EAI Endorsed Transactions
on Pervasive Health and Technology
Research Article EAI.EU

Speckle Noise Removal from Biomedical MRI Images and Classification by Multi-Support Vector Machine

B. Hemalatha*[1], B. Karthik[1] and C. V. Krishna Reddy[2]

[1]Department of ECE, Bharath Institute of Higher Education and Research, Chennai, India
[2]Nalla Narasimha Reddy Education Society's Group of Institutions, Hyderabad, India

Abstract

INTRODUCTION: Image Processing (IP) methods play a vital role in medical images for diagnosing and predicting illness, as well as monitoring the patient's progress. The IP methods are utilized in many applications for example in the field of medicine.
OBJECTIVES: The images that are obtained by the MRI magnetic Resonance imaging and x rays are analyzed with the help of image processing.
METHODS: This application is very costly to the patient. Because of the several non-idealities in the image process, medical images are frequently tainted by impulsive, multiplicative, and addictive noise.
RESULTS: By replacing some of the original image's pixels with new ones that have luminance values which are less than the allowed dynamic luminance range, noise frequently affects medical images.
CONCLUSION: In this research work, the Speckle type noises are eliminated with the help of Mean Filter (MF) and classify the images using Multi-SVM classifier. The entire system developed using python programming.

Keywords: Signal to Noise Ratio, Speckle, MRI Images, Classification, Mean Filter, Multi SVM

Received on 15 November 2023, accepted on 30 January 2024, published on 08 February 2024

doi: 10.4108/eetpht.10.5076

1. Introduction

Medical images are being obtained from patients who take X-Rays and MRI scans from reputed scan centers [1]. In the medical industry, noise is categorized into two stages. A criterion for estimating the presence of impulsive noise makes up the first stage. The image is processed for the second stage of another criterion to determine whether the noise is multiplicative or additive if the outcome of this criterion is negative.
The main reason for this speckle noise is the waves or radiation that has been emitted during scanning in scan centers. There are many types of noises present in medical images. In X-Rays the presence of Poisson noise will be very high. In case of MRI and Ultrasound images we will be having more Speckle noise which will reduce the prediction accuracy during classification [2].
Among all noises in medical imaging, this speckle noise plays a main role in reducing the prediction of diseases or the current state of the patient's status. So, our proposed system will help in clearing and removing this speckle noise in an efficient manner.
Today, image processing methods are applied in a number of medical applications, such as brain tumour classification, liver image validation, and cancer diagnosis. Breast cancer is the most aggressive type of cancer that currently affects women, particularly in developing countries, and the risk associated with it rises with age [3]. Because the exact aetiology of breast cancer is yet unknown, prevention is difficult. The rate of survival can

*Corresponding author. Email: hema.contact@gmail.com

be increased, nevertheless, by earlier disease detection and treatment.

By removing noise, the image denoising technique enhances the quality of noisy photos. Given that noise and other important properties of images, such as edges and textures, have relatively identical upper frequencies, it may be difficult to discern them apart, which may result in the loss of some image components.

In this paper, Ayana et al. (2022) introduced a method for de-speckling breast ultrasound images known as rotationally invariant block matching (RIBM-NLM). The suggested method for reducing speckles on breast photos acquired from open and commercial databases was compared to three well-known de-speckling techniques. The MSE value, which is lower than that of cutting-edge techniques, shows how well the RIBM-NLM method works to reduce speckle while maintaining exact elements. The PSNR value implies that the suggested approach outperforms the existing filters in terms of de-speckling because it is higher, particularly for low-quality images. Not to mention, the RIBM-NLM method requires less calculation time than previous methods [4].

A successful method is used by Chakravarthy et al., (2019), to remove impulse noise from digital mammograms. The technique is built upon statistics like mean, median, and standard deviation [5]. This determines the updated intensity that needs to be replaced in the impulse area by computing those measurements in the vicinity of the acquired mammography pictures [6]. The suggested method is only iterative and aims to remove impulsive noise without affecting the image's boundaries and other vitally crucial regions [7].

The following has been declared as the study's objective in light of the background of the field and any pertinent difficulties:

• To suggest a best filtering method in denoising bio medical MRI images.
• Using the mean square error (MSE) and peak signal-to-noise ratio (PSNR) on images tainted by noises like salt-and-pepper, poison, and speckle, determine whether the suggested denoising method is effective.
• To evaluate the suggested filter's accuracy functionality to that of already-used techniques.

