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# Noise reduction in the medical images using hybrid combination of filters with nature-inspired Black Widow Optimization Algorithm

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**Abstract:** This paper proposes an image filtering method to remove the noises in medical images in a controlled manner. To achieve this goal, the optimal parameters of the conventional filters are determined using the nature-inspired black widow (BWO) optimization algorithm to remove the noise efficiently. The BWO algorithm is chosen over other optimization algorithms because it quickly explores the optimal parameter values due to its procreate and cannibalism steps. The procreate step explores new solutions, whereas the cannibalism steps remove the inappropriate solutions while exploring the optimal solution. In the proposed method, speckle and sharpening filters are considered. In the proposed method, initially, medical images are read. After that, they are enhanced using the power law method because images are either low or high contrast. In the power law method, the gamma value plays an important role. Therefore, the optimal gamma value is determined using the BWO algorithm as done for the filter values. After that, noise addition is performed on them and removed them using the speckle filter. Further, the edges of the image are filtered using the sharpening filter. The proposed method is validated on the standard dataset images downloaded from Kaggle. It is found that the proposed method enhances the image and removes the noise in a controlled manner. Besides that, it achieves better Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) in the output.

## Introduction

In the medical field, digital image processing is crucial for the early detection of potentially life-threatening disorders (Aslam et al., 2020). In the present era, numerous ultrasounds, x-ray and other similar instruments, generate innumerable medical images regularly (Goel et al. 2016). These images contain critical information about various diseases that doctors analyse to treat patients. However, these images contain unwanted noises (Maity et al., 2015). These noises are generated due to image sensors affected due to environmental conditions such as low light, conflict in the transmission channel and dust particles (Maity et al., 2015).

The most important noise that is presented in the medical images includes “salt and pepper”, “impulse”, “gaussian noise”, and “speckle noise” (Sanchez et al., 2012; Ravishankar et al., 2017; Ali, 2018; Gupta et al., 2018). Out of these noises, speckle noise is common in ultrasound images and it gradually distorts an image. In addition, it causes uneven pixel distribution. The following equation describes speckle noise as the sum of multicative and additive noise (Arulpandy and Pricilla, 2020):

$$G(i,j) = g(i,j) * \gamma(i,j) + \eta(i,j) \quad (1)$$

In Eq. (1), $G(i,j)$ is the observed image, $\gamma(i,j)$ is a multiplicative noise, $g(i,j)$ is the noise-free image, and $\eta(i,j)$ is additive noise. Due to this noise edges, texture, and lines of the images are affected. Various filter methods are used to remove this noise, such as mean

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filter, medial filter, gaussian filter, speckle filter, wiener filter, and geometric filter (Bharati et al., 2020). However, these filtering methods filter the images without considering the noise level. Besides that, the images face another challenge known as low or high contrast, which negatively impacts the visual analysis to overcome this limitation, enhancement methods like histogram equalization (Patel et al., 2019), contrast stretching (Panse and Gupta, 2021), contrast adaptive histogram equalization (Khan et al., 2020), and the power law method (Jindal et al., 2014). These methods enhance the images without considering the image characteristics. Besides that, out of these methods, the power law method is most preferred because determining the optimal parameter value of this method enhances the image in a controlled manner (Azmi et al., 2019; Singh and Singh, 2010; Dabass and Vig, 2018; Islam and Mondal, 2019). So, the main challenge is identifying the appropriate filtering and power law parameter value.

The main contribution of this paper is to employ the nature-inspired optimization algorithm for power law and filtering methods. The benefit of employing a nature-inspired optimization algorithm for these methods is that it enhances and filters the image in a controllable manner. To achieve this goal, the nature-inspired algorithm is hybrid with existing power law and filtering methods. The main role of the nature-inspired algorithm is to find the optimal parameter values of these methods. We have selected the nature-inspired black widow optimization (BWO) algorithm in the proposed method due to its better exploration rate to find the optimal solution over other algorithms. It is based on the mating process of the black spiders and it has three steps procreation, cannibalism, and mutation (Hayyolalam et al., 2020). The procreate and cannibalism steps play an important role because these steps generate number of offspring and remove irrelevant solutions while exploring the optimal solution. The simulation evaluation is accomplished on the standard dataset images downloaded from *Kaggle* website. Further, subjective, and objective analysis is performed and based on this analysis compared with the existing filtering methods. The results of our method show that it outperforms the existing method.

