Rician Noise Reduction with SVM, LMRD And Iterative Bilateral Filter In Different Type Of Medical Images Using Digital Image Processing

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***ABSTRACT*: The main challenge in digital image processing is to remove noise from the original image. This paper reviews the existing denoising algorithms of various medical images and performs their comparative study in image denoising. This technique not only some self-possessed technical difficulties, but also may result in the demolition of the image (i.e. making it blur). Parallel magnetic resonance imaging (pMRI) techniques can speed up MRI scan through a multi-channel coil array receiving signal in parallel way. There are various important component of large number of applications such as in medical diagnosis. In medical research there are different medical images like X- Ray, MRI,PET and CT gave minute to minute information about brain and whole body. The image denoising techniques includes parallel magnetic resonance imaging (pMRI) technique which can speed up MRI scan through a multi-channel coil array receiving signal simultaneously. The proposed method has been validated using both phantom and in vivo brain data sets, producing encouraging results. Specifically, the method can effectively remove both noise and residual aliasing artifact from pMRI reconstructed noisy images, and produce higher peak signal noise rate (PSNR) and structural similarity index matrix (SSIM) than other state-of-the-art De-noising methods. Here we propose image de-noising using low rank matrix decomposition (LMRD) and Support vector machine (SVM). The aim of Low Rank Matrix approximation based image enhancement is that it removes the various types of noises in the contaminated image simultaneously. The noise and aliasing artifacts are removed from the structured Matrix by applying sparse and low rank matrix decomposition method. The support vector machine exhibits video which is converted into different sizes of frames so that it can be enhanced easily. Then noisy image and enhanced image are compared to obtain higher signal to noise ratio and other parameters like Peak Signal to Noise Ratio PSNR, Structural Similarity Index Matrix SSIM and Mean Square Error MSE for qualitative assessment to the enhancement result. This method can effectively remove both noise and residual aliasing artifact from pMRI reconstructed noisy images, and produce higher peak signal noise rate (PSNR) and structural similarity index matrix (SSIM) than other state-of-the-art De-noising methods.**

***Keywords*- Image denoising, Rican noise, pMRI, De-noising, PSNR, MSE, SSIM, Bilateral Filter, Low Rank Matrix Decomposition (LRMD) and Support Vector Machine (SVM)**

1. Introduction

Magnetic resonance imaging (MRI), nuclear magnetic resonance imaging (NMRI), or magnetic resonance tomography (MRT) is a medical imaging technique used in radiology to investigate the anatomy and physiology of the body in both health and disease. Digital images plays very significant role in our daily routine like they are used in satellite television, Intelligent traffic monitoring, handwriting recognition on checks, signature validation, computer resonance imaging and in area of research and technology such as geographical information systems and astronomy. IThe digital signal processing having image which has an input and output (or a set of characteristics or parameters of image) image. In image processing we work in two domains i.e., spatial domain and frequency domain. The Spatial domain refers to the image plane itself, and image processing method in this category are based on direct manipulation of the pixels in an image and coming to frequency domain it is the analysis of mathematical functions or signals with respect to frequency rather than time.

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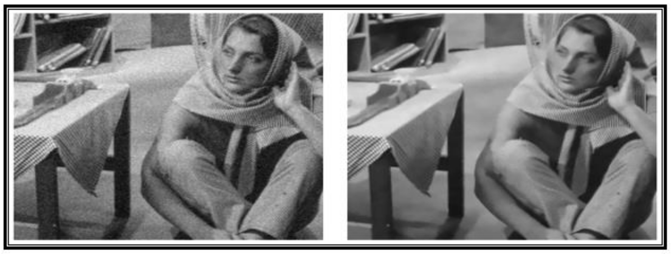

Fig 1: Medical original image and denoised image

1.1. NOISE Types

There are various types of noise have their own characteristics and are inherent in images in different ways.

(a) Amplifier Noise: The amplifier noise might be defined as signals in the system which are unwanted and degrade the desired signal content in the system. A low-noise amplifier is an electronic amplifier that amplifies a very low-power signal. The amplifier system is concerned, noise can be divided into noise and its input the noise generates itself.

Fig 1.1: Gaussian noise and Rician noise image

As the name indicates, this type of noise has a Gaussian distribution, which has a bell shaped probability distribution function given by

$$F\ (g) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(g-m)^2 / 2\sigma^2}$$

Where g represents the gray level, m is the mean or average of the function and σ is the standard deviation of the noise. The Gaussian noise represent in Image 1.2 illustrates the Gaussian noise with mean (variance) as 1.5 (10) over a base image with a constant pixel value of 100.

