Journal of Artificial Intelligence and Engineering Applications

Website: https://ioinformatic.org/

15th June 2025. Vol. 4. No. 3; e-ISSN: 2808-4519

Optimization of Digital Image Processing Through Gaussian Filtering for Noise Reduction

Mazayah Tsaqofah[1], Lailan Sofinah Harahap[2*], Dea Syahfira Hasibuan[3]

[1,2,3] Ilmu Komputer, Universitas Islam Negeri Sumatera Utara:
tsaqofahmazayah@gmail.com[1], lailansofinahharahap@gmail.com[2], deasyahfira16@gmail.com[3]*

Abstract

Digital image processing plays a vital role in various fields such as medical imaging, remote sensing, surveillance, and multimedia. One of the most common challenges in image processing is the presence of noise, which can degrade image quality and affect the accuracy of subsequent analysis. This study focuses on optimizing digital image processing techniques using Gaussian filtering to reduce noise. Gaussian filtering is a widely used linear smoothing filter based on the Gaussian function, effective in reducing Gaussian noise while preserving important image features such as edges. The optimization involves adjusting kernel size and standard deviation parameters to achieve the best balance between noise reduction and detail preservation. Experimental results on different types of noisy images demonstrate that optimized Gaussian filtering significantly improves image clarity and quality, making it a reliable method for pre-processing in various image analysis applications. This research emphasizes the importance of parameter tuning in filtering techniques and highlights the potential of Gaussian filters in enhancing digital image processing systems.

Keywords: *Digital Image Processing, Gaussian Filter, Noise Reduction*

1. Introduction

Digital image processing is a field that is experiencing rapid development and has been widely used in various disciplines. In general, image processing is a process for analyzing images or images that are usually related to real objects. In this process, input and output data are in the form of images or images, with the aim of improving image quality so that the information displayed becomes clearer and in accordance with what is expected [1].

Gaussian filter is a type of linear filter that assigns a weight value to each element based on the Gaussian function form. This filter is often used for image smoothing processes because it has a central characteristic in its kernel, so that the filtering results are smoother and more focused [2]. In recent years, several studies have been conducted to develop more effective and efficient Gaussian Filtering methods. Some of the methods that have been developed include the use of adaptive kernel sizes, the use of different Gaussian functions, and the use of other image processing techniques.

However, there are still some unsolved problems in the use of Gaussian Filtering for noise reduction. One of the most important problems is how to determine the optimal kernel size to reduce noise without losing image details. Therefore, this study will discuss the optimization of digital image processing through Gaussian Filtering for noise reduction.

In this study, we will discuss the optimization of digital image processing through Gaussian Filtering for noise reduction. We will analyze several existing Gaussian Filtering methods and compare the results to determine the most effective method in reducing noise and maintaining image quality.
Image processing is a technique used to manipulate, analyze, and enhance digital images for a specific purpose. A digital image is a visual representation consisting of pixels arranged in a two-dimensional matrix. Each pixel has an intensity value that represents color or gray level information.

Gaussian filter is a very effective method in reducing interference or noise that has a normal distribution pattern (Gaussian noise), which is the type of noise that most often appears in digital images, especially those obtained through the use of cameras. This noise usually arises naturally as a result of the physical properties of light reflection and the response or sensitivity of the light sensor owned by the camera [3].

1.1. Noise

Noise is a disturbance that occurs due to errors or inconsistencies in the storage of digital data received by the image receiving device,

which can reduce image quality. This disturbance can be caused by physical factors (optics), such as dust or dirt attached to the camera lens, or due to the image processing process not being carried out properly [4].

Here are some types of images in digital processing:

1. Binary Image – Consists of only two levels of intensity, namely black (0) and white (1).
2. Grayscale Image – Has an intensity scale from 0 to 255, generally used in 8-bit images.
3. RGB Image (Color) – Consists of three main color components: red (Red), green (Green), and blue (Blue).
4. Multispectral Image – Has more than three color channels and is generally used in digital image processing applications.
5. Hyperspectral Image – Contains hundreds of color spectrum channels for more detailed and in-depth analysis purposes [5].

1.2. Gaussian Filtering

Gaussian Filtering is one of the techniques in image processing that is used to reduce noise or interference in images. This filter is linear and has a response that follows the Gaussian function. The process is done by applying a Gaussian filter to each pixel in the image. This filter uses a kernel in the form of a square matrix of a certain size containing Gaussian coefficient values. The kernel is used to calculate the weighted average of the pixels around the target pixel. The new value of each pixel is obtained through the convolution process between the Gaussian kernel and its neighboring pixels [6].