The remaining paper is defined as follows. Next, relevant literature is explained. After that, in the material and method section, a detailed description of the power law method, sharpening and speckle filter, black widow optimisation algorithm, and proposed method is given. Further, in the result and analysis section, the simulation evaluation of the proposed method is shown. Finally, conclusion is drawn.

Researchers have deployed various filters to remove the noise in the medical images in the literature. Sudha et al. (2009) removed the speckle noise using a wavelet thresholding method. In their method, the optimal threshold value of the wavelet method is determined using the universal threshold function because a small threshold value leaves behind the all-noise coefficient, whereas a high threshold value generates a zero coefficient that produces artifacts and blurs the image. Kumar and Nachamai (2017) evaluated the three filters, wiener, gaussian, and median filters, to remove the “salt and pepper”, “gaussian”, “speckle”, and “poison noise”. The results show that when compared to salt and pepper noise, the median filter works better, while the wiener filter performs better when compared to speckle and gaussian noise. Choi et al. (2018), combined the SRAD, guided filter, and exponential transform to remove the “speckle noise”. Initially, in their work, a SRAD filter is applied. After that, the remaining noise is removed using a guided filter by transforming the noise into logarithms. Finally, the exponential transform is used to get the filtered image in the output. Ahmed et al. (2020), hybridize the filtering and edge detection methods to remove the “speckle noise” and preserve the edges. In their work, five filters and edge detection techniques are taken into consideration to remove speckle noise. Initially, in their work, the five filters are applied individually. After that, the filter that outperforms the others is chosen, and different edge detection techniques are applied to it. The result shows that the hybridization of the lecasort filter with the Sobel filter gives superior performance over others. Pradeep and Nirmaladevi (2021) deployed the spatial and transform domains and CNN methods to remove the speckle noise. Their results show that transform domain approaches outperform spatial domain methods due to the filter window size. On the other hand, CNN outperforms the spatial and transform domains because it extracts various image features. However, CNN provides higher complexity than the spatial and transform domain methods. Khan et al. (2022) used the eight de-speckling filters to remove the speckle noise in the ultrasound images. Out of these filters, the “frost and adaptive homomorphic filters” outperform others in terms of different quality metrics and statistical tests.

In the literature, most of the researchers apply different filters to remove the speckle noise or hybridize it with edge or threshold methods to preserve the edges or remove the artifacts. However, none of the researchers has determined the optimal values of the filter to remove the noise in a controlled manner. This problem is taken

