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Medical Image Enhancement to Extract Brain Tumors from CT and MRI images

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Abstract

Always MRI and CT Medical images are noisy so that preprocessing is necessary for enhance these images to assist clinicians and make accurate diagnosis. Firstly, in the proposed method uses two denoising filters (Median and Slantlet) are applied to images in parallel and the best enhanced image gained from both filters is voted by use PSNR and MSE as image quality measurements. Next, extraction of brain tumor from cleaned images is done by segmentation method based on k-mean. The result shows that the proposed method is giving an optimal solution due to denoising method which is based on multiple filter types to obtain best clear images and that is leads to make the extraction of tumor more precision best.

Keywords: Image Enhancing, Preprocessing, Segmentation, Median filter, Slantlet Filter, K-mean.

تحسين الصورة الطبية لاستخراج أورام الدماغ من الاشعة المقطعية والتصوير بالرنين المغناطيسي

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الخلاصة

تكون الصور الطبية بالرنين المغناطيسي والتصوير المقطعي (CT) دائمًا صاخبة بحيث تكون المعالجة المسبقة ضرورية لتعزيز هذه الصور لمساعدة الأطباء وإجراء تشخيص دقيق. أولاً ، في الطريقة المقترحة ، يتم استخدام مرشحي تقليل الضوضاء (Median و Slantlet) على الصور بالتوازي ويتم التصويت على أفضل صورة محسنة تم الحصول عليها من كلا المرشحات باستخدام PSNR و MSE كقياسات لجودة الصورة. بعد ذلك ، يتم استخراج ورم في المخ من الصور التي تم تنظيفها عن طريق طريقة تجزئة على أساس k–mean. توضح النتيجة أن الطريقة المقترحة توفر حلاً مثالياً بسبب طريقة تقليل الضوضاء التي تعتمد على أنواع متعددة من المرشحات للحصول على أفضل صور واضحة وهذا يؤدي إلى جعل استخراج الورم أكثر دقة.

1- Introduction

Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) are the most widely used techniques to provide of differentiation between brain tissues and to diagnose the brain diseases. It is to use algorithms to analyze the digital images to establish strategies that can distinguish the types and Medical image processing [1, 2]. Medical image is always affected by noise, poor image contrast, and the presence of unwanted components. In recent years, the demand for resolution enhancement of pictorial data in medical images has been increased in order to assist clinicians to make an accurate

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diagnosis [3]. Different types of filters are being used to get rid of the noise and improve the quality of images.

Due to its complexity and the missing of anatomy models that completely identify the deformations, segmentation of MRI and CT Images is a rising problem [4-7]. The segmentation of anatomic structure in the brain plays a crucial role in Nero imaging analysis. Successful algorithms can assist neurosurgeons, physicians and researchers to diagnose the function of the brain in both disease and health persons [8]. Jyothsna et. al. (2015) concluded that it is not so difficult to segment easily the various distribution intensity regions [9]. Sujan et. al. (2016) wrote on the methods of morphology to segment the tumor [10].

Madhi and Mohammed, 2018, proposed a program to detect and allocate of brain tumors according to YCbCr segmentation, the results reflected more than 99% better detection rate with speedy processing [11].

This paper proposed the medical image enhancement method consisting of two stages, smoothing and segmentation. Smoothing operation is to clean up any unwanted noise from images. The smoothing stage is represented by parallel structure of multiple filters (here used only median and slantlet filters).The MRI and CT images are feed into parallel filter lines and the output is the best clean image selected from resulting images based on the measurements of PSNR and MSE. The segmentation operation is used to extract the tumor from images. The segmentation stage is used k-mean method.

2- THEORETICAL BACKGROUND

2-1 Median Filter

The Median Filter is a non-linear digital filtering technique, often used to remove noise from an image or signal. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise, also has applications in signal processing [12, 13].

$$\mathbf{Y[m,n]} = \mathbf{Median}\,\{\mathbf{X[i,j]}, (\mathbf{i,j}) \in \boldsymbol{W} \ldots (\mathbf{1})$$

Where:

W is centered on location [m, n] in the image and identified by the user.