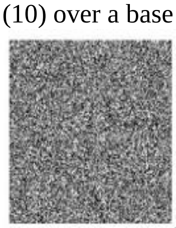

Fig 1.2: Gaussian noise

(mean = 0, variance = 0.05)

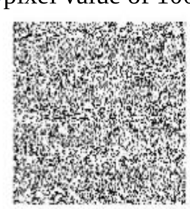

Fig 1.2: Gaussian noise

(mean = 1.5, variance = 10)

(b) Rician Noise: The Rician distribution is popularly known as Rice distribution. It is the probability distribution of the magnitude of an annular bi-variate normal contingent variable with non-zero mean and this was named after Stephen O. Rice. The noise affecting MR images is known as Rician noise. This noise is introduced because of the magnitude image formation of MRI data and follows a Rice distribution function. MRI images are converted to magnitude images and phase images by using magnitude and phase details from the k-space data obtained during image acquisition, respectively. The image intensity in magnetic resonance magnitude images in the presence of noise is shown to be governed by a Rician distribution. Low signal intensities (SNR < 2) are therefore biased due to the noise.

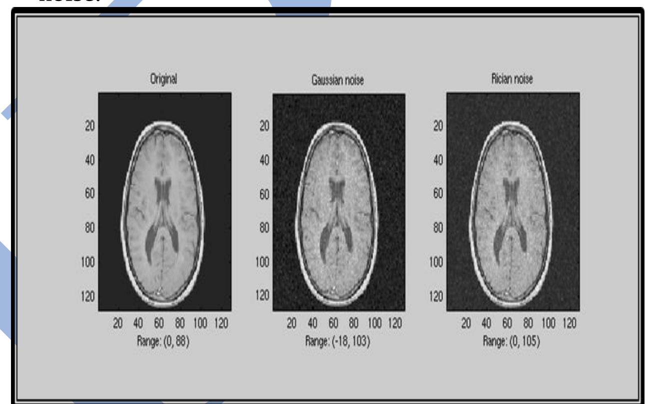

Fig 1.3: Image with Gaussian and Rician Noise

Medical Image denoising

Image denoising is an important image processing task, both as a process itself, and as a component in other processes. Very many ways to denoise an image or a set of data exists. The main properties of a good image denoising model is that it will remove noise while preserving edges. Traditionally, linear models have been used. One common approach is to use a Gaussian filter, or equivalently solving the heat-equation with the noisy image as input-data, i.e. a linear, 2nd order PDE-model. For some purposes this kind of denoising is adequate. One big advantage of linear noise removal models is the speed. But a back draw of the linear models is that they are not able to preserve edges in a good manner: edges, which are recognized as discontinuities in the image, are smeared out.

The different digital medical imaging technologies Such as positron emission tomography (PET), magnetic resonance imaging (MRI), computerized tomography (CT) and ultrasound Imaging has revolutionized modern medicine. Today, many patients no longer need to go through invasive and often dangerous procedures to diagnose a wide variety of illnesses. Here the widespread use of digital imaging in medicine today, the quality of digital medical images becomes an important issue through worldwide. In medical line to achieve the best possible diagnosis it is important that medical images be sharp, clear, and free of noise and artifacts. The major challenges in the study of medical imaging because they could mask and blur important features in the images and many proposed de-noising techniques have their own problems. Image de-noising still remains a challenge for researchers because noise removal introduces artifacts and causes blurring of the images. The factors which affect noise modeling in medical imaging are capturing instruments, information transmission media, image quantization and separate sources of radiation. There are a number of shortcomings and these includes: acquisition noise from the equipment, ambient noise from the environment, the presence of background issue, other organs and anatomical influences such as body fat, and breathing motion. Therefore, noise reduction is very important, as various types of noise generated limits the effectiveness of medical image diagnosis.

2. Techniques Used

There are various main techniques are used to enhance the results of this thesis. These techniques are discussed below:

Low-Rank Matrix Decomposition

LRMD is derived from compressed sensing theory which has been successfully applied various matrix completion issues for example image compression video denoising and dynamic MRI Compared with classical denoising methods. Denoising techniques based on low rank completion enforce fewer external assumptions on noise distribution. These methods rely on the self-similarity of three dimensions (3-D) images across different slices or frames to construct a low rank matrix. The significantly varying contents between different slices or frames may lead an exception to the assumption of low-rank 3-D images and discount the effectiveness of these methods.