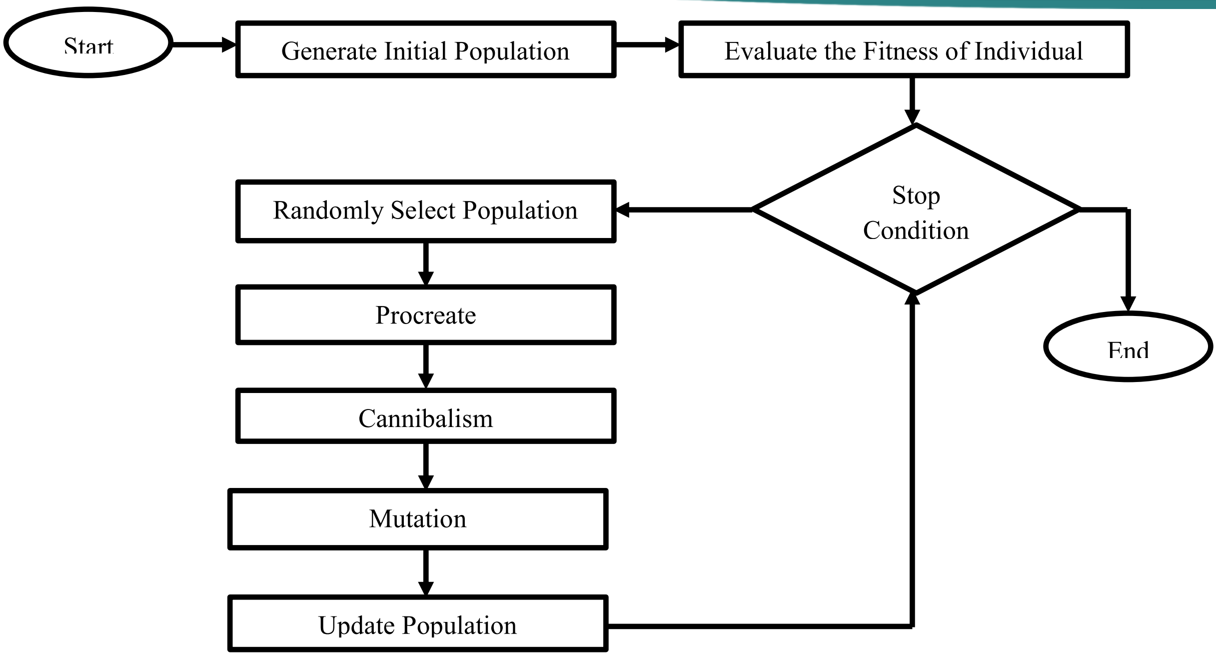


**Figure 1. Flowchart of the BWO Algorithm (Hayyolalam et al., 2020)**

under consideration in this paper, and a filtering method is proposed to determine the optimal parameter values of the filters and an enhancement method based on the BWO algorithm.

## Materials and Methods

In this section, we have explained the power law and filtering methods that are considered for noise removal in medical images. Besides that, a detailed description of the BWO algorithm is given, which is considered to determine the optimal parameter values of the power law and filtering methods.

## Power Law Method

This method is used for gamma correction of the image. The gamma value basically represents the brightness of the image (Azmi et al., 2019). It is calculated using Eq. (2).

$$I_{Out} = 255\left(\frac{I_{in}}{255}\right)^{\gamma} \quad (2)$$

In Eq. (2), $I_{in}$ *and* $I_{Out}$ denotes the input and output image, whereas $\gamma$ is the application-dependent constant and used for enhance the naturalness of the image. A value of $\gamma > 1$ makes the image darker, whereas $\gamma < 1$ makes the image brighter. According to the image contrast, the optimal parameter value of $\gamma$ is determined using the BWO algorithm in the proposed method.

## Filtering Methods

In the proposed noise removal method, sharpening and speckle filters are taken into consideration. Therefore, this section gives a detailed description of the sharpening and speckle filer to understand the proposed method.

## Sharpening Filter

The sharpening filter is used to denoise the edges of the images efficiently. The sharpening filter uses the unsharp method (Bahadur and Lakshmanan, 2020). In the proposed method, we have used the inbuilt function of a sharpening filter (*imsharpen*). The syntax of this function is shown below.

$$j = imsharpen(I, radius, amount, threshold) \quad (3)$$

In Eq. (3), the $I$ denotes the input image, radius, amount, and threshold are variable parameters in it and their optimal values are determined using the BWO algorithm in the proposed method.

## Speckle Filter

This filter uses the speckle-reducing anisotropic diffusion (SRAD) algorithm for reduce the noise ("*Filter image using speckle-reducing anisotropic diffusion-MATLAB specklefilt*"). In the proposed method, we have used the inbuilt function of a speckle filter (*specklefilt*). The syntax of this function is shown below.

$$j = specklefilt(Inoise, degree\ of\ smoothing, number\ of\ iterations) \quad (4)$$

In Eq. (4), the $Inoise$ denotes the input image. On the other hand, the $degree\ of\ smoothing$ parameter value varies between [0-1] and a higher value it denoises the image to a greater degree. Lastly, the number of iterations should be a positive integer and a higher value of efficiently denoise the image. The proposed noise removal method determines the optimal parameter values of the "degree of smoothing" and "number of iterations" using the BWO algorithm.