2-2 Slantlet filter

Slantlet transform (ST) is found based on an improved version of the usual discrete wavelet transform filter bank. Some features of ST are [12]:

- ST is multi-resolution and better time localization.
- ST better compression as compared to DCT
- Filter bank of ST is orthogonal

The Slantlet transform (ST) may be applied to get good properties like orthogonally and of shorter supports, with moments of two zero. [14]

2-3 Segmentation

Image segmentation is to change the image representation into easier and better meaningful to analyze. These regions have two main properties:

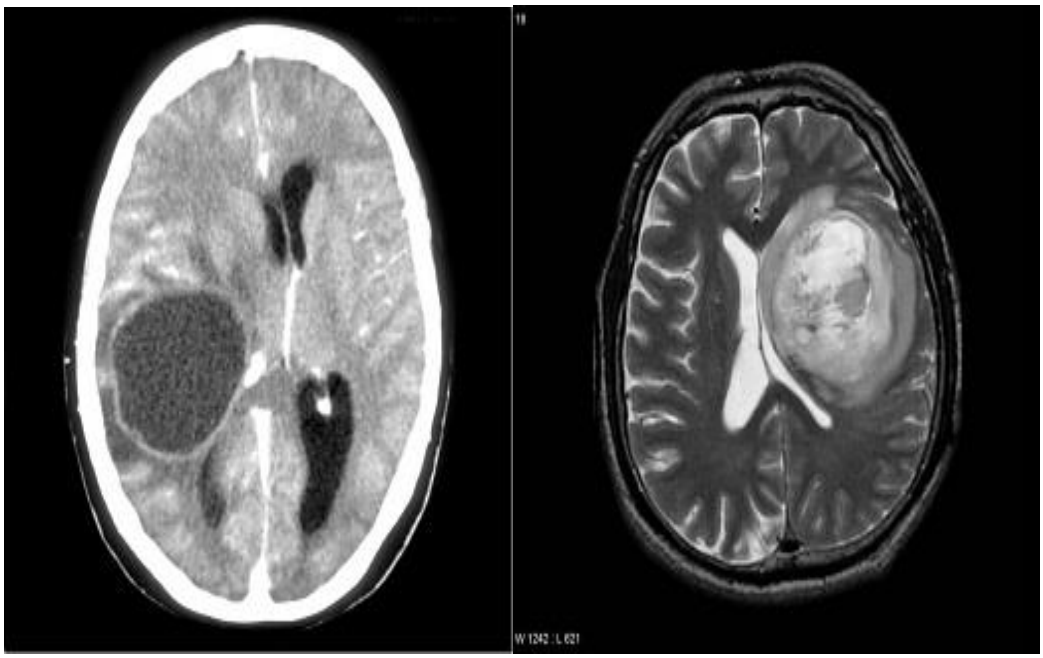
1.) Heterogeneity between the regions.

2.) Homogeneity within a region

The partitioning method that depends on K-means clustering is image segmentation. Any cluster is very close to each other and far from objects. K-means computes cluster centroids variously for any metric distance to minimize the sum consequent to the specify measure [15].

3- MATERIALS AND METHODS

Twenty Different MRI and CT Images are used for the experiments with dimensions of (256×256) were taken from a free source of medical images for educational purposes [16]. As well as some Images were taken from Al Kindy College of Medicine, University of Baghdad. (Figure-1)



(a) CT scan image **(b) MRI image**

Figure 1- Representative of the original images for CT scan (a) and MRI (b) [11-16]

The propose Matlab computer algorithm accepts the CT and MRI images and then filtered preprocess image with Median and plantlet then compare between Filters' results by using Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) as follow:

3-1 The Proposed Algorithm

The proposed algorithm is applied using MATLAB R2013a. The algorithm is started loading medical images for brain tumor, the second step is to involve preprocessing, with applying median and the Slantlet filters, then comparing between them by using MSE and PSNR. Finally, segmentation the tumor from the brain is obtained, (Figure-2).

