Academic Research Journal of Science and Technology (ARJST) e-ISSN: 3048-9644
Peer Reviewed Multidisciplinary Monthly Scholarly International Journal
Volume : 1 Issue: 08, April 2025

AN EXPERIMENTAL EVALUATION OF IMAGE FILTERING ALGORITHMS FOR EARLY DETECTION OF BANANA LEAF DISEASES

Vishnu Prabhakar. V[1], Dr. N. Sudha

1. Research Scholar, Department of Computer Science, Bishop Appasamy college of arts and science. EMail: vishnupchittur@gmail.com
2. Associate Professor, Department of Computer Science, Bishop Appasamy college of arts and science. EMail: sudhanatarajan105@gmail.com

Citation:

ARTICLE INFO

Article history:
Received 20 February 2025
Revised 10 March 2025
Accepted 28 March 2025
Online first
Published 01 April 2025

Keywords:
Filtering algorithms, banana leaf disease detection,

DOI:
10.13140/RG.2.2.31569.85603

ABSTRACT

This research presents a thorough examination and comparison of several image filtering algorithms for the diagnosis and identification of diseases affecting banana leaves. For efficient agricultural management and to reduce crop losses, diseases in banana crops must be promptly identified. The visibility of disease symptoms on banana leaves is greatly improved by image processing techniques, especially filtering algorithms. This study assesses how well a number of popular image filtering techniques—such as the Canny, Sobel, Laplacian, Gaussian, and bilateral filters—perform in enhancing the quality of images of diseased banana leaves. Each algorithm's efficacy is evaluated according to important standards such edge retention, noise reduction, and computational efficiency, with an emphasis on the practical difficulties presented by field-captured images. The findings of the experiments show the advantages and disadvantages of each filtering technique, offering information on how well they can diagnose different diseases of banana leaves. The results highlight how crucial it is to choose the right image filtering methods in order to guarantee precise disease diagnosis and provide suggestions for further study in the area of agricultural image analysis.

1. INTRODUCTION

A crucial component of contemporary agriculture is the identification of plant diseases, especially for crops like banana plants, which are vulnerable to a variety of diseases that can significantly reduce productivity and quality. Effective disease control depends on early disease identification on banana leaves, and image processing has become a potent tool in this field. Disease symptoms like lesions, spots, and discoloration that would be hard to observe in the field might be found by examining images of banana leaves.

The capacity of image filtering algorithms to improve and extract important features from leaf images, so enabling automated disease identification, has drawn a lot of interest in recent years. These algorithms are essential for enhancing image quality, eliminating noise, and emphasizing pertinent edges and textures that are suggestive of disease symptoms. Prior to classification and identification tasks, images are frequently pre-

https://doi.org/10.13140/RG.2.2.31569.85603

processed using conventional methods including edge detection, smoothing filters, and enhancement filters.

The following filtering techniques have demonstrated promise in obtaining significant features from images of banana leaves: Gaussian filters, Sobel filters, Bilateral filters, Canny edge detection, and Laplacian filters. Every one of these filters has a distinct function: While edge detection filters (such as Canny and Sobel) are crucial for emphasizing borders and leaf structures, Gaussian filters aid in noise reduction.

The accuracy and effectiveness of disease detection systems are greatly impacted by the image filtering algorithm selection in the context of diagnosing banana leaf disease. By collecting several facets of leaf condition, including texture, color, and form, combining various filtering techniques frequently produces superior findings and ultimately leads to a more reliable diagnosis. Furthermore, by learning from filtered picture features, data mining algorithms can be combined with image filtering techniques to improve classification performance even more.

An overview of many image filtering algorithms used to diagnose banana leaf disease is provided in this research, along with an analysis of the algorithms' advantages and disadvantages as well as the possibility of incorporating them into automated agricultural systems. We hope to increase the effectiveness and precision of disease identification by utilizing image processing and filtering techniques, which will ultimately lead to more sustainable farming methods and increased banana harvests.