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## Black Widow Optimization Algorithm

The black widow optimization (BWO) algorithm is based on the mating process of black widow spiders (Hayyolalam et al., 2020). The black widow spiders can mate in parallel. Thus, it can generate the number of offspring over the other species. On the other hand, for survival purposes, strong spiders eat weak spiders in the earlier phase of their life because they can't move or search for prey. These characteristics are observed by researchers (Vahideh Hayyolalam and Ali Asghar Pourhaji Kazem, 2020) and they proposed a BWO algorithm. The flowchart of the BWO algorithm is shown in Figure 1. The research defines the offspring generation procedure as a procreate step, whereas eating the weak spiders for survival purposes is a cannibalism step in the optimization algorithm. A detailed description of each step is given below.

- Generate Initial Population: The optimization algorithm population parameter determines how many agents search the solution space. The problem-specific population is randomly started in the lower and upper limits at this point in time. In the BWO algorithm, this parameter defines the total number of black spiders considered.
- Procreate Step: In this step, the initial populations are randomly chosen and some operations are performed between them to generate a new population known as offspring. In the BWO algorithm, the population is basically the spiders taken as parents and the mating process is performed between them to generate new offspring.
- Cannibalism Step: In this step, the inappropriate solutions are removed while exploring the solution space. In the BWO algorithm, this step is basically a survival step where strong spiders eat the weak ones. The benefit of this step is that the inappropriate solutions are removed while finding the optimal solution. Besides that, in the next iterations, the mating process is performed with the best spiders.
- Mutation Step: The mutation step is basically performed to update the population to explore the new solutions. In most of the optimization, its value should be smaller.
- Fitness Function: The optimization algorithms evaluate the populations based on the fitness function. The fitness function is basically and objective function. Based on this parameter, the population are evaluated and which population gives the best fitness is taken as the optimal solution.
- Stopping Condition: The iteration parameter is basically defining the stopping condition. This parameter iterates the whole algorithm for a fixed number of iterations or until the desired solution is achieved.

