Image Denoising using Modified Fuzzy C means and Fractional Convolutional Method

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***Abstract* -** Noises in the image leads to pixels degradation and the quality of the image will be reduced. Removal of noises (Gaussian, Poisson and Speckle) from the image leads to develop the better image. Lowering of radiation dose leads to deterioration of quality of the image. Hence we proposed the new modified fuzzy C means algorithm and fractional convolutional method for image denoising. Modified fuzzy filter is applied at the post processing step to remove the noise in the filtered image. Parameters are carefully formulated and evaluated. Experimental results show the better improvement in image denoising.

***Index Terms* – Modified fuzzy C means and Fractional Convolutional, Peak Signal to Noise Ratio (PSNR), Root Means Square Error (RMSE)**

1. INTRODUCTION

Computer Tomography (CT) is widely used in diagnostic, industrial and other applications. One of the challenging tasks in image processing is noise removal. Noises are affecting the visual appearance of the images. Poor generation of transmission in electronic circuits leads to generation of gaussian noise. Poisson noise originates due to movement of packets (Photons). Speckle noise is generated by backscattered signals which affect the image interpretation. Noises will be introduced in the image during transmission or acquisition or hardware issues. General methods of reducing the radiation dose are reducing tube voltage, tube current and scanning time. Quantification of the noise will be determined by the corrupted pixel in the image. If the pixel range becomes high then the quality of image increases and it reduces the noise. The image quality has been represented by distance between the pixels. Over the past decades, many algorithms and techniques were proposed: Fractional Integral filtering [1] - [3], KSVD[4], BM3D[5][6], Convolutional Neural Network (CNN)[7], etc. Various noise detectors are also introduced for the removal of noise ie., DWM[8], RILD-EPR[9], ROR-NLM[10]. Existing algorithms are having less PSNR value, high RMSE and during filtering process additional pixels will be neglected i.e., loss of original information. To overcome these problems, a modified algorithm is proposed. This proposed algorithm shows improved Peak Signal to Noise Ratio (PSNR) and reduced Root Means Square Error (RMSE).

2. ALGORITHM PROPOSED

The proposed algorithm for image denoising is given in the following steps.

After the preprocessing and histogram equalization,

i) Addition of artificial noise with the original image

ii) Application of fuzzy c means and fractional convolutional method

iii) Obtain mask coefficients

iv)Calculation of weighted sum of coefficients

v) Approximation of pixel derivative

vi) Filtering through modified fuzzy c means filter.

vii) Calculation of PSNR and RMSE.

In addition to the above algorithm, a modified fuzzy filter is applied to remove the gaussian noise. Some of the existing filters are mean filter, wiener filter, geometric filter, harmonic filter, etc. The original information will be lost when converting RGB to grayscale image. But this modified filter performs its function on both color and grayscale images.

$$F = \begin{pmatrix} 1, \quad if\ fp = 0\ or\ 255 \\ \exp\left(-\frac{fp - \text{fmax}}{2X8X\sigma}\right)^2, \quad otherwise \end{pmatrix}$$

The membership value is 1 if the intensity is either 0 or 255, otherwise the value can be calculated by the function $\exp\left(-\frac{fp-\text{fmax}}{2X8X\sigma}\right)^2$.

Initially gaussian noise is introduced with zero mean and standard deviation of 0.001 and it is reduced to 0.0001 during the process and the speckle noise with variance = 0.04 is added.

A group of 9 CT images with 512 X 512 pixels with bit depth 8 is considered. All the images are individually passed through the algorithm and the parameters are measured.

