

# Performance Analysis of Gaussian Filter with Different Kernel Sizes in Removing Gaussian Noise

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**ABSTRACT:** Image processing has become one of the most prominent areas of research. Images are usually affected by different types of noises such as Gaussian noise, Salt and Pepper noise, Speckle noise, Poisson noise etc. The present work analyses the performance of Gaussian Filter with different kernel sizes in removing Gaussian Noise. Mean Squared Error and Peak Signal-to-Noise Ratio have been considered as parameters for analysing the performance of Gaussian Filter in the context of removing Gaussian noise. The results obtained show that for a kernel of size  $n \times n$  pixels, when applied with Gaussian Filter to Gaussian noise corrupted images, the Mean Squared Error obtained between the original image and the filtered image remains same for all  $n$  when  $n$  is odd and it is also evident that the Mean Squared Error obtained between the original image and the filtered image remains same for all  $n$  when  $n$  is even.

**KEYWORDS:** Kernel, Gaussian Noise, Gaussian Filter

## I. INTRODUCTION

An image is a two dimensional representation of a picture. Digital images are prone to different types of noise. Noise is the result of errors in the image acquisition process that result in pixel values that do not reflect the true intensities of the real scene. There are several ways that noise can be introduced into an image, depending on how the image is created. If the image is scanned from a photograph made on film, the film grain is a source of noise. Noise can also be the result of damage to the film, or be introduced by the scanner itself. If the image is acquired directly in a digital format, the mechanism for gathering the data can introduce noise. Electronic transmission of image data can introduce noise. Images are easily susceptible to different types of noise such as Gaussian noise, Poisson noise, Salt and pepper noise, Speckle noise etc. Gaussian noise is statistical noise having a probability density function equal to that of Gaussian distribution. Gaussian distribution is also known as Normal distribution. The Gaussian distribution is defined

by the following equation: 
$$Y = \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{(x - \mu)^2}{2\sigma^2}}$$
 where  $x$  is a normal random variable,  $\mu$  is

the mean,  $\sigma$  is the standard deviation,  $\pi$  is approximately 3.14159, and  $e$  is approximately 2.71828. Principal sources of Gaussian noise in digital images arise either during acquisition or transmission.

Filtering is a technique for modifying or enhancing an image. Filtering is a neighbourhood operation, in which the value of any given pixel in the output image is determined by applying some algorithm to the values of pixels in the neighbourhood of the corresponding input pixel. A pixel's neighbourhood is some set of pixels, defined by their

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locations relative to that pixel, which is called the center pixel. A kernel is a small matrix useful for blurring, sharpening, embossing, edge-detection etc. A Gaussian filter is a filter whose impulse response is a Gaussian function.

Gaussian filters have the properties of having no overshoot to a step function input while minimizing the rise

and fall time. In one dimension, the Gaussian function is given by  $G(x) = \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{x^2}{2\sigma^2}}$ . In two

dimensions, the Gaussian function is given by  $G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2 + y^2)}{2\sigma^2}}$ . Gaussian filtering is used to remove noise. It is more effective at smoothing images. It has its basis in the human visual perception system. It has been found that neurons create a similar filter when processing visual images. The Gaussian function is used in numerous research areas. In Image processing, Gaussian functions are used for Gaussian blurs. In Signal Processing, Gaussian functions are used to define Gaussian filters. In Mathematics, Gaussian functions are used to solve heat equations and diffuse equations.

Mean Squared Error and Peak Signal-to-Noise Ratio have been considered as parameters for performance evaluation of Gaussian filter with different kernel sizes.

Mean Squared Error (MSE) is defined as the cumulative squared error between the original image and the noise corrupted image. It is given by the following formula.

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

where  $I(i, j)$  is the original image and  $K(i, j)$  is the

Noise corrupted image.

Peak Signal-to-Noise Ratio (PSNR) is defined as the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. It is measured in decibels. It is given by the following formula.

$$PSNR = 10 \log_{10} \left[ \frac{MAX_I^2}{MSE} \right]$$

where  $MAX_I$  is the maximum possible pixel value of the image and  $MSE$

is the Mean Squared Error.