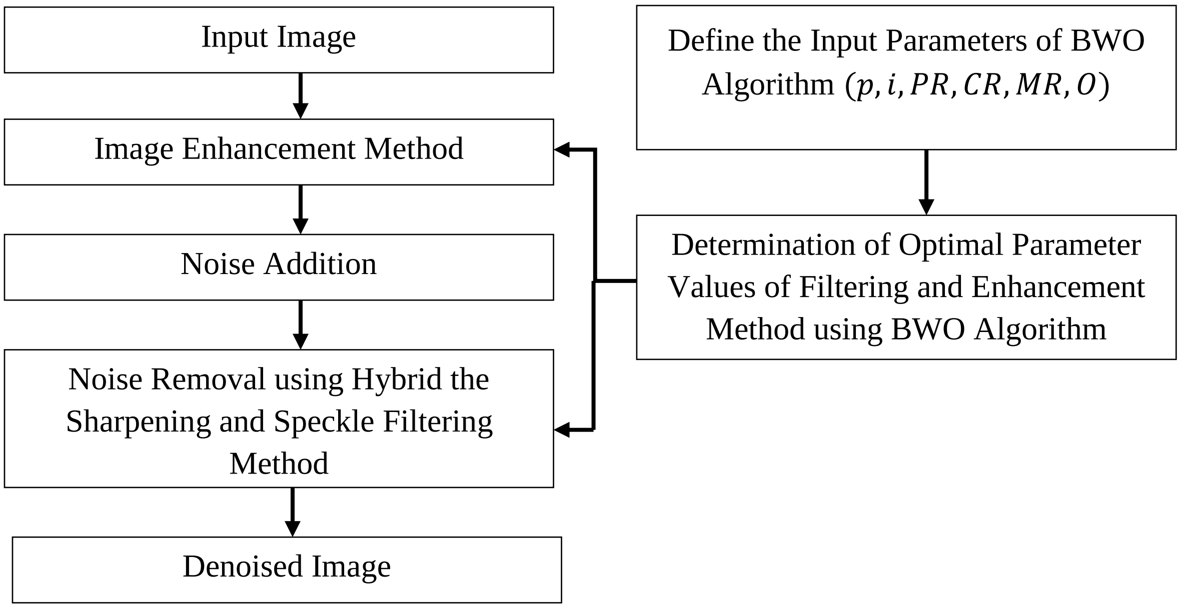



**Figure 2. Flowchart of the Proposed Method based on BWO Algorithm**

## Proposed Method

This section explains the proposed noise removal method is designed to remove the noise in a controlled manner. The flowchart for it is shown in Figure 2. In this model, BWO algorithm is utilized to find the parameter values of the power-law and filtering methods.

Initially, a standard dataset of ultrasound images is downloaded from the *Kaggle* dataset. The ultrasound images are low-contrast images therefore, it is enhanced using the power law method. The objective function

**Table 1. Performance Parameters**

| Parameters | Equation |
|---|---|
| Entropy | $E = \sum_{k=0}^{L-1} \mathrm{p(k)} \log_2 p(k)$ (5) |
| MSE | $MSE = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} (I_{in} - I_{out})^2$ (6) |
| RMSE | $RMSE = \sqrt{MSE}$ (7) |
| PSNR (in dB) | $PSNR = 10 \log_{10} \frac{P^2}{MSE}$ (8) |
| SNR | $SNR = 10 log \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} (I_{in})^2}{\sum_{i=1}^{M} \sum_{j=1}^{N} (I_{in} - I_{out})^2}$ (9) |
| Sobel Count | It measures the total number of edges in the image. More edges specify more specific characteristics of the image. |
| Execution Time | The execution time parameter is measured to determine how much time the proposed method spends to filter the images. It is measured in seconds. |
| Note: $\boldsymbol{I_{in}}$, $\boldsymbol{I_{out}}$ denotes the input and output images. On the other hand, ***MN*** denotes the rows and columns of the images. | |

**Table 2. Parameter Values of the BWO Algorithm**

| Parameter | Value |
|---|---|
| Total Population | 30 |
| Total Iterations | 50 |
| Procreate Rate | 50% |
| Cannibalism Rate | 50% |
| Mutation Rate | 0.1 |
| Objective Function for Image Enhancement | Entropy |
| Objective Function for Image Filtering Methods | Sobel Count and MSE |
| Lower and Upper Limits for Enhancement Method | [1-4] |
| Lower and Upper Limits for Sharpening Filter Method | Radius: 1.5<br>Amount: [0-2]<br>Threshold: [0-1] |
| Lower and Upper Limits for Speckle Filter Method | Degree of sharpening: [0-1]<br>No. of iterations: Positive Integer |

**Table 3. Objective Analysis of the Proposed Noise Removal Method**

| Images | Input Entropy | Output Entropy | MSE | RMSE | PSNR (in dB) | Sobel Count | Execution Time (in Seconds) |
|---|---|---|---|---|---|---|---|
| 1 | 7.687 | 7.6122 | 97.098 | 9.8538 | 28.259 | 21.238 | 218.8606 |
| 2 | 7.6054 | 7.5666 | 86.467 | 9.2987 | 28.762 | 21.099 | 212.5027 |
| 3 | 7.6709 | 7.5933 | 113.82 | 10.669 | 27.569 | 20.931 | 231.2834 |
| 4 | 7.6555 | 7.638 | 107.6 | 10.373 | 27.813 | 21.214 | 210.3578 |
| 5 | 7.7124 | 7.5907 | 181.94 | 13.489 | 25.531 | 20.599 | 216.3684 |
| Average | 7.66624 | 7.60016 | 117.385 | 10.7367 | 27.5868 | 21.0162 | 217.8746 |

determines the ideal gamma value for the power law approach to regulating image enhancement.

