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Implementing Various Noise Reduction Filters On Infected Coconut Images

Sangeetha Muthiah, A. Senthilrajan

Abstract: ***In recent times, more people are returning to farming. The inexperienced farmers facing problems in getting high crop yield. One of the challenges is to control crop diseases and pests. The farmers are not aware of the Climate change-induced agricultural diseases and pests. The image processing techniques have an important part in recognizing the diseases and pests infestations in the agricultural crop. The image must be free of noise for effective diagnosis. This paper analyses the performance of various noises and different de-noising techniques on an infected coconut image. In this paper, a suitable de-noising technique to remove various kinds of noise in an image. The performance of the filters is compared for different types of noises and the quality is measured based on PSNR and MSE.***

Keywords: De-noising, Gaussian filter, MSE, PSNR

I. INTRODUCTION

Noise corrupts the true image details and degrades the appearance of the image. Noise removal is the pre-processing stage for many applications. One such application is detection of plant disease with the help of digital image processing. Detection [1] of disease in plants in its initial stage is beneficial. According to the previous study the image noise is random fluctuation of brightness or color information in images, and is usually an aspect of electronic noise. Image has some level noise presence. The challenge [2] is in removing noise and restoring the original image. The author [3] proposed an adaptive smoothing filter which employs five filters logically in detecting disease in paddy crop. The aim of this paper is to analyze and compare the performance of Gaussian, median and wiener filtering methods on Gaussian noise, salt & pepper noise and Poisson noise. The measurement parameters considered are PSNR, MSE.

II. NOISE MODELS

In an image noise can be termed as visual distortion. Noise comes from acquisition and in transmission of an image. The filtering is applied according to the type of noise. It is important to know the noise models in applying de-noising techniques.

A. Salt and Pepper Noise

The salt and pepper noise can be visually recognized by the black and white color grains. It normally occurs during transmission. Also known as impulse noise and has pixel values for pepper noise close to ‘0’ or the salt noise close to ‘1’ distributed randomly. The probability density function (PDF) for the model is given as (1)

$$PDF_{sp} = \begin{cases} A & for\ p = a \\ B & for\ p = b \\ 0 & othewise \end{cases} \qquad (1)$$

B. Gaussian Noise

The Gaussian noise is a statistical noise having a probability density function equal to that of the normal distribution. The PDF of the Gaussian model is given as (2)

$$PDF_g = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(z-\mu)^2}{2\sigma^2}} \qquad (2)$$

Where μ is the mean, σ is the standard deviation, z is the grey value of the pixel.

C. Photon Noise

Digital noise [4] has photon shot noise presence, when the image is captured at low light condition. The random fluctuations in photon levels sensed at different intervals during exposure cause Poisson noise. The square root of the signal function is the shot noise.

The PDF of the Poisson noise is given as (3)

$$P(F(X = K)) = \frac{\lambda^k}{k!} e^{-\lambda} \qquad (3)$$

III. DE-NOISING FILTERS

Noise in an image cannot be avoided. Eliminating noise in the corrupted infected leaf images is a low level processing for several agro-based applications. Noise [5] reduction can be achieved by blurring with a linear and by non-linear filtering. If the image is noisy, the signs and symptoms of plant diseases could not be identified and managed at the earliest. The image de-noising filters considered in this paper are Median Filter, Gaussian Filter and Weiner Filter.

A. Median Filter

The median filter is a non-linear statistical filtering technique, which eliminates impulse and speckle noise from an image signal with less blurring effect. The principle idea of this filter is to take each pixel in the image replaced by the median value of the other pixel values in the neighbourhood as in Fig. 1.

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* Correspondence Author

Sangeetha Muthiah*, PG Scholars, SRM University, India.

A. Senthilrajan, PG Scholars, SRM University, India.

It works better at removing salt and pepper noise without losing high-frequency details of the image. The filter can be expressed as (4)

$$f(x,y) = median\{g(s,t)\} \quad where\ (s,t) \in s_{x,y} \qquad (4)$$

Input

0	2	2	1	1	1
1	0	0	5	0	0
1	1	1	1	5	5
3	2	5	2	5	1
1	0	3	4	1	3
2	5	0	5	5	2

Output

0	2	2	1	1	1
1	0	0	5	0	0
1	1	1	1	5	5
3	2	2	2	5	1
1	0	3	4	1	3
2	5	0	5	5	2

Sorted list:0, 1, 1,1,2 2, 3, 4, 5

Median : 2 centre value 5 is replaced by 2

Fig. 1. Median Filtering example (3 x 3 window)

