure 2). The mathematical method of beta calculation and distribution are as follows(12):

Beta function is:

$$B(\alpha,\beta)=\int_0^1 x^{\alpha-1}(1-x)^{\beta-1}dx \quad \alpha,\beta>0$$

Beta function evaluation is depend on Gamma function Γ as:

$$B(\alpha,\beta)=\frac{\Gamma(\alpha)\Gamma(\beta)}{\Gamma(\alpha+\beta)}$$

Probability density function (PDF) for continuous random variable x has:

$$f(x)=\frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)}x^{\alpha-1}(1-x)^{\beta-1}, \alpha,\beta>0, 0\le x\le 1;\ x\sim Beta(\alpha,\beta)$$

$\mu=\frac{\alpha}{\alpha+\beta}$ is the mean of beta distribution(13).

$\sigma^2=\frac{\alpha\beta}{(\alpha+\beta)^2(\alpha+\beta+1)}$ is the variance of Beta distribution.

The above parameters μ and σ^2 are used to calculate α and β parameters as follow(14):

$$\alpha=\frac{\mu^2-\mu^3-\sigma^2\mu}{\sigma^2} \quad ; \quad \beta=\frac{\mu^3-2\mu^2+\sigma^2\mu+\mu-\sigma^2}{\sigma^2}$$

Alpha (α) and beta (β) are considered as shape construction parameters.

Beta distribution is normalized in this work to fit Mont Carlo simulation. The image data (x) is bounded to the minimum (Mn) and the maximum (Mx) values of the data. Beta distribution shape is controlled by the most like hood value (Ml) obtained from image data (Figure 3). The mean and variance shown in the above equation should be recalculated to follow Monte Carlo simulation. In this work a novel Monte Carlo simulation is suggested to set the mean and variance based on Beta shape topology as follows(15):

M l = mean(x)

$$\text{Beta mean} = \frac{Mn(x)+(2.9*Ml(x))+Mx(x)}{4.9}$$

$$\text{Beta variance} = \frac{Mx(x)-Ml(x)}{4.64}$$

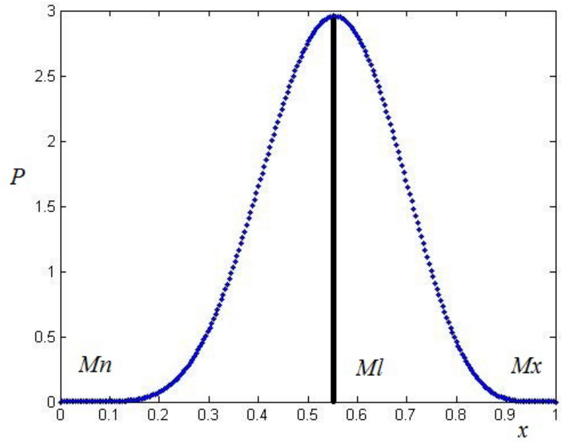

Figure 3: Normalization by Monte Carlo simulation for Beta probability distribution (p).

RESULTS

To test the efficiency of the proposed filter, a set of standard 255 x 255 images were used. The images used in the test were artificially exposed in various degrees. Lena, Peppers, Boats, Baboon and two other MRI test images are used in the tests. The standard images are used to easy verifying and comparing with other papers and previous works. The noise that is shed on the images is of the impulse noise type, with varying proportions, distributed on the image randomly and with a probability factor of *p*. The experimental procedure shows the results when p = 5% and 10% of the image body.

The images were processed and the noise was removed using classic filters. The suggested filter containing a predictive structure was highlighted on the images and the results were calculated in both cases for the purpose of comparison.

The efficiency of the filters was measured by calculating the objective quality factor (PSNR) of the images used. A significant outperformance of the proposed candidate using the specular prediction coefficient (PF) over the performance of the classic median-type (MF) filter was observed in both cases of subjective and objective quality measures.