## II. EXPERIMENTAL RESULTS





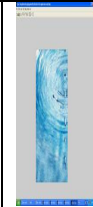

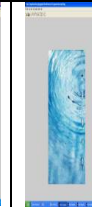

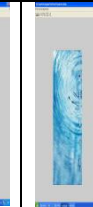
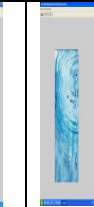




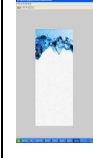
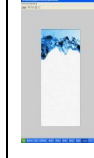
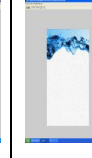
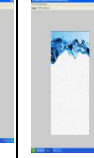
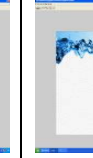
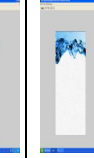
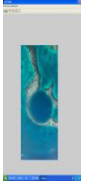




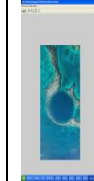
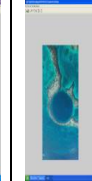

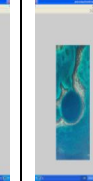
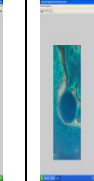










Images of different sizes (250×224 pixels, 400×324 pixels, 700×524 pixels, 850×624 pixels, 1000×724 pixels, 1200×824 pixels, 1400×924 pixels, 1600×1027 pixels) have been considered and then they are corrupted with Gaussian noise. A Gaussian Filter with kernel of different sizes (3×3, 4×4, 5×5, 6×6, 7×7, 8×8, 9×9, 10×10) has been applied to the Gaussian noise corrupted images and the resulting images are analysed. Mean squared error obtained between the original image and the filtered image which was obtained by applying Gaussian filter with different kernel sizes to Gaussian noise corrupted images has been calculated and tabulated. Similarly Peak Signal-to-Noise ratio obtained between the original image and the filtered image has also been calculated.

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**Table-1: Analysis of the Quality of Images obtained after applying Gaussian Filter with different kernel sizes on Gaussian noise corrupted images**








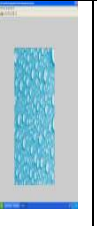
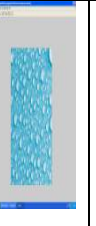






























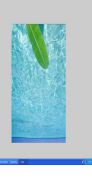
Size of the Image in pixels	Original Image	Image corrupted with Gaussian Noise	Image obtained after applying Gaussian filter with kernel of size 3×3 pixels	Image obtained after applying Gaussian filter with kernel of size 4×4 pixels	Image obtained after applying Gaussian filter with kernel of size 5×5 pixels	Image obtained after applying Gaussian filter with kernel of size 6×6 pixels	Image obtained after applying Gaussian filter with kernel of size 7×7 pixels	Image obtained after applying Gaussian filter with kernel of size 8×8 pixels	Image obtained after applying Gaussian filter With kernel of size 9×9 pixels	Image obtained after applying Gaussian filter with kernel of size 10×10 pixels
<b>250×224</b>										
<b>400×324</b>										
<b>700×524</b>										
<b>850×624</b>										

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**Table -1: Continued**

Size of the Image	Original Image	Image corrupted with Gaussian Noise	Image obtained after applying Gaussian filter with kernel of size 3×3 pixels	Image obtained after applying Gaussian filter with kernel of size 4×4 pixels	Image obtained after applying Gaussian filter with kernel of size 5×5 pixels	Image obtained after applying Gaussian filter with kernel of size 6×6 pixels	Image obtained after applying Gaussian filter with kernel of size 7×7 pixels	Image obtained after applying Gaussian filter with kernel of size 8×8 pixels	Image obtained after applying Gaussian filter with kernel of size 9×9 pixels	Image obtained after applying Gaussian filter with kernel of size 10×10 pixels
1000 × 724										
1200 × 824										
1400 × 924										
1600 × 1027										

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**Table-2: Analysis of Mean Squared Error obtained from the original image and the filtered image which was obtained from Gaussian noise corrupted image by applying Gaussian Filter with different kernel sizes**