1.3. Optimalisasi Gaussian Filtering

Optimizing Gaussian filtering involves determining the most appropriate parameters and kernel size to maximize noise reduction without losing important details in the image. Several studies have used evaluation methods with metrics such as Peak Signal-to-Noise Ratio (PSNR) and Mean Squared Error (MSE) to assess how effective the noise reduction process is. In addition, some approaches adopt adaptive methods or combine them with machine learning algorithms to automatically set filter parameters based on the noise characteristics of a particular image [7].

2. Research Methodology

2.1. Methodology

In this study will be conducted on the type of digital image data that is generally often used and has a relatively small size and can provide information. This study includes flower images, and then the flower image will be converted from RGB to Grayscale.

In this process, noise reduction will be carried out through the image smoothing process (noise reduction), to carry out this process the author uses the gaussian filter method. And the final process the author increases the contrast or pixel intensity adjustment so that the image appears brighter and clearer.

2.2. Flowchart

Flowchart or flow diagram is a visual representation of an algorithm in the form of a diagram. This diagram consists of various two-dimensional graphic shapes (nodes) that are connected to each other by connecting lines. Each graphic shape represents a specific process or action, and usually contains text that explains the step. The following flowchart presents the overall sequence of processes or logic in improving image quality, especially at the noise reduction stage. This diagram also illustrates the level of detail in solving the problem using the Gaussian Filter method.

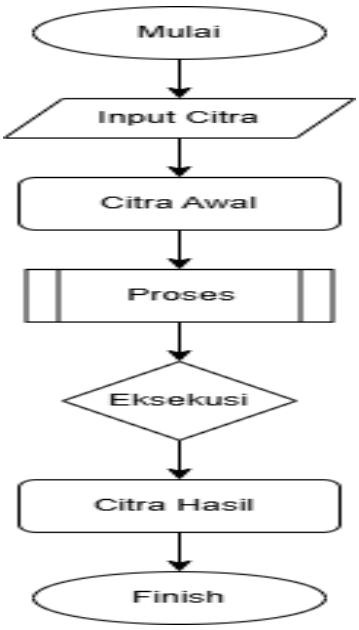

Fig. 1: Flowchart

3. Result and Discussion

In digital image processing, visual quality is an important aspect that influences further analysis processes such as segmentation, classification, or object detection. One common problem often found in images is noise, which is random interference in the form of bright or dark dots that reduce the sharpness and clarity of the image. To overcome this, a Gaussian Filter-based approach is used, which is included in the low-pass filter category.

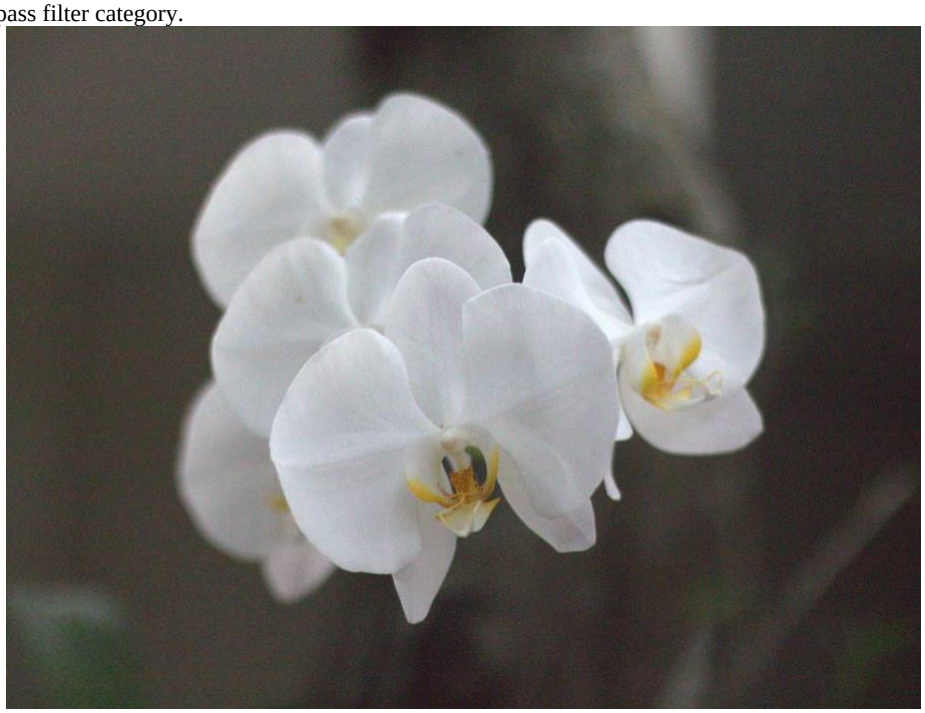

Fig. 2: Image of a flower with noise

In this study, the process of improving the quality of digital images was carried out with a focus on noise reduction and lighting enhancement using the Gaussian Filter method and lighting adjustment function. This section is the result of testing to reduce Gaussian noise using the Gaussian filter method.