The improvement process is very noticeable through the increase in the PSNR value [dB] when using the proposed filter in different cases of pulse noise ratios. Table 1 and 2 show the results when 5% and 10% of the pulse noise are shed on the test images.

Figures 4 illustrates the preservation of the fine detail and texture involved in applying the proposed structure. Figure 5 shows a removing operation of noise from MRI image and prediction of the lost parts of the pixels by using PF filter compared with MF filter.

Table I : Rejection of 5% Impulse Noise by using the proposed filter (PF) and compared with classical Median Filter (MF).

Input Image	Filter output in PSNR [dB]		
	Distorted Image	MF Filter	PF Filter
Baboon	12.55	15.56	24.89
Boats	12.41	21.55	29.59
Lena	12.39	23.43	31.52
Peppers	12.21	25.15	32.28

Table II: Rejection of 10% Impulse Noise by using the proposed filter (PF) and compared with classical Median Filter (MF).

Input Image	Filter output in PSNR [dB]		
	Distorted Image	MF Filter	PF Filter
Baboon	10.56	15.38	21.84
Boats	10.40	20.91	26.51
Lena	10.44	22.78	28.31
Peppers	10.23	24.30	28.82

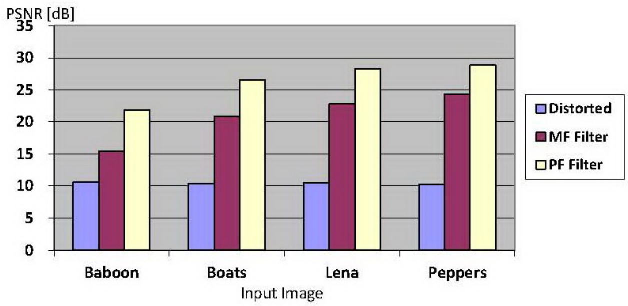

Figure 4: Impulse Noise Rejection Graph comparison using proposed filter (PF) compared with Median Filter (MF).

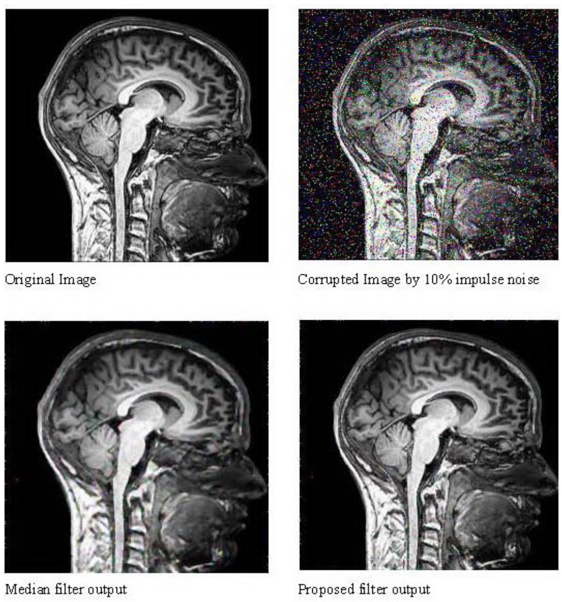

Figure 5: Rejection of 10% impulse noise by using proposed filter (PF) compared with median filter (MF).

DISCUSSION

Most previous work using the filter to be applied to the whole image contains (16). These kinds of filters can remove the noise as well as some fine details of the not corrupted parts of the images. Some works tried to avoid filtering of the not corrupted parts by using switching structures. These works depend on local area around the corrupted pixels of the test images (17). In real applications may these filters are suffering from different image situation and negatively improving the filters output. In this work, a novel way of noise detection by eye simulation since the eye is easily detecting the noise. The nonlinear filters is applied only where the noisy pixel is detected and leaving the other part of the image without filtering.

A new algorithm is developed in this work for the calculation of the spatially distributed noise taking into account the human eye tracking system. The tracking system is simulated by Beta distribution and Monte Carlo simulation. Proper structure is designed using this algorithm for noise removal while maintaining the important details of the image unchanged. The test results are improved objectively by measuring the PSNR and subjectively by presenting the output images before and after filtering compared with traditional filters.