We have taken entropy as the objective function for enhancement purposes. After that, noise addition is performed on it. The ultrasound images present numerous types of noises, such as salt and pepper, impulse, gaussian, and speckle noises. Out of these, speckle noise is the most common. Therefore, we have combined the two filters, namely, the sharpening and speckle filter, to remove the noise in a controlled manner. In the sharpening filter, three parameters (radius, amount, and threshold) and two parameters in the speckle filter, such as degree of smoothing and iteration, play an important role. Therefore, optimal parameter values of the power law method and filtering methods are determined using the black widow optimization algorithm. Finally, the proposed method's subjective and objective analysis is done.

As shown in Table 1, subjective analysis compares input, intermediate, ad output images based on visual quality, whereas objective analysis measures MSE, RMSE, PSNR, SNR, entropy, and sobel count. The BWO algorithm determines the optimal parameter values for the power law and filtering methods in the proposed method. Thus, how the BWO algorithm is adapted for the proposed method is explained below.

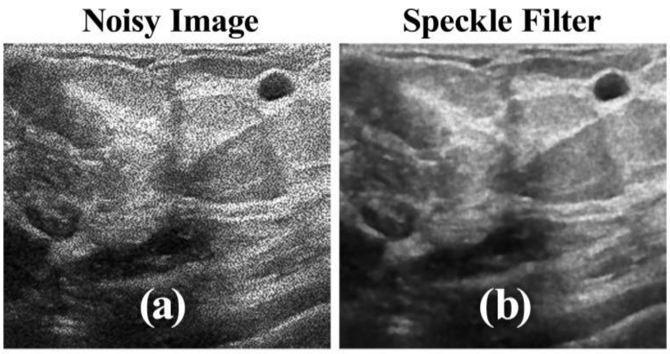
- Initially, parameter values of the BWO algorithm are defined, such as population size (*p*) Iterations (*i*), procreate rate (*PR*), cannibalism rate (*CR*), mutation rate (*MR*), and objective function (*O*).
- The population array is randomly generated in the lower and upper limits of the parameter value is taken under consideration. The size of the population array is dependent on the population size.
- The fitness evaluation of the population is done based on the objective function is taken under consideration.
- 


**Figure 3. Subjective Analysis of the Proposed Noise Removal Method. (a) Image after Noise Addition (b) Output Image (After Speckle Filter)**

- After that, populations are selected randomly as parents and according to the procreate rate, offspring generation is done and fitness evaluation is done.
- The initial population array and array generated in the procreate step due to offspring are concatenated.
- In the cannibalism step, according to the cannibalism rate, the inappropriate solutions are removed based on the fitness function.
- In the mutation step, according to the mutation rate, the population array value is updated to explore new solutions.
- The operation is repeated until iterations are not finished.

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## Results and Discussion

This section shows the simulation results and comparative analysis with the existing filtering method. The standard dataset images are downloaded from Kaggle website. The Kaggle website contains a huge library of medical images. Further, Table 2 demonstrates that the BWO algorithm parameter values are considered for image enhancement and filtering technique parameter optimization.

### Subjective Analysis

Figure 3 shows the subjective analysis of the proposed method. In the subjective analysis, the input image with noise and output images are compared based on the visual quality. The result shows that the output images are enhanced and noise is removed from them.

Table 3 shows the outcomes of the objective analysis of the proposed noise removal method based on the various parameters. It achieves better entropy, low MSE, and a high value of PSNR.

### Comparative Analysis

This section compares the proposed method based on MSE and PSNR parameter with the existing filtering method. The result demonstrates that the proposed method achieves 117.385 MSE and 27.5868 dB PSNR whereas bilateral filter achieves 460.854 MSE and 21.614 dB.

**Table 4. Comparative Analysis**

| Methods | MSE | PSNR (in dB) |
|---|---|---|
| Bilateral Filter | 460.854 | 21.614 |
| Proposed Method | 117.385 | 27.5868 |

We have found the following key finding from the analysis. The population size and total iterations are important in the nature-inspired algorithm. The number of agents that will be used to seek the solution space is determined by a parameter known as population size. In addition, the iteration parameter establishes the number of times a nature-inspired algorithm is iterated in order to accomplish the desired goal. The parameter population size defines how many agents are considered to search the solution space. Further, the iteration parameter defines how often a nature-inspired algorithm is iterated to achieve the desired objective. On the other hand, procreate and cannibalism rate plays an important role in the BWO algorithm. The higher value of procreate and cannibalism rate defines more offspring generation and inappropriate solution reduction in each iteration and vice versa. The proposed method takes a longer execution time than the conventional power law and filtering methods because the BWO algorithm is hybrid and it searches the best parameter values based on the objective function.

