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IMPROVEMENT OF DIGITAL IMAGE USING A COMBINATION OF ALPHA TRIMMED MEAN FILTER AND ARITHMETIC MEAN FILTER

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Abstract

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The development of technology at this time causes the provision of information to increase through social media. Many social media users convey information by including digital images. Digital images are very important in conveying the accuracy of information. However, digital images often experience various disturbances, such as decreased pixel quality, less sharpness, blurring, and the appearance of noise in the image. Noise contained in the image causes a decrease in image quality. Image degradation can be caused by uneven light intensity and can also be caused by dirt adhering to the camera lens. There are various types of noise found in digital images, including Salt And Pepper Noise, Speckle Noise, and Rayleigh Noise. There are many filtering methods that can improve digital images from noise interference. Some of them are the Mean Filter method, Geometric Mean Filter, Harmonic Mean Filter, Arithmetic Mean Filter, Median Filter, Midpoint filter, Alpha Trimmed Mean Filter and so on. Based on the research conducted, the combination of the Alpha Trimmed Mean Filter and Arithmetic Mean Filter methods can reduce Salt and Pepper noise, Speckle noise and Rayleigh noise better than the Alpha Trimmed Mean Filter and Arithmetic Mean Filter methods based on the MSE, RMSE and PSNR parameters.

Keywords : Image, Noise, Filter, Alpha Trimmed Mean Filter, Arithmetic Mean Filter.

1. INTRODUCTION

Digital images are very important in conveying the accuracy of information. However, digital images often experience various disturbances, such as decreased pixel quality, less sharpness, blurring, and the appearance of noise in the image. Noise contained in the image causes a decrease in image quality. Image degradation can be caused by uneven light intensity and can also be caused by dirt adhering to the camera lens [1]. There are various types of noise found in digital images, including Salt And Pepper Noise, Speckle Noise, and Rayleigh Noise. Salt And Pepper Noise is shaped like black and white spots in the image. Speckle Noise is a noise model that gives black color at the point affected by noise [2], while Rayleigh Noise usually appears in the range of radar and moving images [3]. In such conditions, image enhancement is needed which aims to get an image display with a better form of visualization.

There are many filtering methods that can improve digital images from noise interference. Some of them are the Mean Filter method, Geometric Mean Filter, Harmonic Mean Filter, Arithmetic Mean Filter, Median Filter, Midpoint filter, Alpha Trimmed Mean Filter and so on.

Digital image improvement requires a method called Filtering. Filtering methods can improve digital images from noise interference and improve image quality [4]. There are many filtering methods that can improve digital images from noise interference [5]. Some of them are the Mean Filter method, Geometric Mean Filter, Harmonic Mean Filter, Arithmetic Mean Filter, Median Filter,

Midpoint filter, Alpha Trimmed Mean Filter and so on. Several studies have been conducted to reduce noise in digital images. The Alpha Trimmed Mean Filter method is the best method in reducing Speckle Noise and Rayleigh Noise when viewed based on the MSE, PSNR and Running Time parameters of performance [6]. Other studies also conclude that the combination of the Geometric Mean Filter and Alpha Trimmed Mean Filter methods can reduce noise well [7].

While the Arithmetic Mean Filter method is a linear filter that functions to smooth and remove noise in an image that works by increasing the pixel value by the average of the pixel value with the neighboring pixel values [8]. Arithmetic Mean Filter is an algorithm that refines the image by calculating the average intensity of the image in each image block that is managed. Research conducted by [9] concluded that the Arithmetic Mean Filter method is a better method for reducing Exponential Noise compared to the Contraharmonic Mean Filter algorithm based on the MSE (Mean Square Error) and PSNR (Peak Signal-to-Noise) values.

This study applies the combination of Alpha Trimmed Mean Filter Method and Arithmetic Mean Filter Method in reducing Salt and Pepper noise, Speckle noise, and Rayleigh noise.