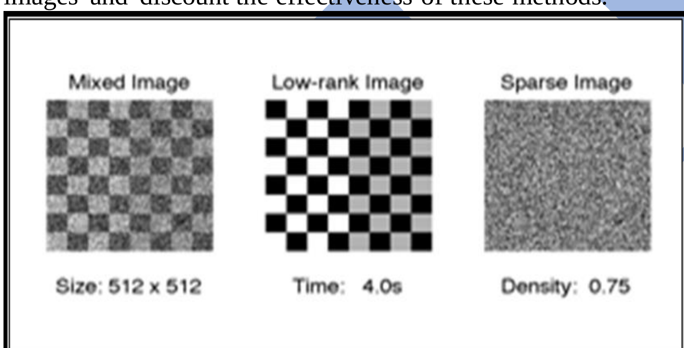

Fig 2.1: Image represents Low-rank matrix decomposition

Low-Rank Matrix Decomposition It is derived from compressed sensing theory has been successfully applied various matrix completion problems, e.g., image compression video denoising and dynamic MRI Compared with classical denoising methods. Denoising methods based on low rank completion enforce fewer external assumptions on noise distribution. The aim of Low Rank Matrix approximation based image enhancement is that it removes the various types of noises in the contaminated image simultaneously. The main contribution is to explore the image denoising low-rank property and the applications of LRMD for enhanced image denoising. Nonetheless, significantly varying contents between different slices or frames may lead an exception to the assumption of low-rank 3-D images, and discount the effectiveness of these methods. In this paper, we propose to remove both noise and aliasing artifacts in pMRI image by using a sparse and low rank decomposition method.

Support Vector Machine (SVM)

Support Vector Machine is an advanced technique for classification and brought in by Boser, Guyon and Vapnik in year 1992. The essential assets of SVM are the competence for initiating non-linear opinion boundaries utilizing the approaches enclosed for linear classifiers. Exceptional function accepted as 'kernel' is adopted in support vector machine that acknowledge the individuals for employing a classifier onto the data which do not hold a permanent dimensional vector space description .SVMs belong to the general category of kernel methods. A kernel method is an algorithm that depends on the data only through dot-products. When this is the case, the dot product can be replaced by a kernel function which computes a dot product in some possibly high dimensional feature space. This has two advantages: First, the ability to generate non-linear decision boundaries using methods designed for linear classifiers. Second, the use of kernel functions allows the user to apply a classifier to data that have no obvious fixed-dimensional vector space representation.

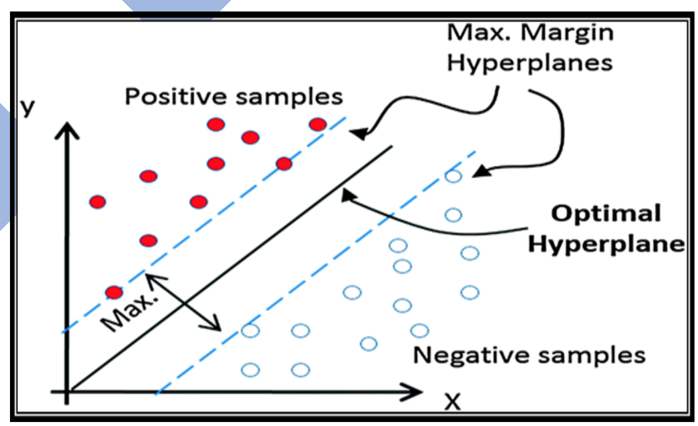

Fig 2.2: Support Vector Machine with positive and negative samples

The support vector machines have proved to achieve good generalization performance with no prior knowledge of the data. The principle of an SVM is to map the input data onto a higher dimensional feature space nonlinearly related to the input space and determine a separating hyper plane with maximum margin between the two classes in the feature space. The SVM is a maximal margin hyper plane in feature space built by using a kernel function. This results in a nonlinear boundary in the data space.

Filters:

In Image processing filters are mainly used to suppress either the high frequencies in the image that is smoothing the image or the lower frequencies that is enhancing or detecting edges in the image. The image can be filtered in frequency domain or in the spatial domain. In spatial domain there are two types of filters namely linear filters and non linear filters:

Linear filters: It consist of linear operations such as multiplying each pixel in the neighborhood by a corresponding coefficient and summing the result to obtain the results at each point (x, y). The coefficients are arranged as a matrix called filter mask or window.

Non-Linear Filters: This method involves a non-linear operation on the pixels of neighborhood. Median filter is a type of the non-linear filter.

This text provides a graphical, intuitive introduction to bilateral filtering, a practical guide for efficient implementation and an overview of its numerous applications, as well as mathematical analysis. The formulation of it is simple and each pixel is replaced by a weighted average of its neighbors. This aspect is important because it makes it easy to acquire intuition about its behavior, to adapt it to application-specific requirements, and to implement it.

