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Combining an Alternating Sequential Filter (ASF) and Curvelet for Denoising Coronal MRI Images

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Abstract

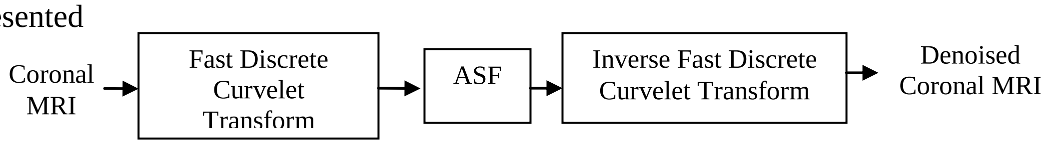
A special member of the emerging family of multiscale geometric transforms is the curvelet transform which was developed in the last few years in an attempt to overcome inherent limitations of traditional multistage representations such as wavelets. Mathematical is a set and lattice theoretic methodology for image analysis, which aims at quantitatively describing the geometrical structure of image objects. The a Coronal MRI images were denoised using both an alternating sequential filter and curvelet transform and results are presented in this paper.

Keywords: Denoising, ASF, Curvelet Transform, image

1 Introduction

Medical images are generally of low contrast and they often have a complex type of noise due to various acquisitions, the display devices and transmission storage and also because the application of different types of enhancement algorithms, quantization and reconstruction. The entire medical image contains a visual noise. A presence of noise gives an image a grainy, mottled, snowy or textured appearance. Image noise obtained from the variety of sources. Never image method is free of noise, yet noise is very much [4] [11] prevalent in certain types of image procedures than the others. A Coronal MRI is generally the noisiest. So noise is also significant in Magnetic Resonance Imaging (MRI), and ultrasound imaging, especially IVUS (Intra Vascular Ultra Sound). Therefore noise gives an image an undesirable appearance and the most significant factor is that noise can cover and reduce the visibility of certain features...

A special member of multiscale geometric transforms is the Curvelets which was developed and used in the last few years until to overcome inherent limitations of old multistage representations such as wavelets transform. The curvelet transform (CT), like the wavelet transform, is a multiscale transform, with frame elements indexed by scale and location parameters. [7] The transform was designed to detect singularities and edges along curves much more efficiently than old transforms, so using many fewer coefficients for a given accuracy of reconstruction. Therefore to represent an edge to squared error 1/N wavelets, 1/N requires and only 1/√N curvelets [6] [10]. Extrema in grayscale images are used to extract the structure in an image i.e if an image is considred as the topographic relief where grayscale correspond to the altitude of relief, the light and dark structures of the image correspond to the maxima and the minima of the relief [12][9]. Mathematical morphology (MM) is the approach of digital image processing based on the geometrical shape that's why morph means shape of objects in image using the tools of set theory. It needs two sets, one is the original image to be analyzed and the other is the structuring element called strel. There are two most morphological operations: erosion and dilation. Closing and Opening are two derived operations defined in terms of dilation and erosion. These operations are investigated. An important operation in MM is to use a morphological filter to efficiently extract the crucial structures images. The morphological filter called Filter alternate sequential (FAS) is nonlinear image technique used widely in image processing. If the operation in MM [1] [2] is composed of dilations and erosions then equal number of dilations and erosions so it constitutes a filter. This paper presents the image de-noising on different a Coronal MRI using a combine algorithm of curvelet transform than a morphological filter (CASF algorithm). The performances of the algorithm [8] are compared in terms of Peak Signal to Noise Ratio (PSNR) and the results are presented



2 CASF Algorithm:

a- Compute The Fast Curvelet Transform: Transition to Cartesian arrays i.e the transition of the basic curvelet according to the new tiling, where rotation is replaced by shearing so we use the ansatz given by:
$\Phi_{j,0,0}(\xi) = 2^{\frac{-3j}{4}} W(2^{-j}\xi_1) V\left(\frac{2^{\lfloor j/2 \rfloor}}{\xi_1}\xi_2\right)$ [13]

b- Apply ASF.

c- Compute the Fourier transform of f by means of a 2D FFT d- Compute $\hat{f}\left(S_{\theta_{j,l}}\,\xi\right)$ [100] by interpolation.

e- Compute the product $\hat{f}\left(S_{\theta_{j,l}}\,\xi\right)\phi_{j,0,0}(\xi)$ [13].

f- Apply the inverse 2D FFT in order to obtain the discrete coefficients.

3 Materials and Methods

Coronal MRI of patients was denoised using CASF algorithm. Various types of noise like the Random noise, Gaussian noise, Salt, Pepper and speckle noise were added to the image.

- A Noise factor of 25 is used for random noise.
- In case of Gaussian white noise, the mean is 0 and variance is 0.03.
- The noise density used in case of salt and pepper noise is 0.04.