2. Literature Review

Several studies that support this research can be seen from the research conducted by previous authors related to image improvement, namely research (Ismail, 2017) conducted research on the Comparison of the Combination of Alpha Trimmed Mean Filter and Geometric Mean Filter Methods for Reducing Noise in Digital Images. The test results conclude that Gaussian Noise is best reduced by the Geometric Mean Filter method. Speckle Noise is best reduced by combining the Geometric Mean Filter method with the Alpha Trimmed Mean Filter. While Uniform Noise is best reduced by a combination of the Alpha Trimmed Mean Filter method with the Geometric Mean Filter. (Restima, 2021) in research on the Implementation of Alpha Trimmed Mean Filter and Adaptive Median Filter Methods to reduce Poisson Noise in Digital Images. The results of the study concluded that the Adaptive Median Filter (AMF) was better used to reduce Poisson Noise compared to the Alpha Trimmed Mean Filter (ATMF). In the comparative analysis of the performance of the Mean Filter, Median Filter and Alpha Trimmed Mean Filter methods on Noise Reduction Speckle and Rayleigh conducted by (Riza et al., 2021) concluded that visually, the performance of the Mean Filter and Median Filter methods in reducing Speckle Noise and Rayleigh Noise produces almost the same image quality compared to the Alpha Trimmed Mean Filter method. However, based on the MSE, PSNR and Running Time parameters, the Alpha Trimmed Mean Filter method is the best method for reducing Speckle Noise and Rayleigh Noise. (Furqan et al., 2020) in a comparative study of the Contraharmonic Mean Filter Algorithm and Arithmetic Mean Filter for Reducing Exponential Noise concluded that the Arithmetic Mean Filter algorithm is a better algorithm for reducing Exponential Noise compared to the Contraharmonic Mean Filter algorithm which is proven based on the MSE (Mean) value. Square Error) and PSNR (Peak Signal-to-Noise Ratio).

3. Method

3.1 Alpha Trimmed Mean Filter

The Alpha Trimmed Mean Filter method is a filtering method that can reduce noise density and maintain edges [6]. The Alpha Trimmed Mean Filter method serves to give the lowest gray-level d/2 value and the highest d/2 value of g(s,t) in the neighborhood. This filter replaces the value of a pixel with the average value of the gray level in the subimage under the adjacency window of size mxn after subtracting the smallest d/2 value and d/2 largest value. The formula for the Alpha Trimmed Mean Filter method can be defined in the following equation:

$$f(x,y) = \frac{1}{mn-d}\sum (s,t) \in S_{xy}\, g\,(s,t)$$

Where *f(x y)* is a filtered coordinates, *mn* is the filter kernel dimension, *d* is input value (0-9), *g*(s,t) is the pixel intensity value that will be replaced by the filtering result value and $\sum(s,t) \in S_{xy}$ is the number of pixel intensities affected by the filtering process.

3.2 Arithmetic Mean Filter

The Arithmetic Mean Filter method has the property of eliminating noise by flattening the gray level value in a pixel [10]. The larger the filter size used, the more noise will disappear and result in a blurry image. Arithmetic mean filter can eliminate gaussian type noise that causes defects in the image and image background. Image quality improvement is done by influencing the amount of color intensity that composes the image. The following is the equation of the Arithmetic Mean Filter method:

$$f(x,y) = \frac{1}{mn} \sum_{(s,t) \in S_{xy}} g\,(s,t)$$

Where *f(x y)* is a filtered coordinates, *mn* is the filter kernel dimension, and s,t is the intensity value.

3.3 Mean Square Error (MSE)

Mean Square Error (MSE) is the average square of the error value between the original image before the filtering process and the resulting image after the filtering process. Mathematically MSE can be formulated:

$$MSE = \frac{1}{MN} \sum_{x=1}^{M} \sum_{y=1}^{N} (S_{xy} - C_{xy})^2$$

Where MN is the length and width of the image, S_{xy} is the value of the image intensity at the point *(x,y)* before filtering, and C_{xy} is the value of the image intensity at the point *(x,y)* after filtering.