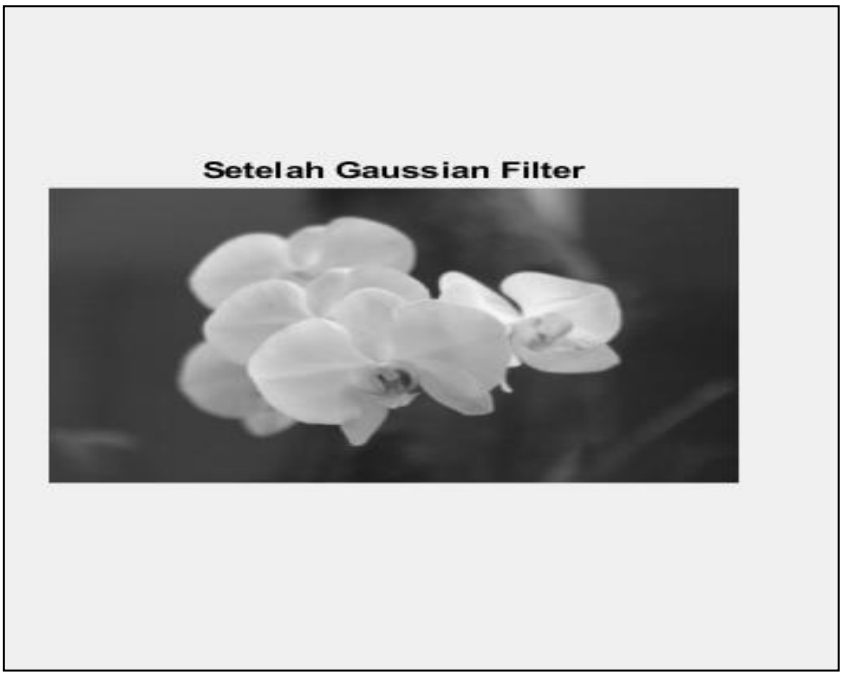

Fig. 3: Flower image after gaussian filter

Fig. 4: Flower image after brightening

4. Conclusion

Optimizing the use of Gaussian Filtering in digital image processing plays an important role in improving image quality by reducing noise without losing important details. Adjusting parameters such as kernel size and sigma value greatly affects the final result. Evaluation of effectiveness through metrics such as PSNR and MSE, as well as adaptive approaches based on noise characteristics, can significantly improve filter performance. Thus, optimized Gaussian Filtering becomes a reliable method in the digital image pre-processing stage, especially for advanced analysis purposes in various application fields.

In this section you should present the conclusion of the paper. Conclusions must focus on the novelty and exceptional results you acquired. Allow a sufficient space in the article for conclusions. Do not repeat the contents of Introduction or the Abstract. Focus on the essential things of your article.

References

[1] M. G. Tatuin, Y. P. . Kelen, dan S. S. Manek, "Pengaruh Ukuran Jendela Ketetanggaan (Window) Terhadap Hasil Redukasi Noise pada Metode Median Filter dan Gaussian Filter," *J. Krisnadana*, vol. 3, no. 3, hal. 142–154, 2024, doi: 10.58982/krisnadana.v3i3.601.

[2] P. Novantara dan J. Mutiara, "Perbandingan Metode Gaussian Filter dengan Median Filter dalam Mereduksi Noise Pada Citra Digital," *JEJARING J. Teknol. dan Manaj. Inform.*, vol. 6, no. 1, hal. 19–25, 2021, doi: 10.25134/jejaring.v6i1.6736.

[3] P. H. Wijaya, R. Wulanningrum, dan R. Halilintar, "Perbaikan Citra Dengan Menggunakan Metode Gaussian Dan Median Filter," *Semin. Nas. Inov. Teknol.*, vol. 5, no. 5, hal. 100–105, 2021.
[4] F. Sugandi, "Implementasi Metode Gaussian Filtering Dalam Mengurangi Noise Pada Pengolahan Citra Digital," *Int. Res. Big-Data Comput. Technol. I-Robot*, vol. 7, no. 2, hal. 21–26, 2023, doi: 10.53514/ir.v7i2.237.
[5] S. K. M. K. Mustakim *et al.*, *PENGOLAHAN CITRA DIGITAL*. Yogyakarta: Cendikia Mulia Mandiri, 2025.
[6] L. A. Drianto *et al.*, *Inovasi Teknologi Kecerdasan Komputer*. jak: SIEGA Publisher, 2023.
[7] H. Fitriyah dan R. C. Wihandika, *Dasar-Dasar Pengolahan Citra Digital*. Malang: Universitas Brawijaya Press, 2021.