2. Literature Review

One of the key significant challenges in medicinal IP is removing noise from medical-based images (Image Processing). Abdulaziz Saleh Yeslem Bin-Habtoor et al., 2016 applied three kinds of filters on the images and compared the efficiency of the filtering techniques. The choice of the filtering concept is not based on the type of application. Due to that reason selecting denoising concepts for the concerned application is very important. Here the authors apply the adaptive median filtering on the medical type images and compare the outcome of this technique with other filtering concepts like mean and median type filters. The investigational outcome shows that the proposed filter is suitable for medical-type images [8].

Ultrasonic machines are playing a key role in disease identification. The main issue during disease identification is the deformation of visual type signals due to the wave signals transmission. This deformation is called Speckle type noises. Denoising is one of the major stages for the exact disease diagnosis. The present requirement of healthcare institutions is to protect the information with fewer noises. Speckle-type noises decrease the image contrast level. K. Karthikeyan et al, 2011 presented a study to decrease the speckle type noises from ultrasonic components. The authors use a hybrid system that combines wavelet-based BayesShrink, anisotropic diffusion based on PDE, and SRAD type filtering. The standard filters are used to evaluate the proposed model filter. Investigations as a result demonstrates the hybrid type filter is effective and creates the best quality denoised, clear, and smoother picture [9].

In this current scenario noise removal from medical images is the hottest research topic. Speckle-type noise images increase the negative impression on the image interpretation process. In recent days, various efforts have been taken to design an efficient denoising model. But various methods are still not effective due to their computational effectiveness, features destructive and less speckle trimming. Ahmed S. Bafaraj 2019 presents a novel approach for speckle type noise removal in medical images using an efficient and optimized gaining combined model. The suggested model contains three important phases. Initially, the speckle type noise datasets are selected. Then optimized gaining combined models are offered with various filters. Finally, the histogram results are displayed and measure the quantitative and qualitative metrics. Among the various filters, the ideal type of filter shows a better noise ratio and superior structural likeness less mean square error rate [10].

Noise elimination approaches are an important process in medical-related image handling for learning the human anatomy framework. Managing nosing issues various de-nosing models like filters are used [11]. Nalin Ku et al., 2017 done research work with Weiner, Gaussian, and median filter with medical related images. The common noises that affected the MRI images are Speckle, Salt and Pepper, and Poisson-type noises. The three filters mentioned above were tested with a variety of noises, including Speckle, Salt and Pepper, and other noises. Based on the filters' age, histogram level, and image clarity level, their performances are evaluated. According to the outcome of this research work, a median type of filter suitable for eliminating Poisson and salt and pepper type noises from the gray level images. The Weiner type filter is opted for removing Gaussian type and Speckle type noises. Gaussian type filter handling blurred type noises from the given images. Here the authors use 20 various images for eliminating noises [12].

Nowadays, AI (Artificial Intelligence) techniques and ML models are generally applied in the medical field to diagnose diseases. Mainly speckle type noises influence all types of medical-related images. So, reducing speckle-type noises is necessary for the medical domain. These noises decrease the accuracy rate of the classification results. Pichid Kittisuwan et al., 2018 recommended a new speckle-noise elimination technique using Bayesian evaluation with wavelet type methods due to its efficiency and less processing time. The authors propose the MAP (Maximum a Posteriori) estimator for handling speckle-type noises. This new method produces better denoising outputs [13].

S. Rameshkumar et al., 2016 implemented a novel filter known as WB-Filter for reducing images from the medical images. WB-Filter is the mixture of median and bilateral filters. It executes at every pixel of an image, is exchanged with weighted mean intensity values from neighborhood pixels and decreases the MSE value among measured and the desired value. This suggested filter is mainly suitable for speckle and Gaussian type noise removal. The resultant image quality is evaluated using MSE, RMSE, and PSNR values. The outcome says that the new WB-Filter approach produces an optimum quality of the medical images [14].

Problem Statement:

- Usually in all cases accuracy will be always less and non-constant when applying classification algorithms.
- MSE Error will be high during training and testing which means higher MSE means lower accuracy.
- Improper Precision and Recall rate in the terms of output in each and every iteration which makes the model to perform less in any dataset.
- If the dataset is huge the constructed model is facing a problem of execution time during simulation.
- Some models constructed are very complex and not understandable.