3.4 Root Mean Squared Error (RMSE)

Root Square Mean Error (RMSE) is used to measure the error in the reduced image compared to the original image, shown as follows:

$$RMSE = \sqrt{\frac{1}{MN} \sum_{x=1}^{M} \sum_{y=1}^{N} (f(x,y) - f'(x,y))^2}$$

3.5 Peak Signal to Noise Ratio (PSNR)

Peak Signal to Noise Ratio (PSNR) is often used as a comparison parameter between the constructed image (noised or filtered) and the original image. PSNR is a comparison value between the maximum color value in the filtering image and the noise quantity which is the root of the average square of the error value (√MSE). Mathematically, the PSNR value can be formulated:

$$PSNR = 20 \log 10 \left(\frac{255}{\sqrt{MSE}}\right)$$

4. Results and Discussion

In this study, The filtering method was tested on 15 images with different image dimensions. The following are some of the images tested in this study:

Table 1. Filtering Test Results for Salt And Pepper noise

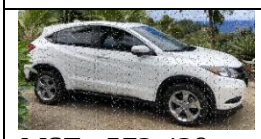
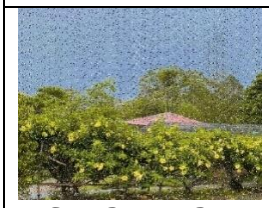
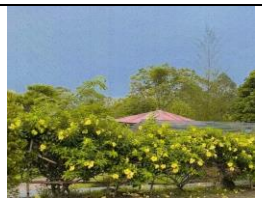
Salt and Pepper Noise	Result Image of ATMF + AMF	Result Image of Alpha Trimmed Mean Filter	Result Image of Arithmetic Mean Filter
 *MSE* : 572.429 *RMSE* : 32.8573 *PSNR* : 12.6939	 *MSE* : 149.339 *RMSE* : 38.6515 *PSNR* : 40,5180	 *MSE* : 179.708 *RMSE* : 42.3919 *PSNR* : 31,5140	 *MSE* : 226.170 *RMSE* : 47.5574 *PSNR* : 19,9053
 *MSE* : 352.413 *RMSE* : 17.2393 *PSNR* : 24.1465	 *MSE* : 176.513 *RMSE* : 39.5672 *PSNR* : 30.9782	 *MSE* : 198.746 *RMSE* : 41.1593 *PSNR* : 28.4637	 *MSE* : 212.687 *RMSE* : 46.9891 *PSNR* : 26.7654
 *MSE* : 875.189 *RMSE* : 48.8261 *PSNR* : 9.2456	 *MSE* : 348.674 *RMSE* : 26.1981 *PSNR* : 15.8796	 *MSE* : 493.881 *RMSE* : 28.9474 *PSNR* : 13.4563	 *MSE* : 521.329 *RMSE* : 31.5437 *PSNR* : 12.7590

Table 2. The average value of MSE, RMSE, and PSNR in reducing Salt and Pepper Noise on 15 test images

Filter Method	MSE Average	RMSE Average	PSNR Average
Combination of ATMF and AMF	1426.915	165.127	25.3037
Alpha Trimmed Mean Filter	1601.674	186.191	24.1552
Arithmetic Mean Filter	1850.621	193.627	23.2739

Based on table 1 and 2, the combination method of Alpha Trimmed Mean Filter and Arithmetic Mean Filter is the best in reducing Salt and Pepper noise, because it is able to produce the smallest MSE average value of 1426.915, RMSE value of 165.127 and the largest PSNR value of 25.3037 compared with the method before the combination.

Table 3. Filtering Test Results for Speckle noise

Speckle Noise	Result Image of ATMF + AMF	Result Image of Alpha Trimmed Mean Filter	Result Image of Arithmetic Mean Filter