Iterative Bilateral Filter:

In image processing filters are commonly used to suppress either the high frequencies in the image that is smoothing the processing image. The lower frequencies of the filters is enhancing or detecting edges in the image. The Bilateral filter is also known for its effectiveness in edge-preserved image denoising in image processing. For filtering the Rician noise in the magnitude magnetic resonance images the iterative bilateral filter is used and it improves the denoising efficiency and preserves the fine structures and also reduces the bias due to Rician noise. The quality of the image, visual and diagnostic is well preserved.

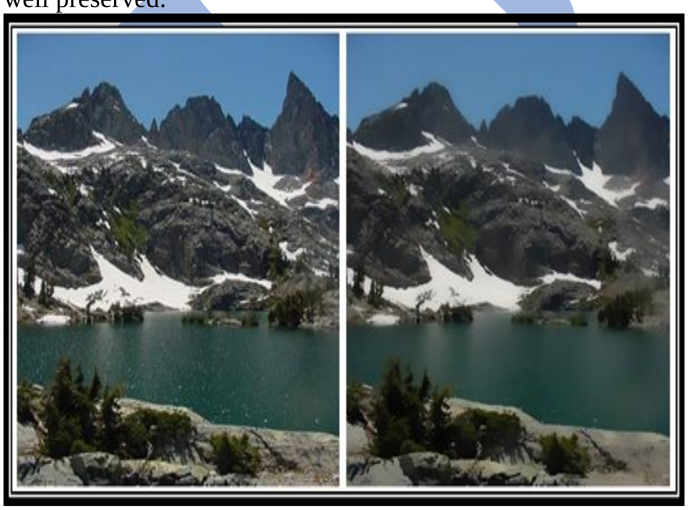

Fig 2.3: Image processed with Bilateral filter

3. Parameters Used

Following are the two main parameters that are used to calculate the results of the proposed work in this thesis. These parameters are:

Peak Signal-to-Noise Ratio (PSNR):

Peak signal-to-noise ratio is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a wide dynamic range and PSNR is usually expressed in terms of the logarithmic decibel scale. Peak signal-to-noise ratio is the maximum gray scale value of the pixels in the fused image. Higher the value of the PSNR is better the performance of the fusion algorithm.

Mean Square Error (MSE):

The mean square error (MSE) of a procedure for estimating an unobserved quantity measures the average of the squares of the errors that is, the difference between estimator and what is estimated. It would have the same effect of making all the values positive as the absolute value. There are two basic techniques used to compare the various image are the mean square error (MSE) and the peak signal-to-noise ratio (PSNR). A commonly utilized reference based assessment metric is the Mean Square Error (MSE). The MSE between a reference image and a fused image is given by the reference and fused images respectively and image dimensions. The MSE is the cumulative squared error between the compressed and the original image, whereas PSNR is a measure of the peak error. Smaller the value of the MSE is better the performance of the fusion algorithm.

Structure Similarity Index Matrix (SSIM)

Structure similarity index matrix is a method for measuring the similarity between two images and it is a full reference matrix. In other words the measuring of image quality based on an initial uncompressed or distortion free image. This parameter is employed for measure the similarity between two images. SSIM enforced to recover on ancient ways like peak signal-to-noise ratio and mean square error. The distinction with reference to different parameters like MSE or PSNR is that it estimates perceived.

4. Conclusions

The proposed method simultaneously removes noise and aliasing artefacts by leveraging sparse and low rank matrix factorization. Experimental results demonstrate that the proposed algorithm can benefit both visual diagnostic and quantitative methodologies.The formalism presented in this paper demonstrates that the LRMD and SVM techniques are combined to propose a new technique to further reduce the noise in medical images. In this paper, we propose different techniques like LMRD, MSE, Bilateral filter and SVM as a tool for image de-noising and enhancement. Low rank matrix decomposition and SVM will be used. The evaluation will be based on the PSNR and mean SSIM with their improved values as compare to the previous research. The sharpness of the image is retained unlike in the case of linear filtering. In the case where an image is corrupted with various noises.The parameter introduced is mean square error(MSE), it is proposed approach i.e. improved technique for medical image de-noising using these techniques and SVM will exhibit outcomes of noise reduction and image quality improvements with different noise levels which will qualify it to be suitable for image processing and denoising. The proposed approach drastically improves the quality of Parallel MRI scanning in particular medical images. Future work may be further applied new formulas or algorithm for the enhancement of denoised images. The proposed algorithm has been implemented on MATLAB tool. This approach can also be an effective technique to denoise the images used for digital image processing. The proposed method could be extended to multiple dimensions imaging by exploiting the redundancy and similarity between multi-slice and multi-frame images to achieve a higher gain that is warranted in a future study.

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