The algorithm of proposed system

Input:	brain tumor of CT and MRI
Output:	SEGMENTED IMAGE
Step1	Load the input image
Step2	Preprocess the image with Median and Slantlet filters. And compare between their results using MSE and PSNR
Step 3	Segment the image with adaptive K-mean clustering
Step 4	Segmented tumor

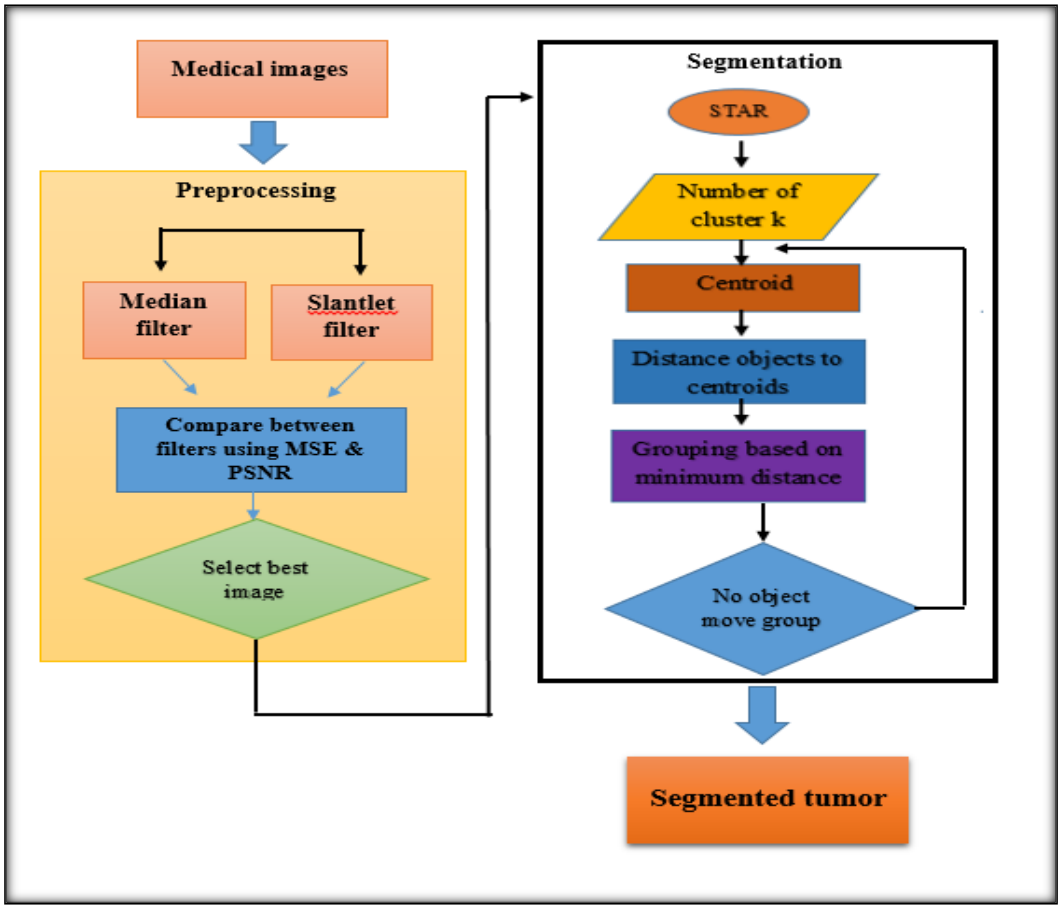


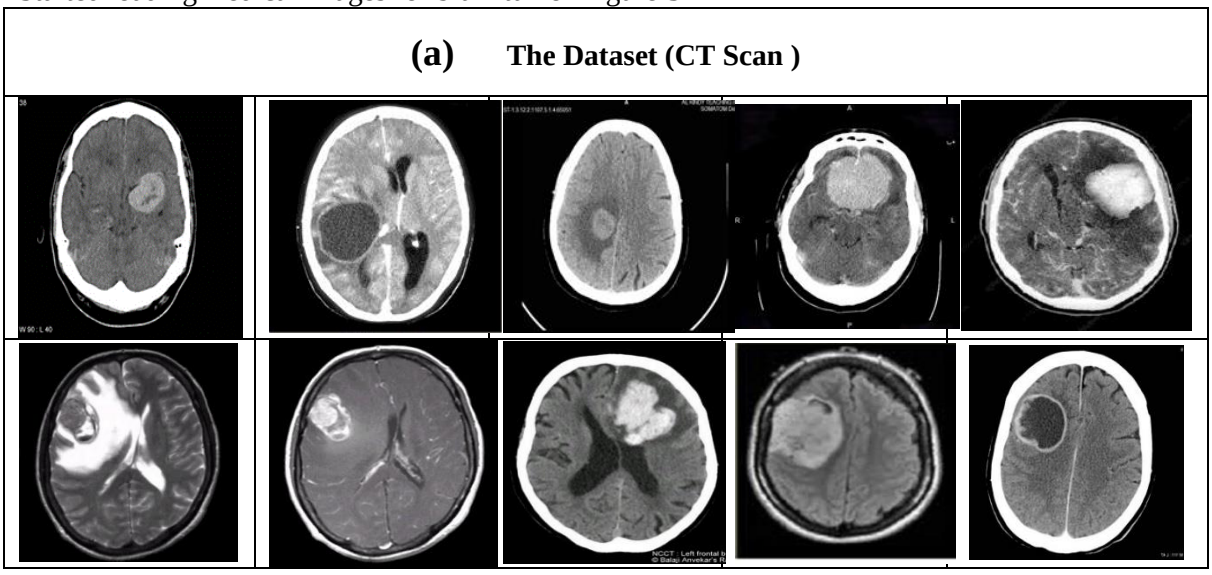
Figure 2-The proposed system segmentation framework.

4- RESULT AND DISCUSSION

The input data of the proposed system is ten CT scan and ten MR original images, the algorithm is started loading medical images for brain tumor. The enhancement and denoising were done using Median and the Slantlet filters (Figure-3). Comparison between these images was made by applying MSE and PSNR to detect the efficient parameters (Tables 1 and 2). Then the identifying of the tumor inside the brain image is found or neglected the image:

4-1 The Dataset of medical images

Started loading medical images for brain tumor Figure-3



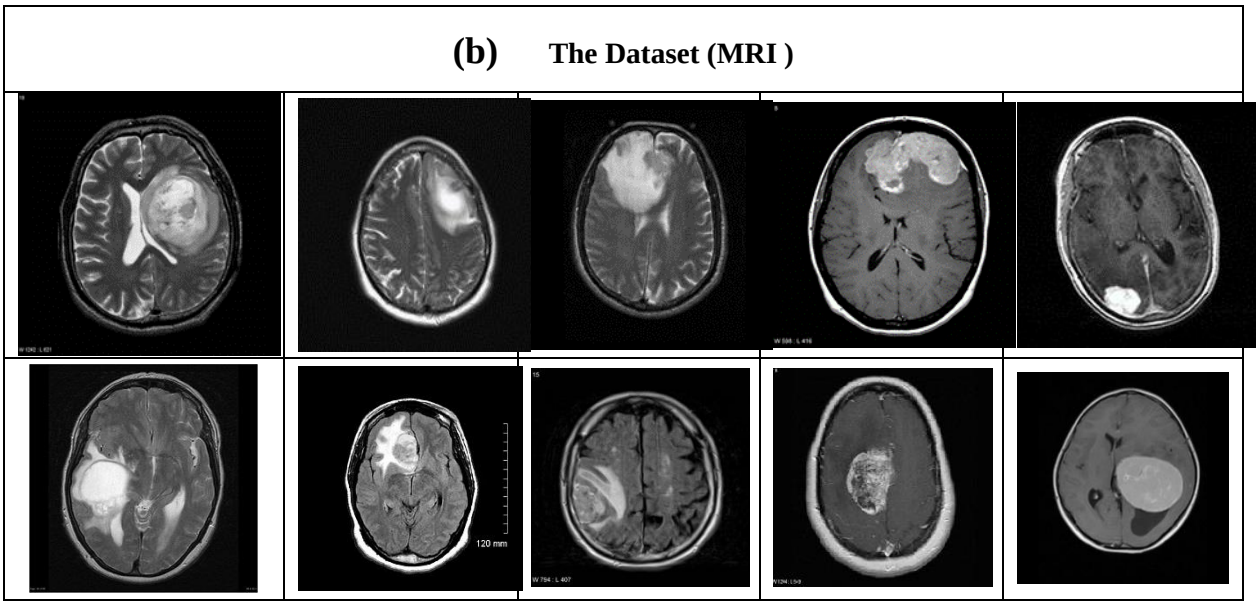
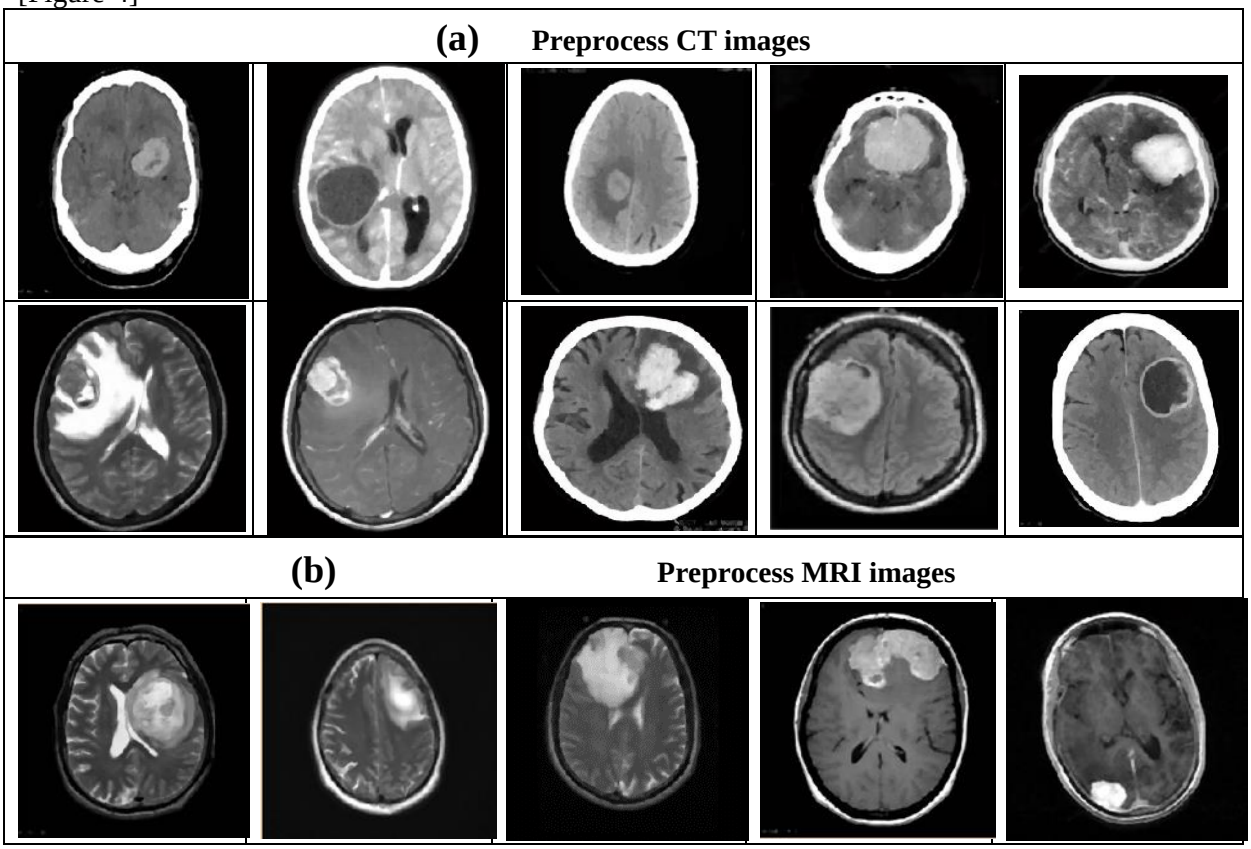


Figure 3-Representative of the used original images (a) CT scan and (b) MRI

4-2 Preprocess:

Pre-Processing involves conversion to greyscale image, noise removal and image reconstruction [17, 18]. The used Median filter is the very widely used for noise elimination and it is a 'non-linear' filtering technique [18, 19]. Moreover, applying the Slantlet transform (ST) that has been recently proposed as an improvement over the classical DWT, can provide better time localization and can be implemented employing filters of shorter supports with maintaining the desirable characteristics [20]. [Figure-4]



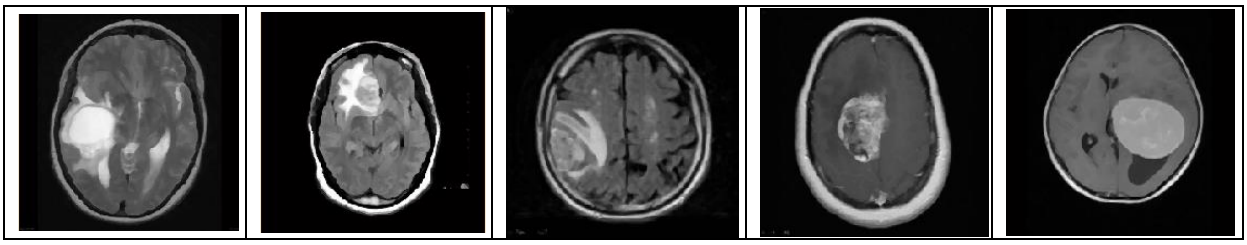


Figure 4-Representative of the preprocess images for CT scan (a) and MRI (b)

The image quality assessment based on pixel difference method has been done by calculating MSE and PSNR value. They are the error metrics used to compare images. (Tables- 1 and 2)
Mean Square Error (MSE): It is the cumulative squared error between the original image and the noise added image. The lower the level of MSE, lower the error. MSE is defined as follows: [17]

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{i=0}^{n-1}[I(i,j) - K(i,j)]^2 \dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Where:
m is the image height.
n is the image width.
I (i, j) is original image.
K (i, j) is the reconstructed image

Peak Signal to Noise Ratio: (PSNR) IS mathematical measure for image quality assessment between original image and noise added image. It shows the measure of peak error.

$$PSNR = 10\ \log_{10}\left(\frac{MAX^2}{MSE}\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

Where MAX is the maximum possible pixel value of the image

Table 1-MSE & PSNR values for Median & Slantle filters for CT images

No. of images	Filters	MSE	PSNR	The Best is
1	Median filter	15.7342	36.1964	Slantlet
	Slantlet filter	0.9942	48.1900	
2	Median filter	15.9538	36.2353	Slantlet
	Slantlet filter	0.0795	59.1621	
3	Median filter	15.8577	36.1623	Slantlet
	Slantlet filter	0.6978	49.7278	
4	Median filter	16.3853	36.0203	Slantlet
	Slantlet filter	1.0820	47.8224	
5	Median filter	16.2256	36.0628	Slantlet
	Slantlet filter	0.2084	54.9751	
6	Median filter	8.9251	38.6587	Slantlet
	Slantlet filter	0.2236	45.6691	
7	Median filter	7.2122	39.5841	Slantlet
	Slantlet filter	0.0923	58.5106	
8	Median filter	12.7299	37.1165	Slantlet

	Slantlet filter	**0.4722**	**51.4234**	
9	**Median filter**	**8.3107**	**38.9684**	**Slantlet**
	Slantlet filter	**0.3568**	**52.6404**	
10	**Median filter**	**14.5685**	**36.5307**	**Slantlet**
	Slantlet filter	**0.5453**	**50.7988**	