## Conclusion

In this paper, we have successfully applied the nature-inspired black widow optimization algorithm for power law and filtering methods. The proposed BWO algorithm enhances and filters the image depending on the objective function. Besides that, the BWO algorithm quickly explores the optimal parameter values of the power law and filtering methods due to procreate and cannibalism stage. Further, subjective analysis of the proposed method shows that images are enhanced after the power law method. Further, noise is removed after sharpening and speckle filter method. Finally, the comparative analysis based on MSE and PSNR shows that the proposed noise removal method achieves better results over the existing method.

## Conflict of Interest

None

## References

Ahmed, M., Sanad, A., Mohmed, H., & Ibrahim, A. (2020). Reduction of Speckle Noise and Image Enhancement in Ultrasound Image Using Filtering Technique and Edge Detection. *Journal of Clinical Engineering*, *45*(1), 51–65. https://doi.org/10.1097/jce.0000000000000378

Ali, H. M. (2018). MRI medical image denoising by fundamental filters. *High-Resolution Neuro-imaging -Basic Physical Principles and Clinical Applications*, *14*, 111-124. https://dx.doi.org/10.5772/intechopen.72427

Arulpandy, P., & Pricilla, M. T. (2020). Speckle noise reduction and image segmentation based on a modified mean filter. *Computer Assisted Methods in Engineering and Science*, *27*(4), 221-239. http://dx.doi.org/10.24423/cames.290

Aslam, M. A., Munir, M. A., & Cui, D. (2020). Noise Removal from Medical Images Using Hybrid Filters of Technique. *Journal of Physics: Conference Series*, *1518*(1), 012061. https://doi.org/10.1088/1742-6596/1518/1/012061

Bahadur, D. J., & Lakshmanan, L. (2022). A Novel Method for Optimizing Energy Consumption in Wireless Sensor Network Using Genetic Algorithm. *Microprocessors and Microsystems*, 104749. https://doi.org/10.1016/j.micpro.2022.104749

Bharati, S., Khan, T. Z., Podder, P., & Hung, N. Q. (2020). A Comparative Analysis of Image Denoising Problem: Noise Models, Denoising Filters and Applications. *Cognitive Internet of Medical Things for Smart Healthcare*, 49–66. https://doi.org/10.1007/978-3-030-55833-8_3

Choi, H.-H., & Jeong, J. (2018). Speckle noise reduction in ultrasound images using SRAD and guided filter. *2018 International Workshop on Advanced Image Technology (IWAIT)*. https://doi.org/10.1109/iwait.2018.8369653

Dabass, J., & Vig, R. (2018). Biomedical Image Enhancement Using Different Techniques - A Comparative Study. *Data Science and Analytics*, 260–286. https://doi.org/10.1007/978-981-10-8527-7_22

*Filter image using speckle-reducing anisotropic diffusion - MATLAB specklefilt*. (n.d.). Www.mathworks.com. https://www.mathworks.com/help/medical-imaging/ref/specklefilt.html

Goel, N., Yadav, A., & Singh, B. M. (2016). Medical image processing: A review. *2016 Second International Innovative Applications of Computational Intelligence on Power, Energy and Controls with Their Impact on Humanity (CIPECH)*. https://doi.org/10.1109/cipech.2016.7918737

Guadalupe Sanchez, M., Vidal, V., Verdu, G., Mayo, P., & Rodenas, F. (2012). Medical image restoration with different types of noise. *2012 Annual International Conference of the IEEE Engineering in Medicine and Biology Society*. https://doi.org/10.1109/embc.2012.6346937

Gupta, M., Taneja, H., & Chand, L. (2018). Performance Enhancement and Analysis of Filters in Ultrasound Image Denoising. *Procedia Computer Science*, *132*, 643–652. https://doi.org/10.1016/j.procs.2018.05.063

Hayyolalam, V., & Pourhaji Kazem, A. A. (2020). Black Widow Optimization Algorithm: A novel meta-heuristic approach for solving engineering optimization problems. *Engineering Applications of Artificial Intelligence*, *87*, 103249.