3. Proposed Methodology

Ultrasound imaging is a non-invasive, real-time, and radiation-free imaging modality when compared to other imaging technologies like X-rays, CT, and MRI. However, speckle noise invariably distorts ultrasound images because of coherent imaging. Denoising is therefore essential for enhancing an image's ultrasonic quality. As a pre-processing phase, denoising aids picture post-processing tasks like image segmentation, classification, and registration. The proposed noise removal model's block diagram is shown in Figure 1.

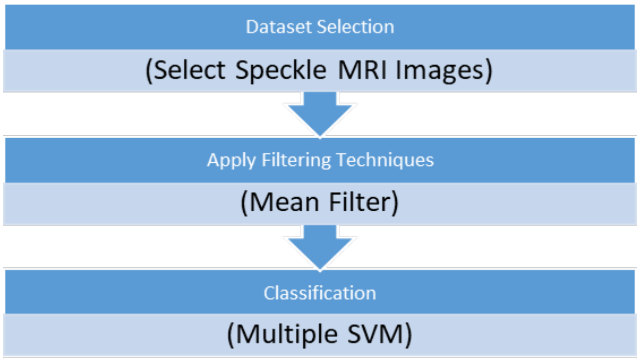

Figure 1. Proposed Noise Removal Model

Speckle images have mainly occurred in laser, ultrasonic, radar, and MRI images. This noise amplitude value has Gaussian distribution, and it is represented as the following Eqn. (1)

$$A = A_R + j\,A_1 ------(1)$$

Here $A_R A_R$ denotes the phase element, and $A_1 A_1$ indicates the e quadrature element for speckle amplitude. The Speckle type noise intensity value is described as Eqn. (2)

$$u = A_R^2 + A_1^2 --------(2)$$

The speckle noise intensity value negative exponential type distribution is denoted as the Eqn. (3)

$$p(u) = \frac{1}{u} ------(3)$$

From the above equation, u represents the speckle intensity mean value.

According to S. Anitha, L. Kola P et al., [14], the standard model of speckle type noises is illustrated as Eqn. (4).

$$I(x,y) = R(x,y)u(x,y) ------(4)$$

Here $(x,y)(x,y)$ identifiers denote the spatial coefficients, II indicate the acquired image. The identifier RR denotes the scene and is the speckle noise.

In this research work, the speckle noises are removed using the Mean Filter (MF) approach. MF is the easiest and simple filter for decreasing the noise level of images. In the MF technique, exchange every pixel in the images with the neighbor's average value. According to B. Deepa et al., [15] MF approach in image processing is expressed using Eqn. (5)

$$g(i,j) = \frac{1}{M} \sum_{(k,l)\in N} f(k,l) --------(5)$$

From Eqn. 5, M stands for the neighborhood's total number of pixels. f(k,l) denotes a given image, while N. g(i,j) denotes the processed image.

The classification process is used to classify the filtered images based on their features. SVM is a kind of supervised ML model that assists in categorization or regression issues [15-17]. The main aim of the SVM model is to discover the best edges among the probable results. SVM model does the complex type data based on selected kernel method and it aims to increase the division of boundaries among the given data points based on defined labels.

The performance of the existing and suggested systems is compared in the accompanying Table 1 and Figure 2. From the table we can see that performance of existing algorithms such as Naive Bayes (NB) is 68%, K Nearest Neighbour (KNN) is 74%, Random Forest (RF) is 82%, Decision Tree (DT) is 89% and proposed Multi Support Vector Machine (MSVM) produces 91% respectively.

Table 1: Existing and Proposed Performance Analysis

Algorithms	Performance %
Naive Bayes (NB)	68
K Nearest Neighbour (KNN)	74
Random Forest (RF)	82
Decision Tree (DT)	89
Multi Support Vector Machine (MSVM)	91