The PSNR is the most commonly used as a measure of quality of reconstruction in image denoising. The PSNR for both noisy and denoised images were identified using the following formula: $MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\|I(i,j) - K(i,j)\|^2$

Mean Square Error (MSE) [3] which requires two m x n grey-scale images I and K where one of the images is considered [5] as a noisy approximation of the other is defined as:
The PSNR is defined as:

$$\mathrm{PSNR} = 10\log_{10}\left(\frac{\mathrm{MAX}_I^2}{\mathrm{MSE}}\right) = 20\log_{10}\left(\frac{\mathrm{MAX}_I}{\sqrt{\mathrm{MSE}}}\right)$$

Here, MAXI is the maximum pixel value of the image. The PSNR [9]of the images denoised is compared using only curvelet transform and CASF algorithm for each type of noise mentioned above. Then the mean and standard deviation of each noise was calculated

4 Results and Discussion

The coronal MRI image of a patient containing the same four types of noises has been denoised using Curvelet transform and CASF algorithm and the PSNR value was obtained for the denoised image. The output has been shown for coronal MRI the patient in figures 1 to 4.
We compared the result images after applying Curvelet transform and CASF algorithm to Coronal MRI images. It can be observed that region in the result image of CASF algorithmis restored smoother than Curvelet transform. The visual quality of various directional texture region of coronal MRI image with CASF is also as clear as Curvelet. And the texture region of the coronal MRI image is

evident as in result image of curvelet transform. These observation results shows that the CASFalgorithm obtains better visual quality result image than Curvelet transform. Peak signal noise ratio (PSNR) is often employed to compare and measure the difference between result image and original image. It can be observed that the CASF algorithm obtains the highest PSNR value. So the CASF approach improves the PSNR value while obtaining high visual quality result images.

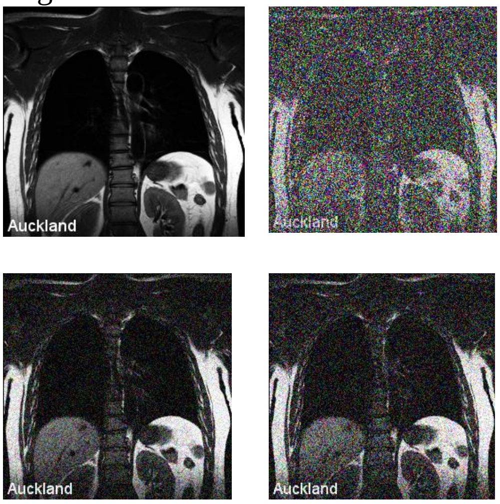


Figure.1: From the left to right: Original image, Noisy image (random noise), Denoised image (CASF algorithm) PSNR=15.83 and Denoised image (Curvelet) PSNR=11.22

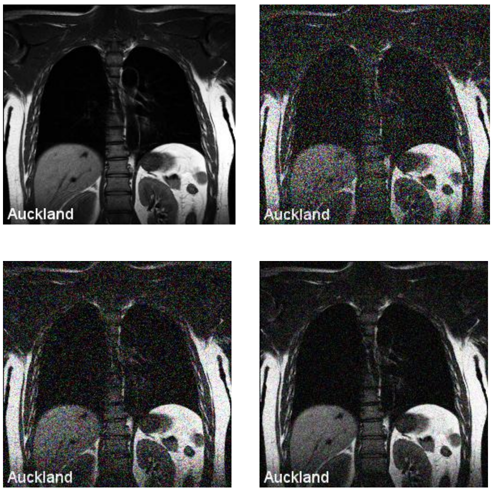


Figure.2: From the left to right: Original image, Noisy image (Gaussian noise), Denoised image (CASF algorithm) PSNR=11,.83 and Denoised image (Curvelet) PSNR=12.53

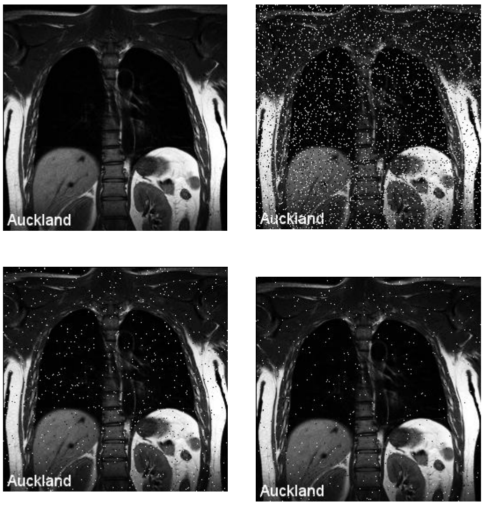


Figure.3: From the left to right: Original image, Noisy image (Salt and pepper noise), Denoised image (CASF algorithm) PSNR=13,.83 and Denoised image (Curvelet) PSNR=16,52

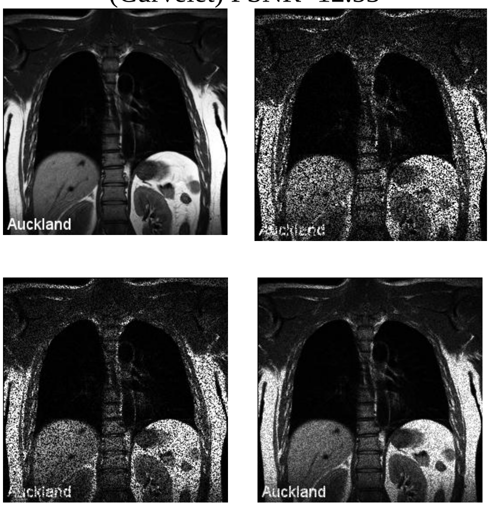


Figure.4: From the left to right: Original image, Noisy image (Speckle noise), Denoised image (CASF algorithm) PSNR=17,32 and Denoised image (Curvelet) PSNR=45,32

5 Conclusion

In the all cases it was found that the CASF algorithm outperforms the Curvelet transform in terms of PSNR and the CASF denoised images appear visually more pleasant than the Curvelet denoised images. The CASF algorithm doesn't effectively remove the Salt and Pepper noise and Speckle noise from the MRI coronal, and so CASF algorithm isn't suited for removal of these two noises though it recovers the edges perfectly. The CASF algorithm provides high PSNR values and can remove the Random noises and Gaussian white from MRI images very efficiently than the Curvelet transform

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