2. IMAGE FILTERING ALGORITHMS

i) Canny Filtering Algorithm

Known for its remarkable accuracy in detecting sharp edges, the Canny filtering algorithm is one of the most widely used edge detection methods in image processing. After smoothing the image to remove noise, it calculates the intensity gradient to emphasize regions of sudden changes in pixel values. The method uses a multi-step process that includes finding intensity gradients, employing non-maximum suppression to thin the edges, and applying a Gaussian filter to reduce noise. After determining which edges are strong and which are weak using a double thresholding technique, it uses edge tracking to finish the detection. Because of its ability to produce thin, distinct edges, the Canny algorithm is particularly useful for applications like object identification, medical imaging, and even the diagnosis of plant diseases in agriculture. Because of its accurate edge localization method and great reliability in detecting edges in noisy environments, it is an essential tool in many image analysis applications.

ii) Sobel Filtering Algorithm

A popular edge detection approach in image processing is the Sobel filter, which is intended to draw attention to regions in an image that exhibit sharp changes in intensity

https://doi.org/10.13140/RG.2.2.31569.85603

and correspond to edges. It measures the pace at which pixel values change by computing the gradient of the image intensity at each pixel. Two convolution kernels are used by the Sobel operator: one for horizontal edge detection and another for vertical edge detection. Two gradient images are created by the Sobel filter when these kernels are applied to the image; one shows the changes in the horizontal direction, while the other shows the changes in the vertical direction. These two gradient images are then combined to calculate the edge strength.

The Sobel filter is well regarded for its ease of use and effectiveness, which makes it a perfect option for applications requiring edge detection, like feature extraction, object recognition, and image segmentation. Compared to other edge detection algorithms, the Sobel filter's ability to minimize image noise makes it less sensitive to slight changes in intensity. This is one of its main advantages. It may, however, occasionally result in thicker margins and necessitate further processing, like thinning or refining, in order to precisely define fine boundaries. Nevertheless, because of its efficiency and simplicity of use, the Sobel filter continues to be a fundamental method in image processing.

iii) Laplacian Filtering Algorithm

In image processing, the Laplacian filter is a second-order derivative filter that finds regions of abrupt intensity shift to identify edges. The Laplacian filter calculates the image's second derivative, emphasizing areas where the intensity changes dramatically, in contrast to first-order filters like the Sobel operator, which gauge the rate of intensity change. For identifying edges, corners, and other important elements in an image, this filter works especially well. Usually, a 3x3 mask is used to convolve the picture with a kernel that highlights the central pixel in comparison to its neighbors in order to apply the Laplacian operator. It can recognize edges even in areas with low contrast because it can distinguish zero-crossings, which are locations where the intensity changes sign.

iv) Gaussian Filtering Algorithm

A popular smoothing method in image processing, the Gaussian filter applies a Gaussian function to the image to assist minimize noise and detail. The filter averages the values of the pixels in a neighborhood, and the weights assigned to the nearby pixels follow a Gaussian distribution, decreasing with distance from the center pixel. This produces a blurring effect in which the value of each pixel is substituted with a weighted average of its neighbors, with the average being higher for nearby pixels. The degree of smoothing is determined by the Gaussian function's standard deviation (sigma); a larger sigma number results in a more noticeable blur, whereas a lower sigma value generates less smoothing.

In several image processing tasks, including edge identification, noise reduction, and image enhancement, Gaussian filtering is frequently employed as a preprocessing step. One of its main benefits is that, in comparison to other smoothing methods like box filters or average filters, it decreases high-frequency noise while maintaining edges. Because of this, it is especially helpful for applications like feature extraction, computer vision, and medical imaging where it is crucial to preserve significant image information while minimizing extraneous noise. Furthermore, the Gaussian filter may be used independently in two dimensions (rows and columns) due to its separability, which greatly increases computational efficiency. To prevent losing tiny details in the picture, it's crucial to balance the level of blurring.

v) Bilateral Filtering Algorithm

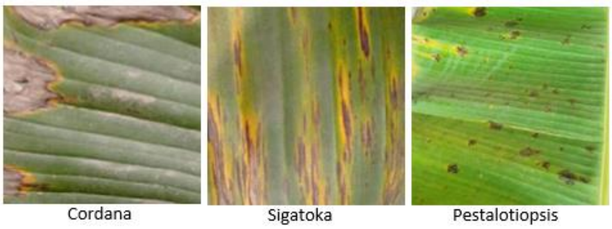
In image processing, the bilateral filter is a non-linear, edge-preserving smoothing method that filters by simultaneously taking into account the spatial separation and intensity difference between pixels. The bilateral filter modifies each nearby pixel's contribution according to both its spatial distance from the central pixel and its intensity similarity, in contrast to standard filters that treat every pixel in a neighborhood identically. Accordingly, pixels that are nearer and have comparable intensities to the core pixel will be given more weight, but pixels that are farther away or different would have less of an impact. The bilateral filter works well for tasks like picture denoising, texture smoothing, and detail enhancement because it reduces noise while maintaining sharp edges and small details.