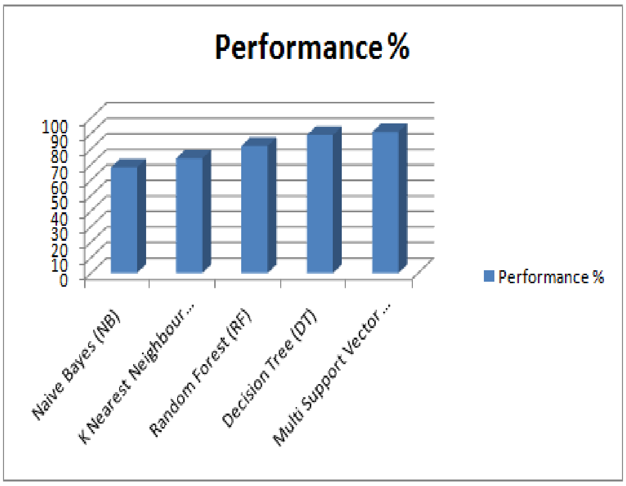

Figure 2. Existing and Proposed Performance Analysis Graph

4. Results and Discussions

OC_8702 data set: This data collection was acquired from an internet repository. The dataset comprises 275 female patients who came in for scans to check on uterine issues. Peak (Ciphergen), LogFC, p-value, corrected p, Peak (Cormwell), and other key characteristics are included.

Now let us see how our suggested Multi-SVM handles speckle noise removal and segmentation. Images for the input were taken from online datasets. After that, the algorithm receives this image. The algorithm will first resize the image, after which the noise in the image will be examined and eliminated using the Wiener filter. The data is segmented using multi-SVM.

The accompanying Figure 3 displays the input image, noise image, and denoised image. After our research and work the value of PSNR of noisy images is 20.194928 db and PSNR value of denoised image is 24.473850 db.

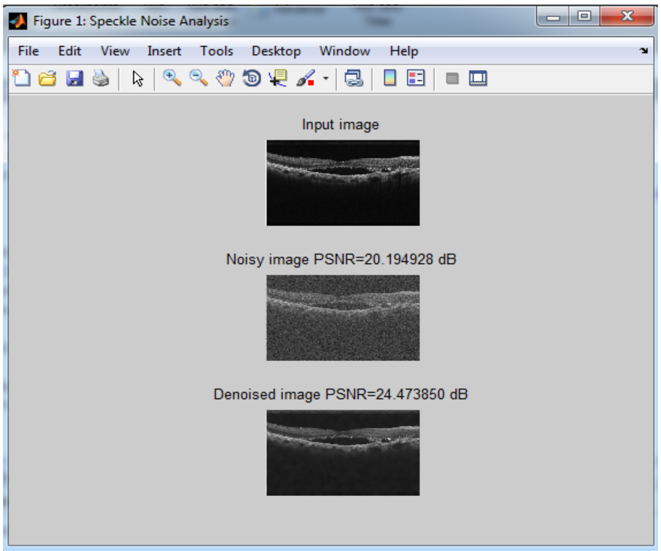

Figure 3. Output Analysis

The following Table 2 and figure 4 represents the accuracy obtained after simulation. The total number of images used for testing is 220. After testing the accuracy of Decision Tree ranges from 88.2% to 90.1% and MSVM accuracy ranges from 88.7% to 90% respectively. So, it's been proved our algorithm works best.

Table 2: Accuracy Comparison of DT and MSVM

No of Images	Decision Tree Accuracy %	MSVM Accuracy %
20	88.2	88.7
40	88.5	89
60	88.7	89.2
80	88.8	89.4
100	88.9	89.5
120	89	89.7
140	89	89.8
160	89.5	89.9
180	89.9	90
200	90.1	90.3
220	90.2	90.5

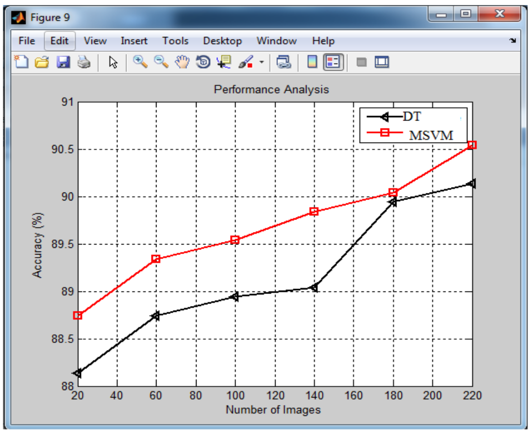

Figure 4. Accuracy Comparison of DT and MSVM Comparison Graph

5. Conclusion

IP techniques are mainly used in the medical domain for identifying and classifying diseases in an earlier manner. Various kinds of noises occurred due to different causes. In the medical domain, noises are decreasing image qualities. Denoising can assist healthcare professionals to detect diseases. In this research work, the MRI image speckle noises are removed from the images using MF. The filtered images are then classified using the Multi SVM model. The findings of the suggested system's Python implementation are contrasted with those of more conventional methods. Future neural network algorithms, including Convolution Neural Networks (CNN) and Recurrent Neural Networks (RNN), will provide results that are more accurate than those of our suggested approach.