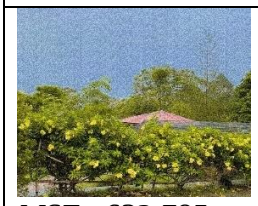
 *MSE* : 652.496 *RMSE* : 41.7865 *PSNR* : 8.72887	 *MSE* : 246.229 *RMSE* : 16.9389 *PSNR* : 21.6784	 *MSE* : 381.709 *RMSE* : 21.5890 *PSNR* : 14.7893	 *MSE* : 412.603 *RMSE* : 28.6753 *PSNR* : 11.8790
 *MSE* : 632.785 *RMSE* : 21.8962 *PSNR* : 20.6753	 *MSE* : 125.985 *RMSE* : 15.6535 *PSNR* : 22.7430	 *MSE* : 281.672 *RMSE* : 17.8779 *PSNR* : 23.9053	 *MSE* : 380.215 *RMSE* : 18.7854 *PSNR* : 24.8853
 *MSE* : 980.531 *RMSE* : 30.9874 *PSNR* : 19.8753	 *MSE* : 597.732 *RMSE* : 22.9864 *PSNR* :24.89543	 *MSE* : 658.765 *RMSE* : 24.9854 *PSNR* :22.9875	 *MSE* : 764.982 *RMSE* : 28.9764 *PSNR* : 19.8636

Table 4. The average value of MSE, RMSE, and PSNR in reducing Speckle Noise on 15 test images

Filter Method	MSE Average	RMSE Average	PSNR Average
Combination of ATMF and AMF	6073.241	650.127	23.80647
Alpha Trimmed Mean Filter	8764.358	869.191	22.74214
Arithmetic Mean Filter	9154.216	936.276	21.59628

Based on table 3 and 4, the combination method of Alpha Trimmed Mean Filter and Arithmetic Mean Filter is the best in reducing Speckle noise, because it is able to produce the smallest MSE average value of 6073.241, RMSE value of 650.127 and the largest PSNR value of 23.80647 compared to other methods. before combining.

Table 5. Filtering Test Results for Rayleigh noise

Rayleigh Noise	Result Image of ATMF + AMF	Result Image of Alpha Trimmed Mean Filter	Result Image of Arithmetic Mean Filter
 *MSE* : 784.998 *RMSE* : 53.7649 *PSNR* : 9.72922	 *MSE* : 346.278 *RMSE* : 20.8932 *PSNR* : 15.1827	 *MSE* : 481.293 *RMSE* : 29.4127 *PSNR* : 13.2746	 *MSE* : 523.917 *RMSE* : 32.8737 *PSNR* : 12.4573

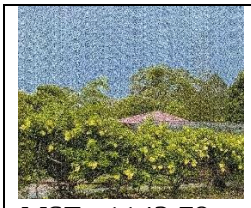
 *MSE* : 1143.78 *RMSE* : 74.8945 *PSNR* : 17.9956	 *MSE* : 570.3541 *RMSE* : 37.4326 *PSNR* : 21.8564	 *MSE* : 657.843 *RMSE* : 40.9743 *PSNR* : 20.6527	 *MSE* : 786.477 *RMSE* : 59.7346 *PSNR* : 19.8738
 *MSE* : 1363.732 *RMSE* : 89.4572 *PSNR* : 16.8724	 *MSE* : 754.665 *RMSE* : 52.7654 *PSNR* : 19.9675	 *MSE* : 897.214 *RMSE* : 64.8963 *PSNR* : 18.8703	 *MSE* : 940.532 *RMSE* : 73.7419 *PSNR* : 17.9631

Table 6. The average value of MSE, RMSE, and PSNR in reducing Rayleigh Noise on 15 test images

Filter Method	MSE Average	RMSE Average	PSNR Average
Kombinasi ATMF dan AMF	4281.029	196.339	25.2612
Alpha Trimmed Mean Filter	4687.125	245.407	24.5978
Arithmetic Mean Filter	5494.483	389.162	22.1173

Based on table 5 and 6, the combination method of Alpha Trimmed Mean Filter and Arithmetic Mean Filter is the best in reducing Rayleigh noise, because it is able to produce the smallest MSE average value of 4281.029, RMSE value of 196.339 and the largest PSNR value of 25.2612 compared to with the method before the combination.

5. Conclusions

The combination method of Alpha Trimmed Mean Filter and Arithmetic Mean Filter succeeded in reducing the noise contained in the image based on the MSE, RMSE, and PSNR values where the MSE and RMSE values produced were smaller, while the PSNR value was larger than the resulting image before the combination was carried out. The combination method of Alpha Trimmed Mean Filter and Arithmetic Mean Filter produces a clearer image than the filter results before the combination.

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