3. EXPERIMENTAL SIMULATION AND ANALYSIS

For this research we have used MATLAB to process the input images.

DATASET

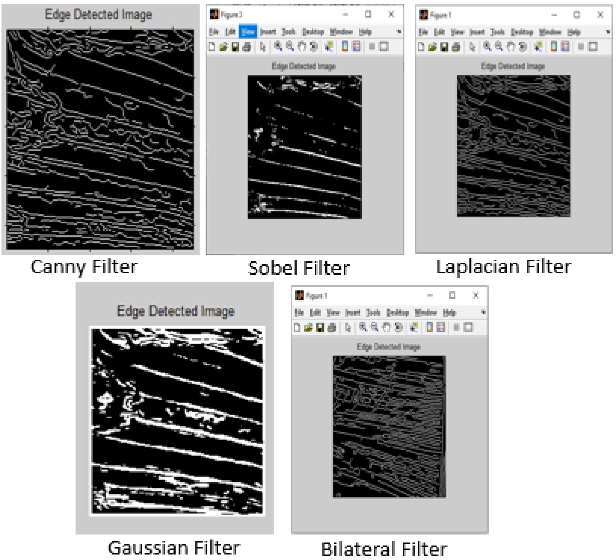
The efficient technique for identifying banana leaf diseases and pre-processing images is compared using filtering algorithms in the suggested method. The expert dataset containing banana leaves from three distinct disease kinds (Cordana, Sigatoka, and Pestalotiopsis) has been taken into consideration for this. The infected banana leaves taken into consideration for the assessment are listed below.



Fig(1) Input images

5. RESULTS AND COMPARITIVE ANALYSIS

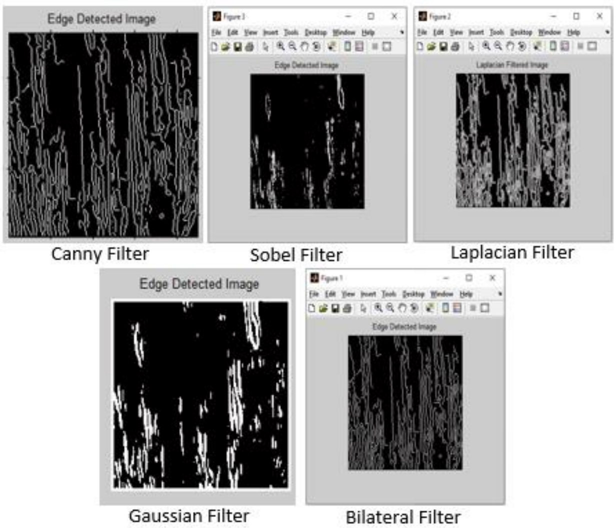
For the analysis we have provided the above input images in MATLAB and preprocessed the original images. Below are the results after pre-processing the images :



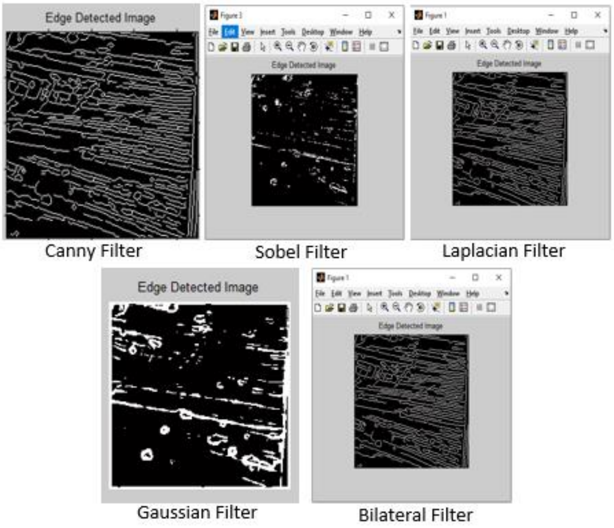
Fig(2)

Fig(2) depicts the results after processing the original Cordana affected leaf with the algorithms such as the Canny filter, sobel filter, Laplacian, Gausssian and Bilateral filter.