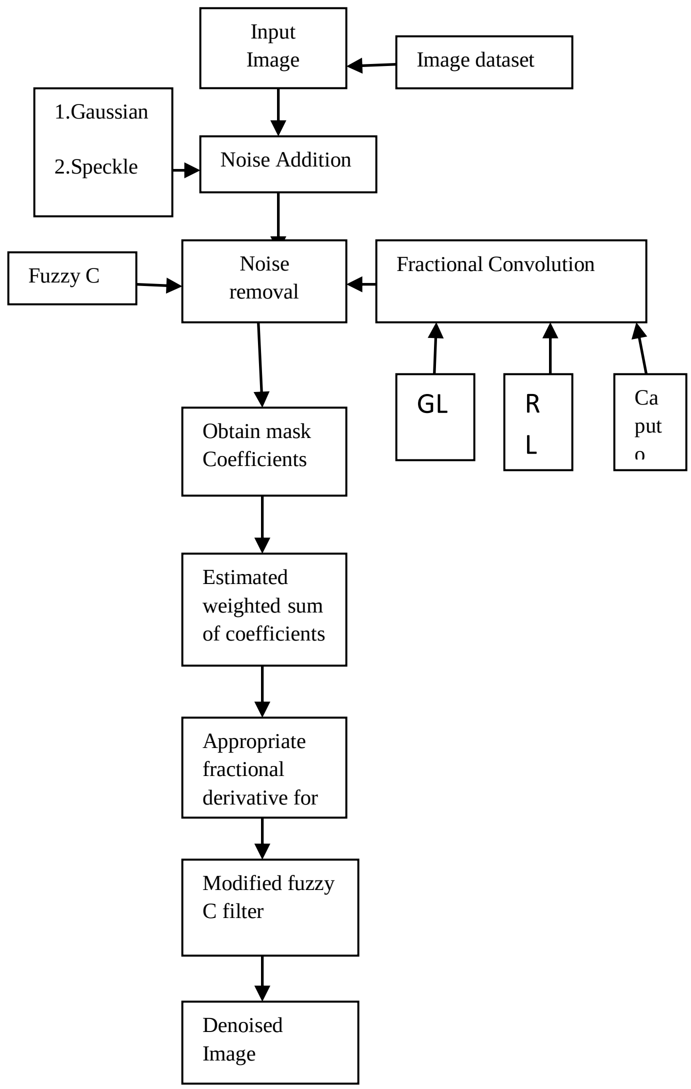

Fig.1 Flowchart of the proposed algorithm

A. Fuzzy C-Means

The Fuzzy C- means (FCM) is also known as fuzzy ISODATA.

Step 1: Initialize the matrix U with the values between 0 and 1

$$\sum_{i=1}^{c} u_{ij} = 1, \forall j = 1, \ldots\ldots n$$

Step 2: Calculate fuzzy c cluster centers c_i, i=1,.....c

$$C_i = \frac{\sum_{j=1}^{n} u_{ij}^m x_j}{\sum_{j=1}^{n} u_{ij}^m}$$

Step 3: Calculate the cost function using the following equation

$$J(U,C) = \sum_{i=1}^{c} \sum_{j}^{n} u_{ij}^m d_{ij}^2$$

Step 4: Compute a new U function

$$u_{ij} = \frac{1}{\sum_{k=1}^{c} \left(\frac{d_{ij}}{\mathrm{kj}}\right)^{2(m-1)}}$$

Considering the position of the centre of the groups, it is seen that all z^{th} coordinate will be havung less noise free heights.

B. Masking

i) Grumwald Letnikov (GL) Masking

Fractional calculus of GL is given by the following equation. For both v<0 and v>0,

$$a^g J_t^V = \lim_{h \to 0} \frac{1}{h^v} \sum_{m=0}^{\left[\frac{t-a}{n}\right]} [-1]^m \binom{V}{m} f(t-mh)$$

ii)Riemann – Liouville Masking

$$a^{D_b^{-v} f(t)} = \begin{cases} \frac{1}{\Gamma[n-v]} \int \frac{f(\varepsilon)}{(t-\varepsilon)^{v+1-n}} \mathrm{d}(\varepsilon), \mathrm{n}-1 < v < n \\ \frac{d^n}{dt^n} f(t), v = n \in N \end{cases}$$

iii)Caputo Masking

$$a^J b^v f(t) = \frac{1}{\Gamma(v)} \oint (t-\tau) \mathrm{f}(\tau) \mathrm{d}(\tau), -1 < v < 0$$

Caputo definition is the improved version of RL and GL definition.

Root Means Square Error (RMSE) is calculated by the following equation

$$RMSE = \sqrt{\frac{1}{N}\sum_{n=1}^{N}\left(u_n - u_{original}\right)^2}$$

Peak Signal to Noise Ratio is calculated by the following equation

$$PSNR = 10\log\frac{\max\left(u_n, u_{original}\right)^2}{\frac{1}{N}\sum_{n=1}^{N}\left(u_n - u_{original}\right)^2}$$

Structural Similarity Index (SSIM) can be calculated by

$$SSIM = \frac{\left(2\mu_x\mu_y + C_1\right)\left(2\sigma_{xy} + C_2\right)}{\left(\mu_x^2 + \mu_y^2 + C_1\right)\left(\sigma_x^2 + \sigma_y^2 + C_2\right)}$$

