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De-Noising Medical Images Using Low Rank Matrix Decomposition, NN and SVM

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Abstract– Medical imaging technology is becoming an important component of larger number of applications such as diagnosis, research and treatment. Medical images like X-Ray, MRI, PET and CT have minute to minute information about brain and whole body. So the images should be accurate and free of noise. Noise reduction plays the necessary role in medical imaging. There are various methods of noise removal like filters, wavelets and thresholding . These methods produced good results but still have some drawbacks. The limitations of the previous methods are considering and analyzing this research and the new proposed technique presents neural networks and SVM as an efficient tool for rician noise reduction. The proposed method gives more clear image with higher PSNR and improved SSIM value than the previous methods. In this paper, the techniques used for proposed work are discussed.

Keywords- Image denoising, Gaussian noise PSNR, MSE, Neural Networks, SVM

I. INTRODUCTION

Medical image enhancement: The arrival of digital medical imaging technologies like Positron emission tomography, Medical Resonance Imaging, Computerized tomography and Ultrasound Imaging has revolutionized modern medicine. Many patients no longer need to go through dangerous procedures to diagnose a wide variety of diseases. Because of increased use of digital imaging in medicine today the quality of digital medical images becomes an important issue and to achieve the best possible diagnosis it is important for medical images to be sharp, clear, and free of noise. While the technologies for acquiring digital medical images continue to improve and resulting in images of higher resolution and quality but removal of noise in these digital images remains one of 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. So different algorithms are used depending on the noise model that is why it is important to reduce noise and other artifacts in images , as various types of noise generated reduces the effectiveness of medical image diagnosis.

Low-Rank Matrix Decomposition

It is derived from com-pressed 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. These methods rely on the self-similarity of three dimensions (3-D) images across different slices or frames to construct a low rank matrix. 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. The denoising of entire coil image can be accomplished by sliding the patch across entire image in a raster fashion. Thus, each pixel is calculated repeatedly between overlapping patches and obtains multiple estimations. The final output of each pixel is calculated by simply averaging all estimates of this pixel from overlapping patches.

Artificial Neural Networks

Artificial neural networks are massively interconnected networks in parallel of simple elements (usually adaptable) with hierarchic organization, which attempt to interact with the objects of the real world in the same way that the biological nervous system does. Artificial neural networks can either be used to gain an understanding of biological neural networks or for solving artificial intelligence problems without creating a model of a real biological system. The real biological system is incredibly complicated. Artificial neural network algorithms try to abstract this complexity and focus on what matters most from an information processing point of view. Artificial neural networks typically start out with randomized weights for all their neurons. This implies that they do not recognize anything and must be trained to solve the particular problem for which they are supposed. Broadly there are two strategies for training associate ANN, depending on the matter it should solve.

A self-organizing ANN is exposed to large amounts of data and tends to discover patterns and relationships in that information. Researchers typically use this kind to investigate experimental data.

A back-propagation ANN is trained by humans to perform specific tasks. This kind is used for psychological research and for problem-solving applications.

Support Vector Machine(SVM)

It is primarily a classifier in which width of the margin between the classes is the optimization criterion, i.e. empty area around the decision boundary defined by the distance to the nearest training patterns. These are called support vectors.. The concept of (SVM) Support Vector Machine was introduced by Vapnik. The objective of any machine that is capable of learning is to achieve good generalization performance, given a finite amount of training data. 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. The optimal separating hyper plane can be determined without any computations in the higher dimensional feature space by using kernel functions in the input space.

This has two advantages:

(1) The ability to come up with non-linear decision representation.

(2) The use of kernel function allows the user to apply a classifier to data that have no fixed dimensional vector space representation.

There are some commonly used kernels that include:

(a) Linear kernel
K(x,y)= x,y

(b) Polynomial Kernel
K(x,y)= (x , y+1) d

SVM Algorithm

Define an optimal hyper plane.

i. Extend the above definition for non liner separable problems.

ii. Map data to high dimensional space where it is easier to classify with linear decision surfaces.