References

[1] Jayachitra, S, Prasanth, A: Multi-feature analysis for automated brain stroke classification using weighted Gaussian naïve Bayes classifier. journal of circuits, systems and computers. 2021; Vol. 30, pp. 1–19.

[2] Sekar J, Aruchamy, P, Lebbe A:. An efficient clinical support system for heart disease prediction using TANFIS classifier. Computational Intelligence. 2022; Vol. 38:pp.610-640.

[3] Braveen, M, Nachiyappan, S, Seetha, R: ALBAE feature extraction based lung pneumonia and cancer classification. Soft Computing. 2023; pp. 1-14.

[4] Ayana G, Dese K, Raj H, Krishnamoorthy J, Kwa T. De-Speckling Breast Cancer Ultrasound Images Using a Rotationally Invariant Block Matching Based Non-Local Means (RIBM-NLM) Method. Diagnostics (Basel).2022; 12(4):862.

[5] S R S Chakravarthy, H Rajaguru. A Novel Noise Removal in Digital Mammograms based on Statistical Algorithms. International Conference on Advances in Computing and Communication Engineering (ICACCE). 2019;14(2):1-4.

[6] Huang Shuoa, Zhou Pinga, Shi Haoa , Sun Yua, Wan Suirena.Image Speckle Noise Denoising by a Multi-Layer Fusion Enhancement Method based on Block Matching and 3D Filtering. International Laboratory for Children's Medical Imaging Research, School of Biological Sciences and Medical Engineering.2020;17(4):1-17.

[7] Melaku Bitew, Haile,Ayodeji, Olalekan Salau, Icon,Belay Enyew,Abebech, Jenber Belay. Detection and classification of gastrointestinal disease using convolutional neural network and SVM. Cogent Engineering.2022;9(1):1-14.

[8] Abdulaziz Saleh, Yeslem Bin-Habtoor, Salem Saleh Al-amri. Removal Speckle Noise from Medical Image Using Image Processing Techniques. International Journal of Computer Science and Information Technologies.2016;7 (1):375-377.

[9] K Karthikeyan, C.Chandrasekar. Speckle Noise Reduction of Medical Ultrasound Images using Bayesshrink Wavelet Threshold. International Journal of Computer Applications 2011;22(9):8-14.

[10] Ahmed S.Bafaraj. Performance Analysis of Best Speckle Filter for Noise Reduction in Ultrasound Medical Images. International Journal of Applied Engineering Research.2019;14(6):1340-1351.

[11] S LeenaNesamani S, Nirmala SugirthaRajini, M S. Josphine, J Jacinth Salome. Deep Learning-Based Mammogram Classification for Breast Cancer Diagnosis Using Multi-level Support Vector Machine. Springer Lecture Notes in Electrical Engineering.2021;700(2):371-383.

[12] Nalin Kumar , M Nachamai. Noise Removal and Filtering Techniques used in Medical Images. Oriental Journal Of Computer Science & Technology.2017;10(1):103-113.

[13] Pichid Kittisuwan. Speckle Noise Reduction of Medical Imaging via Logistic Density in Redundant Wavelet Domain. International Journal on Artificial Intelligence Tools. 2018;27(2):45-52.

[14] S Rameshkumar, J AnishJafrinThilak, P Suresh, S Sathishkumar,N Subraman. Speckle Noise Removal in MRI Scan Image Using WB – Filter. International Journal of Innovative Research in Science, Engineering and Technology.2018; 28(1):1079- 21083.

[15] S Anitha ,L Kola, P Sushma, S Archana. Analysis of filtering and novel technique for noise removal in MRI and CT images. IEEE International Conference on Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT). 2017;2018(2):825-827.

[16] B Deepa, M G Sumithra. Comparative analysis of noise removal techniques in MRI brain images. IEEE International Conference on Computational Intelligence and Computing Research (ICCIC).2015;25(4):1-4.

[17] Rajaguru Harikumar, Chakravarthy Sannasi. Efficient Denoising Framework for Mammogram Images with a New Impulse Detector and Non-Local Means. Asian Pacific Journal of Cancer Prevention.2020;21(4):179-183.