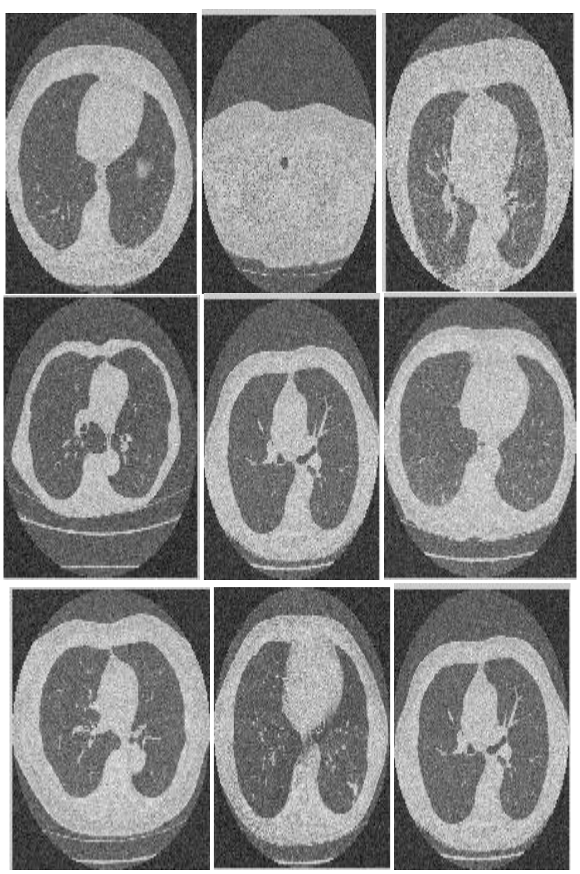

Fig. 1(a-h) – Noisy Images

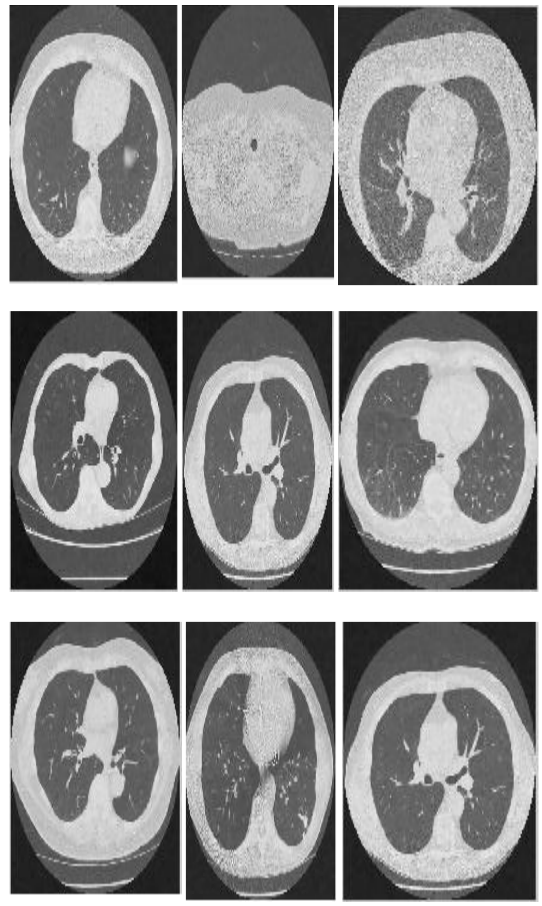

Fig.2 (a-h) – Denoised images

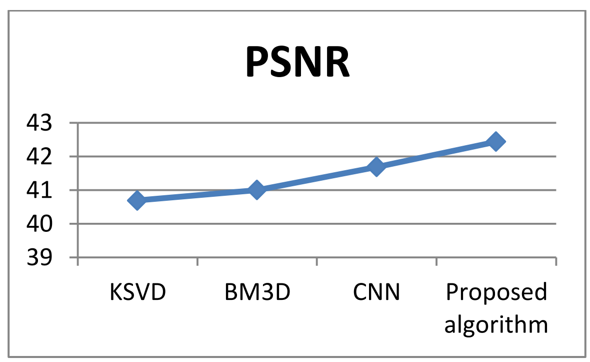

Fig.3 – Graph for comparing PSNR values

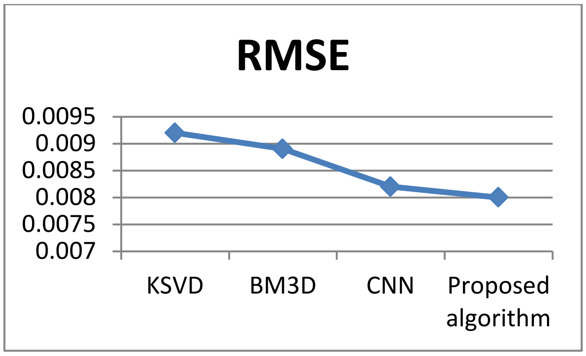

Fig.4 – Graph for comparing RMSE values

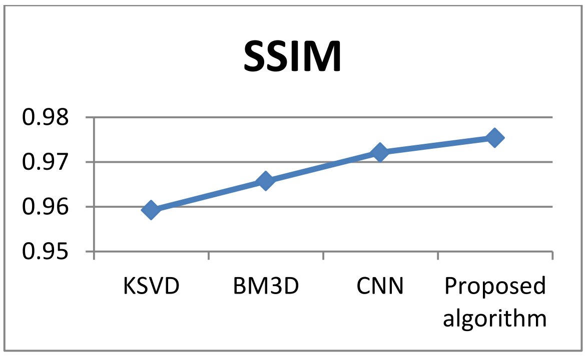

Fig.5 – Graph for comparing SSIM values

Table.1 – Comparison of various algorithms

S.No	Algorithms	PSNR	RMSE	SSIM
1	KSVD	40.6901	0.0092	0.9592
2	BM3D	40.9998	0.0089	0.9657
3	CNN	41.6843	0.0082	0.9721
4	Proposed algorithm	42.4352	0.0080	0.9754

3. CONCLUSION

In this paper, we have implemented fuzzy C means based fractional convolutional method of denoising. At the post-processing stage, a modified fuzzy C filter is applied to improve the noise removal. A set of 50 images is considered for evaluation of the algorithm. This proposed algorithm shows the improvement in Peak Signal to Noise Ratio (PSNR), Root Means Square Error (RMSE) and Structural Similarity Index (SSIM). This algorithm is implemented in MATLAB 2014.

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