Block diagram of proposed system: The following diagram shows the steps of proposed work:

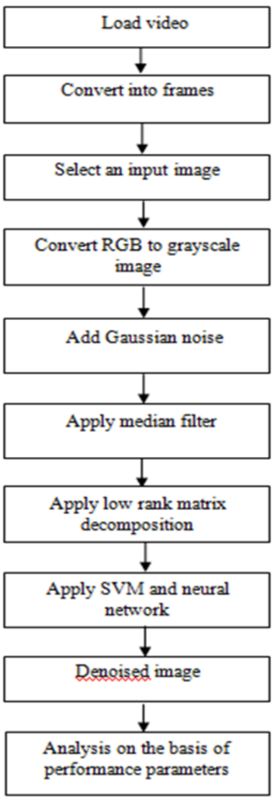


Fig.1 Implementation Flowchart

II. Gaussian Noise

Gaussian noise is statistical noise having a probability density function (PDF) equal to that of the normal distribution, which is also known as the Gaussian distribution. In other words, the values that the noise can take on are Gaussian-distributed.

The probability density function P of a Gaussian random variable z is given by:

$$p_G(z) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(z-\mu)^2}{2\sigma^2}}$$

Where z represents the grey level, μ the mean value and σ the standard deviation.

GAUSSIAN NOISE IN DIGITAL IMAGES:

Principal sources of Gaussian noise in digital images arise during acquisition e.g. sensor noise caused by poor illumination and/or high temperature, and/or transmission. e.g. electronic. In digital image processing Gaussian noise can be reduced using a spatial filter, though when smoothing an image, an undesirable outcome may result in the blurring of fine-scaled image edges and details because they also correspond to blocked high frequencies. Conventional spatial filtering techniques for noise removal include: mean (convolution) filtering, median filtering and Gaussian smoothing.

III. Experimental Results

In this section, we perform comparison to verify the efficiency of our approach. The comparison is done for every method on the basis of previous values of quantitative measures like PSNR and SSIM with the given values to the proposed work. The proposed method as compare to the previous working methods gives better denoising results.

PSNR (Peak Signal to Noise Ratio)

Two quality measures were used for quantitatively evaluating the accuracy of desired results. The first is peak signal to noise ratio (PSNR) metric, which is formed by calculating the ratio between maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation.

$$\mathrm{PSNR} = 20\log_{10}\frac{\max(I^{\mathrm{ref}})}{\|I^{\mathrm{recon}} - I^{\mathrm{ref}}\|_2}$$

The following graph shows comparison of PSNR with respect to previous and proposed method:

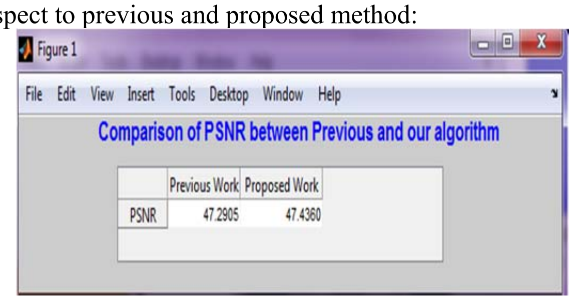


Fig.2 PSNR values of previous and proposed method

The graphical representation of PSNR values shows that PSNR of proposed method is better than the previously used algorithms for Denoising medical images.