Fig(3),Fig (4) depicts the results after processing the original Sigatoka and Pestalotiopsis affected leaf with the algorithms such as the Canny filter, sobel filter, Laplacian, Gausssian and Bilateral filter.



Fig(3)



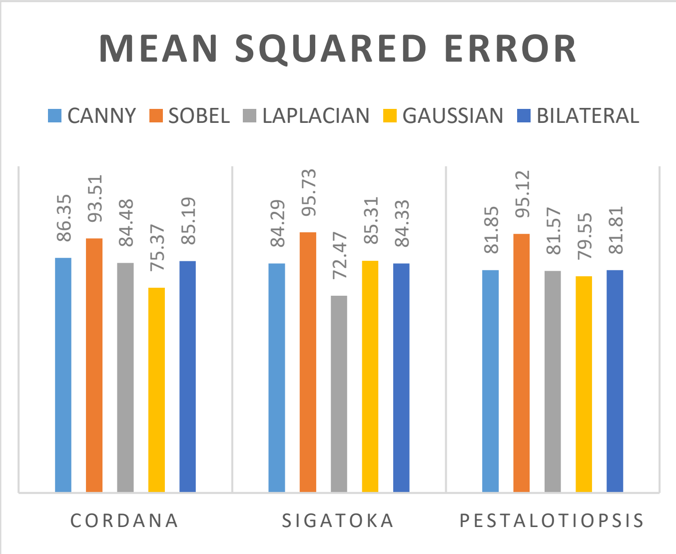
Fig(4)

MSE and PSNR

Peak Signal-to-Noise Ratio (PSNR) and Mean Squared Error (MSE) are often used metrics in image processing to evaluate image quality. MSE quantifies the degree of distortion or error produced during processing by calculating the average squared difference between the original and processed images. The processed image is closer to the original when the MSE value is smaller. On the other hand, PSNR gives the ratio of the image's noise (error) to its maximum pixel value; this ratio is usually given in decibels (dB). Better image quality with less distortion or loss is indicated by higher PSNR values.

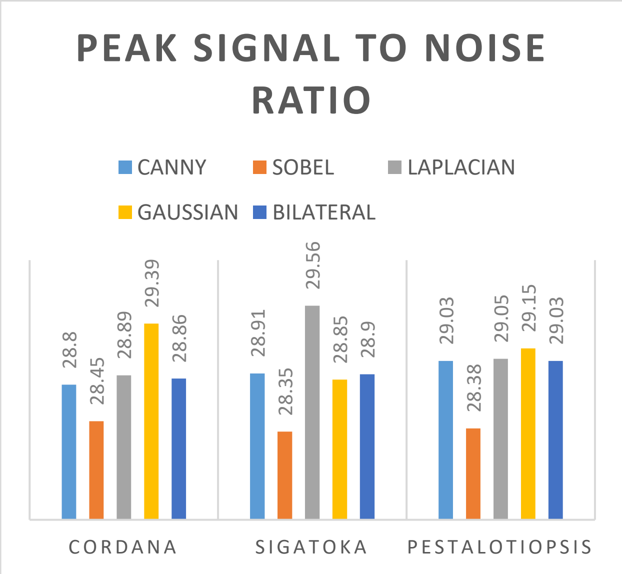
More PSNR values correspond to more fidelity in the processed image, providing a more intuitive grasp of image quality than MSE, which measures error directly. Both measures are frequently used to assess how well image compression, denoising, or enhancement methods work.

1. 2. 3. 4. 5. DISEASE	6. 7. MEAN SQUARED ERROR				
	8. CANNY	9. SOBEL	10. LAPLACIAN	11. GAUSSIAN	12. BILATERAL
13. Cordana	14. 86.35	15. 93.51	16. 84.48	17. 75.37	18. 85.19
19. Sigatoka	20. 84.29	21. 95.73	22. 72.47	23. 85.31	24. 84.33
25. Pestalotiopsis 26.	27. 81.85	28. 95.12	29. 81.57	30. 79.55	31. 81.81



According to the experimental results, Gaussian Filter's MSE value is less than other filters for the diseases Cordana and Pestalotiopsis. For the Sigatoka disease Laplacian filter provides better result than other filters.