CONCLUSION

The defected places of the image appear as impulse noise which annoys the human vision. Normally a nonlinear filter is applied to the image to remove the impulse noise. The nonlinear filters usually applied to the whole image and it may affect the non-interrupted places by noise. Since the noisy places are easy detected by eyes, an eye detection procedure is designed for noise detection. A switching structure is applied to filter only the noisy portions of the image and keeping the other potions unchanged. In this case, removing the noise while and keeping the other important details is ensured. The experimental results have been proving this structure compared with the traditional nonlinear filter results.

ACKNOWLEDEMENT

This work is supported by Al-Nisour University College located in Baghdad, Iraq, according to its annual projects schedule.

REFERENCES

1. Brown RW, Cheng Y-CN, Haacke EM, Thompson MR, Venkatesan R. Magnetic resonance imaging: physical principles and sequence design: John Wiley & Sons; 2014.
2. A Khmag, AR Ramli, SAR Al-Haddad, SJ Hashim, ZM Noh, AAM Najih, Design of natural image

denoising filter based on second- generation wavelet transformation and principle component analysis, Journal of medical imaging and health informatics. 2016; 5(6)1261-1266.
3. Guangyong Chen, Fengyuan Zhu, P. Heng, An efficient statistical method for image noise level estimation. In: Proceedings of the IEEE International Conference on Computer Vision, 2015.
4. A. Khmag, S. Al-Haddad, R. Ramlee, N. Kamarudin, F. Malalla, Natural image noise removal using nonlocal means and hidden Markov models in transform domain, Vis Comput, 2018; 34(12) 1661-1675.
5. Bladt M, Nielsen BF. Matrix-exponential distributions in applied probability: Springer; 2017.
6. Smith JO. Introduction to digital filters: with audio applications: Julius Smith; 2007.
7. Owen AB. Monte Carlo theory, methods and examples. 2013.
8. Dale BM, Brown MA, Semelka RC. MRI: basic principles and applications. 2015.
9. Kalid N, Zaidan A, Zaidan B, Salman OH, Hashim M, Muzammil H. Based real time remote health monitoring systems: A review on patients prioritization and related" big data" using body sensors information and communication technology. Journal of medical systems. 2018;42(2):30.
10. Kalid N, Zaidan A, Zaidan B, Salman OH, Hashim M, Albahri O, et al. Based on real time remote health monitoring systems: a new approach for prioritization "large scales data" patients with chronic heart diseases using body sensors and communication technology. Journal of medical systems. 2018;42(4):1-37.
11. Salman OH, Zaidan A, Zaidan B, Naserkalid, Hashim M. Novel methodology for triage and prioritizing using "big data" patients with chronic heart diseases through telemedicine environmental. International Journal of Information Technology & Decision Making. 2017;16(05):1211-45.
12. Al-Rudaini J, Ruhaima A. Impulse Noise Prediction Filter Using Monte Carlo Simulation. Int J of Recent Scientific Research. 2019;10(08):34511-3.
13. Ruhaima A, Al-Rudaini JK, Hayder D. New Design of Noise Prediction in Digital Color Images. International Journal of Research in Computer Applications and Robotics. 2019;7(7):1-6.
14. Abbas JK, Ruhaima AA, Alanssari A, Pyliavskyi V. Perceptual Method for MRI Medical Images Improvement in Presence of Impulse Noise. Telecommunications and Radio Engineering. 2020;79(1).
15. Hayder DM, Al-Rudaini JK, Ruhaima AA. Mathematical Geometry Based Filters. International Journal of Reserch in Computer Applications and Robotics .2020;8(1):6-11.
16. W. K. Ling, Nonlinear Digital Filters: Analysis and Applications, Academic Press; 1st edition, 2007.
17. Elena Solovyeva, Nonlinear models of digital filters and their application fields, XV International Symposium Problems of Redundancy in Information and Control Systems, 2016.