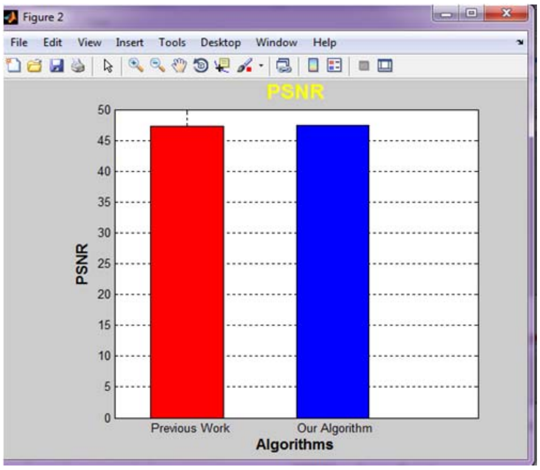


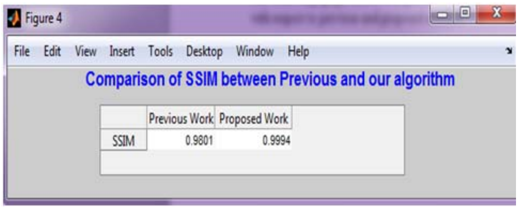
Fig.3 PSNR graph

SSIM (Structural Similarity Index Metric)

SSIM is used for measuring the similarity between two images. It better relates to the human visual system than conventional metrics based on the mean squared error. SSIM between two images I and J is given by

$$\mathrm{SSIM}(\mathcal{I},\mathcal{J}) = \frac{1}{N}\sum_{i\in\mathcal{I},j\in\mathcal{J}} \frac{(2\mu_i\hat{\mu}_j + c_1)(2\sigma_{i,j} + c_2)}{\left(\mu_i^2 + \hat{\mu}_j^2 + c_1\right)\left(\sigma_i^2 + \sigma_j^2 + c_2\right)}$$

Where μ_i and $\hat{}\mu_j$ are the respective local mean values, σ_i and σ_j the respective standard deviations, $\sigma_{i,j}$ covariance value, c_1 and c_2 two predefined constants. The higher PSNR and SSIM indicate more preferable image quality.



	Previous Work	Proposed Work
SSIM	0.9801	0.9994

Fig.4 SSIM values of previous and proposed method

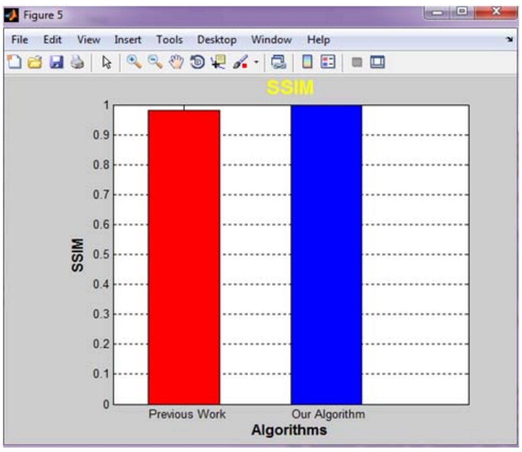
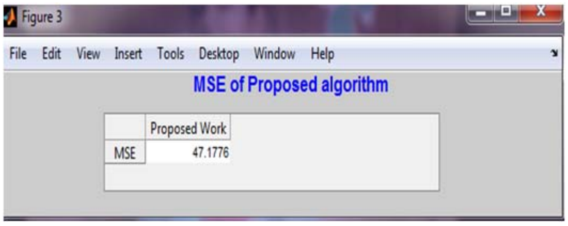


Fig.5 SSIM graph

MSE (Mean Square Error)

The new parameter used in the proposed method is mean square error. In statistics, the mean squared error (MSE) of an estimator measures the average of the squares of the errors, that is, the difference between the estimator and what is estimated.



	Proposed Work
MSE	47.1776

Fig.6 MSE value of proposed method

IV. CONCLUSION

In this paper, we propose the neural networks 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. The new parameter introduced is mean square error(MSE), The proposed approach i.e. improved technique for medical image de-noising using Neural networks 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.

V. FUTURE SCOPE

The proposed method is limited to single image only. This can be extended to multiple images and multi-slice images simultaneously to achieve higher PSNR gain. The size of filter mask can also be increased. In future more quantitative measures can be used by using different algorithm or state-of-the-art methods that is warranted in future study.

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