32. 33. 34. 35. 36. DISEASE	37. 38. PSNR				
	39. CANNY	40. SOBEL	41. LAPLACIAN	42. GAUSSIAN	43. BILATERAL
44. Cordana	45. 28.80	46. 28.45	47. 28.89	48. 29.39	49. 28.86
50. Sigatoka	51. 28.91	52. 28.35	53. 29.56	54. 28.85	55. 28.90
56. Pestalotiopsis 57.	58. 29.03	59. 28.38	60. 29.05	61. 29.15	62. 29.03



The PSNR value is higher for Gaussian filter when compared to Canny, Sobel, Laplacian and Bilateral filters. As per the results, Laplacian filter works very well for Sigatoka disease than the other filters.

7. CONCLUSION

In conclusion, this research highlights the effective application of image processing techniques for identifying banana leaf diseases. By evaluating various filtering algorithms such as Canny, Sobel, Laplacian, Gaussian and Bilateral, it was found that the Gaussian filtering algorithm outperformed the others in detecting Cordana and Pestalotiopsis diseases on banana leaves. The Laplacian filtering algorithm shows better results for Sigatoka disease. The use of these image processing methods along with data mining algorithms can offer significant potential for improving early disease detection, reducing the impact of plant diseases, and enhancing agricultural productivity.

REFERENCES

1. E., Gangadevi and Dr. Shoba Rani R.. "A Canny Edge Detection Algorithm for Automatic Identification of Plant Diseases." *NeuroQuantology* (2022): n. pag.

2. Yedukondalu, Mr. N. et al. "Identifying Plant Diseases on Digital Farming using Canny Edge Detection Algorithm." 2023 Second International Conference on Augmented Intelligence and Sustainable Systems (ICAISS) (2023): 943-947.

3. Patil, Preet et al. "Banana Plant Disease Detection using Image Processing." *2024 IEEE 9th International Conference for Convergence in Technology (I2CT)* (2024): 1-5.

4. Chaudhari, Vandana and Manoj P. Patil. "Banana leaf disease detection using K-means clustering and Feature extraction techniques." *2020 International Conference on Advances in Computing, Communication & Materials (ICACCM)* (2020): 126-130.

5. A, Abisha and Bharathi N. "Impact of Image Pre-Processing in Image Quality and Segmentation for Banana Leaf Disease Prediction." *2023 International Conference on Sustainable Communication Networks and Application (ICSCNA)* (2023): 1302-1307.

6. Roy, Riya. "Plant Leaf Disease Detection using SVM." *International Journal for Research in Applied Science and Engineering Technology* (2021): n. pag.

7. "A Study on Crop Disease Detection of Banana Plant using Python and Machine Learning." *Regular* (2020): n. pag.

8. Kiran, S M and D N Chandrappa. "Plant Leaf Disease Detection Using Efficient Image Processing and Machine Learning Algorithms." *Journal of Robotics and Control (JRC)* (2023): n. pag.

9. Tandekar, Diksha and Snehlata Dongre. "A Review on Various Plant Disease Detection Using Image Processing." *2023 3rd International Conference on Pervasive Computing and Social Networking (ICPCSN)* (2023): 552-558.

10. Sethi, Mohit. "Plant Disease Detection using Image Segmentation." *International Journal of Ayurveda and Herbal Research (IJAHR)* (2023): n. pag.

11. Kulkarni, Pranesh Shridhar et al. "Plant Disease Detection Using Image Processing and Machine Learning." *ArXiv* abs/2106.10698 (2021): n. pag.

12. Khirade, Sachin D. and A. B. Patil. "Plant Disease Detection Using Image Processing." *2015 International Conference on Computing Communication Control and Automation* (2015): 768-771.
13. Vetal, Sagar and Khule R.S.. "Tomato Plant Disease Detection using Image Processing." *International Journal of Advanced Research in Computer and Communication Engineering* 6 (2017): 293-297.
14. Kalaivani, A. et al. "Mobile APP for Banana Leaf Spot Disease Detection and Classification using Convolution Neural Network Model." *Recent Trends in Data Science and its Applications* (2023): n. pag.
15. V. Gokula, Krishnan et al. "An automated segmentation and classification model for banana leaf disease detection." *Journal of Applied Biology & Biotechnology* (2022): n. pag.
16. H R, Chetan et al. "Plant Disease Detection using Deep Learning in Banana and Sunflower." *Journal of Advanced Zoology* (2023): n. pag.

Prepared by:

Department of Library, Nallamuthu Gounder Mahalingam College (NGMCPUB),
Pollachi 642001, TamilNadu, India