Table 2-MSE & PSNR values for median & slantlet filters for MRI images

No. of images	Filters	MSE	PSNR	The Best is
1	**Median filter**	**9.2681**	**38.4949**	**Slantlet**
	Slantlet filter	**0.028**	**63.6861**	
2	**Median filter**	**15.678**	**36.2119**	**Slantlet**
	Slantlet filter	**0.2138**	**54.8649**	
3	**Median filter**	**11.1538**	**37.6906**	**Slantlet**
	Slantlet filter	**0.0789**	**59.1974**	
4	**Median filter**	**9.4946**	**38.39**	**Slantlet**
	Slantlet filter	**0.6713**	**49.8959**	
5	**Median filter**	**12.7728**	**37.102**	**Slantlet**
	Slantlet filter	**0.4025**	**52.1175**	
6	**Median filter**	**20.4879**	**35.0498**	**Slantlet**
	Slantlet filter	**1.5579**	**46.2394**	
7	**Median filter**	**17.5969**	**35.7104**	**Slantlet**
	Slantlet filter	**0.9436**	**48.4168**	
8	**Median filter**	**11.3614**	**37.6105**	**Slantlet**
	Slantlet filter	**0.3572**	**52.6360**	
9	**Median filter**	**7.5530**	**39.3836**	**Slantlet**
	Slantlet filter	**0.2677**	**53.8878**	
10	**Median filter**	**6.1856**	**40.2510**	**Slantlet**
	Slantlet filter	**0.3107**	**53.0241**	

It is well known that the Mean Square Error (MSE) is the cumulative squared error between the original image and the noise added image. The lower of the level of MSE, lower the error. While the Peak Signal to Noise Ratio (PSNR) is mathematical measure for image quality assessment between original image and noise added image to show the measure of peak error. Consequently and according to eq (3), to evaluate PSNR firstly MSE value should be calculated. Kumar, et al, 2018, [21] concluded that the image quality assessment may be based on pixel difference method by calculating PSNR and MSE value to compare images.

The results in Tables-(1, 2) show low values for MSE and high values for PSNR for both median and Slantlet filters in general but they are much less by using Slantlet filter.

To determine the accuracy for the comparison of the results was made between the averages and the standard deviation of obtained values, (Table-3).
The results showed that Slantlet filter for CT scan images gives fewer values of standard deviation for both MSE that is 0.3565, which is less standard deviation values than that of Median filter for both MSE that is 3.659. The same is true for the vales of the std. deviation for MRI images for MSE that show 0.4648 which is less values of std. deviation for Slantlet filter then that of Median filter that indicates 4.5424. Therefore, the Slantlet filter is the best filter, such finding is in accordance with Patil and Yardi, 2012 [20] conclusion that the noise gets reduced better by Slantlet filtering rather than the median filter.

Table 3-accuracy between MSE & PSNR values for Median & Slantle filters for CT and MRI images

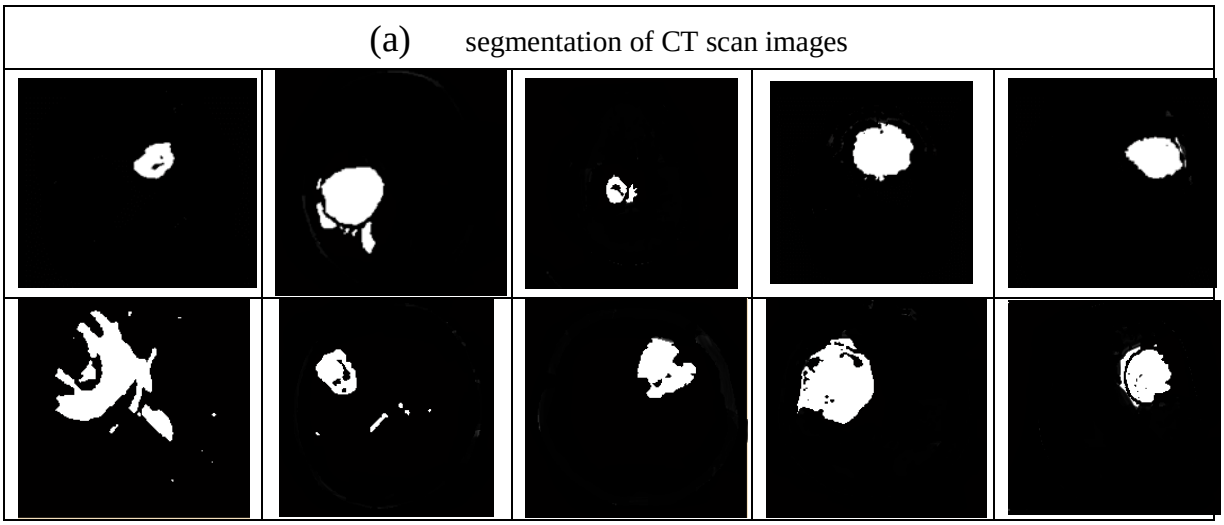
	CT Scan images		**MRI images**	
Median filter				
	MSE	PSNR	MSE	PSNT
Average	13.1903	37.1536	12.1552	37.5895
Std. deviation	3.6590	1.3773	4.5424	1.6293
Slantlet filter				
Average	0.4752	51.8919	0.4832	53.3966
Std. deviation	0.3565	4.4946	0.4648	5.0832