B. Gaussian Filter

The Gaussian filter [6] is a linear low-pass filter which attenuates high frequency details of the image. It is widely used to reduce noise by blurring the image. In one dimension the Gaussian function equation is (5)

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\left(\frac{x^2}{2\sigma^2}\right)} \qquad (5)$$

σ is the standard deviation of the distribution

The Gaussian filter works by convolving 2D Gaussian function with the image. The weights declines as it moves further from the pixel of interest. So it retains much of the edge components compared to mean blur. And in image processing, two-dimensional Gaussian function is used and can be expressed as (6)

$$f(x,y) = \frac{1}{2\pi\sigma^2} e^{-\left(\frac{x^2+y^2}{2\sigma^2}\right)} \qquad (6)$$

The size of the kernel is increased with an increase in the radius of the Gaussian function. The amount of blur depends on the value of σ. The kernel is rotationally symmetric and computes x and y-axis separately. The Fig 2. Presents Gaussian kernel of size 3x3 with a weight value 1.4, the kernel values can be calculated with the 2D Gaussian function using MATLAB.

C. Weiner Filter

The Weiner filter reduce noise and performs smoothing. A filtering technique to minimize the mean square error between the original signal and restored signal. It removes [7] additive noise and blurring simultaneously and can be expressed as (7)

$$W(u,v) = \frac{H^*(u,v)}{H^2(u,v) + \frac{S_n}{S_f}} * G(u,v) \qquad (7)$$

Where H*(u,v) is complex conjugate of the Fourier transform of the filter, sn ,sf are respectively the power spectrum of noise and power spectrum of signal, H2(u,v) is the magnitude of the degradation function, G(u,v) is the observed image.

0.0924	0.1192	0.0924
0.1192	0.1538	0.1192
0.0924	0.1192	0.0924

]

Fig. 2. Gaussian Filter Kernel example (3 x 3 window)

IV. MEASUREMENT CRITERIA

Image similarity is the measure to quantify how similar the restored image with the original image. The quality metrics used in this paper are MSE and PSNR.

The MSE (Mean Squared Error) computes the average of the squared error between the original image and noisy image. The lower the MSE value, the lower the error and can be calculated as (8)

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - k(i,j)]^2 \qquad (8)$$

Where I and K represents the original image and degraded image, m, n are the number of rows and columns of the image.

The PSNR (Peak Signal to Noise Ratio) [8] calculates the peak signal-to-noise ratio between two images and given as (9).

$$PSNR = 20\log_{10}\left(\frac{MAX_j}{\sqrt{MSE}}\right) \qquad (9)$$

Where MAX_j is the maximum value of the pixel.

V. APPROACH

The image selected for de-noising is scale insect infected images of the coconut palm. The image is captured and pre-processed using MATLAB. The image is resized of size 256x256. The image is then de-noised by Gaussian filter, Median filter and Wiener filter. The resultant image is analyzed using PSNR, and MSE. The steps for the process of de-noising are shown in Fig 3.

VI. EXPERIMENTAL RESULTS AND PERFORMANCE ANALYSIS

The sample images of the coconut are taken from Tamilnadu Agricultural University (TNAU) Agri portal. The coconut fruit image and the coconut leaf image are severely infected with aspidiotus destructor. The noise reduction is performed using the Gaussian filter, Median filter, and Wiener filter. The images after applying various filters are shown in Fig 4 and in Fig 5.