Size of the Image in pixels	MSE obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 3×3 pixels	MSE obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 4×4 pixels	MSE obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 5×5 pixels	MSE obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 6×6 pixels	MSE obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 7×7 pixels	MSE obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 8×8 pixels	MSE obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 9×9 pixels	MSE obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 10×10 pixels
250×224	0.0041	0.0043	0.0041	0.0043	0.0041	0.0043	0.0041	0.0043
400×324	0.0034	0.0043	0.0034	0.0043	0.0034	0.0043	0.0034	0.0043
700×524	0.0038	0.0027	0.0038	0.0027	0.0038	0.0027	0.0038	0.0027
850×624	0.0035	0.0042	0.0035	0.0042	0.0035	0.0042	0.0035	0.0042
1000×724	0.0039	0.0028	0.0039	0.0028	0.0039	0.0028	0.0039	0.0028
1200×824	0.0032	0.0031	0.0032	0.0031	0.0032	0.0031	0.0032	0.0031
1400×924	0.0039	0.0029	0.0039	0.0029	0.0039	0.0029	0.0039	0.0029
1600×1027	0.0040	0.0028	0.0040	0.0028	0.0040	0.0028	0.0040	0.0028

From the above table it is clearly evident that for a kernel of size  $n \times n$  pixels, when applied with Gaussian Filter to Gaussian noise corrupted images, the Mean Squared Error obtained between the original image and the filtered image remains same for all  $n$  when  $n$  is odd and it is also evident that the Mean Squared Error obtained between the original image and the filtered image remains same for all  $n$  when  $n$  is even.

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**Table-3: Analysis of Peak Signal-to-Noise Ratio obtained from the original image and the filtered image which was obtained from Gaussian noise corrupted image by applying Gaussian Filter with different kernel sizes**

Size of the Image in pixels	PSNR obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 3×3 pixels	PSNR obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 4×4 pixels	PSNR obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 5×5 pixels	PSNR obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 6×6 pixels	PSNR obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 7×7 pixels	PSNR obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 8×8 pixels	PSNR obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 9×9 pixels	PSNR obtained from the original image and the filtered image which was obtained by applying Gaussian filter with kernel of size 10×10 pixels
250×224	72.0473	71.7955	72.0473	71.7955	72.0473	71.7955	72.0473	71.7955
400×324	72.8413	71.7785	72.8413	71.7785	72.8413	71.7785	72.8413	71.7785
700×524	72.2860	73.8513	72.2860	73.8513	72.2860	73.8513	72.2860	73.8513
850×624	72.7019	71.8877	72.7019	71.8877	72.7019	71.8877	72.7019	71.8877
1000×724	72.2276	73.6593	72.2276	73.6593	72.2276	73.6593	72.2276	73.6593
1200×824	73.0342	73.2431	73.0342	73.2431	73.0342	73.2431	73.0342	73.2431
1400×924	72.2605	73.5306	72.2605	73.5306	72.2605	73.5306	72.2605	73.5306
1600×1027	72.1475	73.6418	72.1475	73.6418	72.1475	73.6418	72.1475	73.6418

From the above table it is clearly evident that for a kernel of size  $n \times n$  pixels, when applied with Gaussian Filter to Gaussian noise corrupted images, the Peak Signal-to-Noise Ratio obtained between the original image and the filtered image remains same for all  $n$  when  $n$  is odd and it is also evident that the Peak Signal-to-Noise Ratio obtained between the original image and the filtered image remains same for all  $n$  when  $n$  is even.

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## III. CONCLUSION

Images are easily susceptible to different types of noise either during acquisition or transmission. Images are often corrupted with Gaussian noise. Filtering is used to remove noise from the images. The present work analysed the performance of Gaussian Filter with different kernel sizes in the context of removing Gaussian noise. The results obtained show that for a kernel of size  $n \times n$  pixels, when applied with Gaussian Filter to Gaussian noise corrupted images, the Mean Squared Error obtained between the original image and the filtered image remains same for all  $n$  when  $n$  is odd and it is also evident that the Mean Squared Error obtained between the original image and the filtered image remains same for all  $n$  when  $n$  is even. Similarly the results obtained show that for a kernel of size  $n \times n$  pixels, when applied with Gaussian filter to Gaussian noise corrupted images, the Peak Signal-to-Noise Ratio obtained between the original image and the filtered image remains same for all  $n$  when  $n$  is odd and it is also obtained that the Peak Signal-to-Noise Ratio obtained between the original image and the filtered image remains same for all  $n$  when  $n$  is even.

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