3 Segmentation brain tumors

After the preprocessing propose system will use K-mean cluster for segmentation for both CT and MRI images (Figure-5). Most image processing techniques use K-Means algorithm for image segmentation. It is very useful for large images with poor contrast. But it has been realized that K-Means is susceptible to the selection of samples and establishments of fuzzy sets [15-17].

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^{(j)} - c_j \right\|^2 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4)$$

J: objective function
K: number of c
N: number of cases
C_j: centroid of cluster 'j



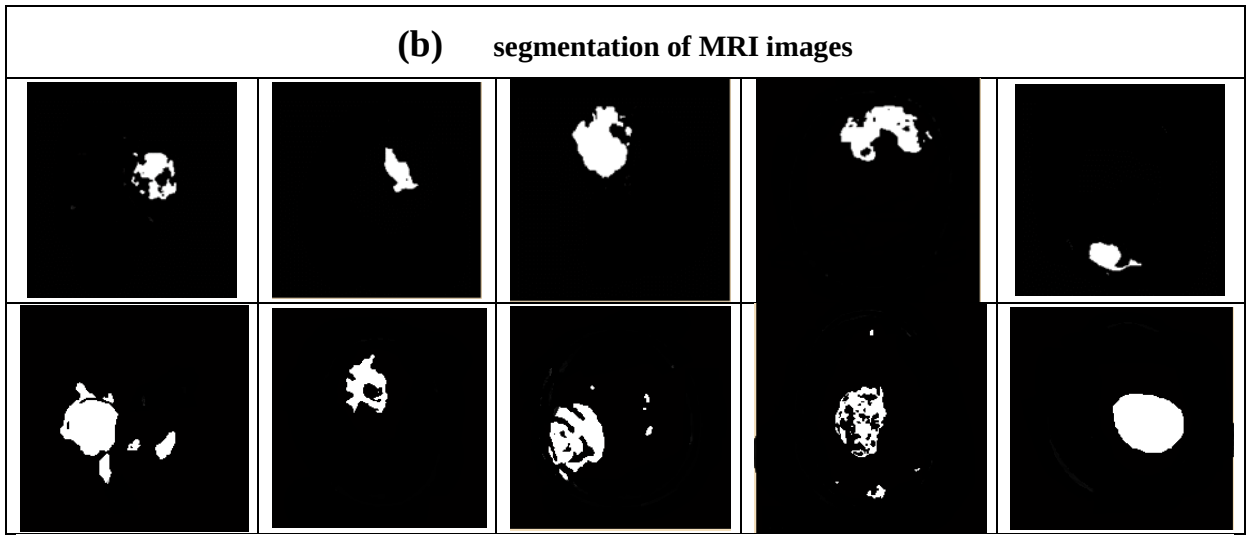


Figure 5-Representative of the Segmentation brain tumors for CT scan (a) and MRI (b)

The results for CT and MRI images segmentation show that the MRI segmentation relatively more clear than CT segmentation but both of them are useful to help the specialist and medical doctors to identify the brain tumor much more easier (Table-5). Such findings are in agreement with the results of Min and Kyu, 2017, [13] in their enhancement method that proposed for a combination of k-means clustering and tumor segmentation morphology [13].

CONCLUSION

The CT and MRI brain images are denoising and resolution by enhancement in order to improve the quality of an image, the enhance gets reduced better slantlet filters by applying PSNR and MSE.
The image denoising and resolution enhancement methods are vital to improve the qualitative performance of an image, focus on brain tumor image segmentation. Both of CT and MRI brain images segmentation is useful to help the specialist and medical doctors to identify to brain tumor much easier.

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