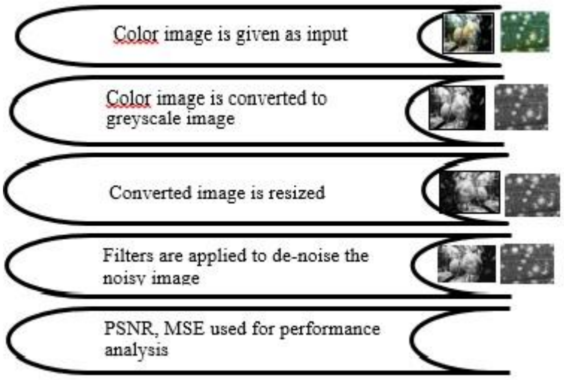
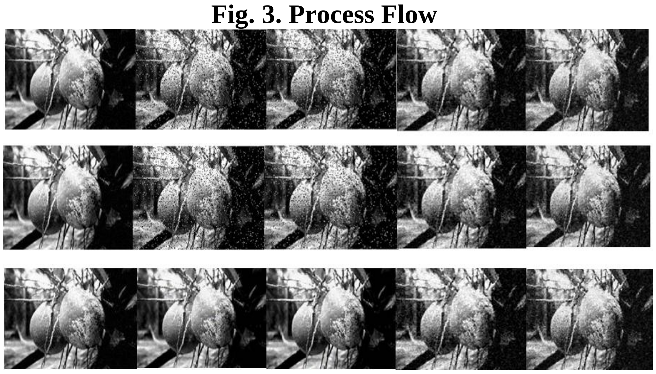
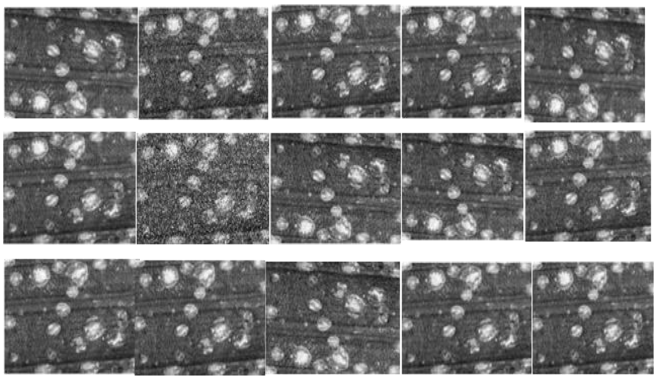


Fig. 3. Process Flow



a. b. c. d. e.

Fig. 4. 1st row gaussian noise, 2nd row salt pepper noise, 3rd row poisson noise. a.Input image b.Noisy image c.Gaussian filter d.Median filter e.Wiener filter



a. b. c. d. e.

Fig. 5. 1st row gaussian noise, 2nd row salt pepper noise, 3rd row poisson noise. a.Input image b.Noisy image c.Gaussian filter d.Median filter e.Wiener filter

From analyzing the Tables, the performance of the Gaussian filter gives good results The Gaussian filter removes Gaussian noise effectively as the noise arises during the acquisition and transmission of an image. The performance of the median filter gives satisfactory results in removing salt & pepper noise. The median filter does not blur out the edges. The wiener filter works well for Poisson noise.

Table- I: Performance of Filters based on PSNR on Coconut fruit image.

Noises	Gaussian	Median	Wiener
Gaussian	27.03	21.73	24.89
Salt & Pepper	23.66	25.96	20.97
Poisson	29.84	23.24	27.92

Table- II: Performance of Filters based on on MSE on Coconut fruit image

Noises	Gaussian	Median	Wiener
Gaussian	129.82	440.45	212.45
Salt & Pepper	281.87	166.27	636.68
Poisson	68.06	310.62	105.69

Table- III: Performance of Filters based on PSNR on Coconut leaf image.

Noises	Gaussian	Median	Wiener
Gaussian	31.01	27.82	28.36
Salt & Pepper	23.94	26.83	21.76
Poisson	29.02	22.48	26.65

Table- IV: Performance of Filters based on MSE on Coconut leaf image.

Noises	Gaussian	Median	Wiener
Gaussian	31.01	27.82	28.36
Salt & Pepper	23.94	26.83	21.76
Poisson	29.02	22.48	26.65

The performance evaluation has been done in MATLAB. The performance of the filters are analysed based on PSNR and MSE values. The high PSNR and the smaller MSE value represents the high quality of the filtered image. Both of the input image shows similar result. One can infer from PSNR values of Table 1 and Table 3, that Gaussian filter is effective in removing Gaussian noise compared to other filtered images. Similarly, the high PSNR in Table 1 and Table 2 shows the median filter performance in removing salt & pepper noise. The visual quality of the median filtered is good and also preserves edges. The wiener filter and the Gaussian filter shows similarity for Poisson noise. This allows the conclusion that the median filter gives quality results for salt & pepper noise where the Wiener filter is not successful. The Gaussian filter proves effective in reducing Gaussian noise as well as Poisson noise.

VII. CONCLUSION AND FUTURE WORK

The image must be free of noise for effective diagnosis of the infected coconut image. This paper analysed the performance of different de-noising techniques on noise corrupted images. The resultant image should be free of noise and retain sharp edges. The performance is measured based on PSNR and MSE values. According to the results, the median filter is suitable for salt & pepper noise. The Gaussian filter shows better performance in removal of Gaussian noise and Poisson noise. The visual quality of the wiener filtered image for Poisson noise was good. Regardless, the result of the images after applying the same noise level may differ according to the size, nature, and quality of the image taken as input.

With respect to the above nature filtering methods can be chosen. The future work might further experiment de-noising in wavelet methods and the suitable de-noising technique is chosen as a pre-processing step for the future research work.

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