Islam, S. M., & Mondal, H. S. (2019, July 1). *Image Enhancement Based Medical Image Analysis*. IEEE Xplore. https://doi.org/10.1109/ICCCNT45670.2019.8944910

Jindal, K., Gupta, K., Jain, M., & Maheshwari, M. (2014). Bio-medical image enhancement based on spatial domain technique. *2014 International Conference on Advances in Engineering & Technology Research (ICAETR - 2014)*. https://doi.org/10.1109/icaetr.2014.7012932

Khan, M. N., & Altalbe, A. (2022). Experimental evaluation of filters used for removing speckle noise and enhancing ultrasound image quality. *Biomedical Signal Processing and Control*, *73*, 103399. https://doi.org/10.1016/j.bspc.2021.103399

Khan, S. A., Hussain, S., & Yang, S. (2020). Contrast Enhancement of Low-Contrast Medical Images Using Modified Contrast Limited Adaptive Histogram Equalization. *Journal of Medical Imaging and Health Informatics*, *10*(8), 1795–1803. https://doi.org/10.1166/jmihi.2020.3196

Kumar, N., & Nachamai, M. (2017). Noise removal and filtering techniques used in medical images. *Orient. J. Comput. Sci. Technol.*, *10*(1), 103-113.

Maity, A., Pattanaik, A., Sagnika, S., & Pani, S. (2015). A Comparative Study on Approaches to Speckle Noise Reduction in Images. *2015 International Conference on Computational Intelligence and Networks*. https://doi.org/10.1109/cine.2015.36

Mohd Azmi, K. Z., Abdul Ghani, A. S., Md Yusof, Z., & Ibrahim, Z. (2019). Natural-based underwater image color enhancement through fusion of swarm-intelligence algorithm. *Applied Soft Computing*, *85*, 105810. https://doi.org/10.1016/j.asoc.2019.105810

Panse, V., & Gupta, R. (2021). Medical Image Enhancement with Brightness Preserving Based on Local Contrast Stretching and Global Dynamic Histogram Equalization. *2021 10th IEEE International Conference on Communication Systems and Network Technologies (CSNT)*. https://doi.org/10.1109/csnt51715.2021.9509670

Patel, S., Bharath, K. P., Balaji, S., & Muthu, R. K. (2019). Comparative Study on Histogram Equalization Techniques for Medical Image Enhancement. *Advances in Intelligent Systems and Computing*, 657–669. https://doi.org/10.1007/978-981-15-0035-0_54

Pradeep, S., & Nirmaladevi, P. (2021, February). A review on speckle noise reduction techniques in ultrasound medical images based on spatial domain, transform domain and CNN methods. In *IOP*

*Conference Series: Materials Science and Engineering* (Vol. 1055, No. 1, p. 012116). IOP Publishing.

Ravishankar, A., Anusha, S., Akshatha, H. K., Raj, A., Jahnavi, S., & Madhura, J. (2017). A survey on noise reduction techniques in medical images. *2017 International Conference of Electronics, Communication and Aerospace Technology (ICECA).* https://doi.org/10.1109/iceca.2017.8203711

Singh, T. R., & Singh, K. M. (2010). Image Enhancement by Adaptive Power-Law Transformations. *Bahria University Journal of Information & Communication Technologies (BUJICT), 3*(1). https://ojs.bahria.edu.pk/index.php/bujict/article/view/26

Sudha, S., Suresh, G. R., & Sukanesh, R. (2009). Speckle noise reduction in ultrasound images by wavelet thresholding based on weighted variance. *International Journal of Computer Theory and Engineering*, *1*(1), 7.

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