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# Comparison of processing results of median filter and mean filter on Gaussian noise

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**Abstract.** In people's daily lives, if the image is polluted with noise, it will become very blurred, so it is pretty necessary to use filtering to denoise the image and get a clearer image to assist people in work and study. The purpose of this article is by comparing the denoising result of the Median filter and Mean filter on Gaussian noise, and the filtering method which is more suitable for reducing Gaussian noise is found. Matlab is a very accurate and reliable scientific calculation standard software tool, which is very common in people's lives. The Median filter is a kind of nonlinear filter. It is so virtual at decreasing impulse noise. The common basic theory of the Median filter is to supersede the gray value of pixels with the median of the gray value in a neighborhood of the pixels, and not use the average proportion. The Mean filter is a sort of plain sliding-window space filter that takes the place of the central value with the mean of all the pixel values in the plain window. This essay takes advantage of Matlab to complete the process of adding Gaussian noise in photos, reducing Gaussian noise, and calculating the PSNR. The processing result of two types of noise reducers on Gaussian noise is compared. And by observing the image clarity, PSNR and MSE evaluation techniques to find which is a better filter to decrease Gaussian noise.

**Keywords:** Median Filter, Mean Filter, Gaussian Noise.

## 1. Introduction

Images are one of the sources of vital information people obtain in daily life. By looking at various pictures, people can better understand, analyze and use the information. However, the photo quality sometimes becomes poor when some photo data is collected. Therefore, the information contained in the image is often decreased by noise. Therefore, people used the denoising method to improve the pictures' quality. Image intensifier technology is needed to enhance the quality of pictures and made the amount of information that exists in the input photo get the peak value, in order for it can get a sort of visualization that is preferable, convenient explained, and understood by humans and computer machines [1]. Median filtering can resultful suppressing noise on the strength of the statistical element of ranking. The foundational theory of Median filtering is to take the place of the value of a point in a digital photo or sequence with the median value of every point in a neighborhood of the point, in order for the circumambient pixel value is border on the actual value, to decrease insular noise points. As a classical noise filtering method, traditional Median filtering has the advantage of reducing the influence of impulse noise, but this method may destroy the details of the image and change the value of information points [2]. Actually, Mean filtering is a way that obtains the average value of the target pixel and its circumambient pixels and then pads the goal pixel to achieve the filtering purpose [3]. The

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experiment described in this paper mainly studies adding Gaussian noise to the photo, adding Median filtering and Mean filtering to process it, observing the denoising result of the image, and using the imnoise function of Matlab to add noise pollution to a picture, it's called noise pollution image function, which is widely used in Gaussian noise. The fSpecial function is then used to generate a predefined filter. Finally, the MSR and PSNR are calculated by the formula. By observing the denoising result of images and comparing the PSNR, the author can judge whether the Median filter has the preferable denoising result on Gaussian noise or the Mean filter has the preferable denoising result on Gaussian noise. Finally, the MSR and PSNR are calculated by the formula. By observing the denoising result of images and comparing the PSNR, the author can judge whether the Median filter has a preferable denoising result on Gaussian noise or the Mean filter has a preferable result on Gaussian noise. Through the experiment, the author draws the conclusion that it is better to use the Mean filter to reduce the Gaussian noise. The author can observe by looking at the photos After the above processing, the author can see that the Mean filtering is better than the Median filtering in suppressing Gaussian noise, and the processed image has less edge blur. The author finds that Median filtering is not as good at reducing Gaussian noise, because Gaussian filtering is a sort of weighted average filtering, noise is difficult to reduce, and it will affect the normal pixels.

## 2. Main body

### *2.1. Types of filtering*

Common denoising processes in daily life include Mean filtering, Median filtering, K-nearest neighbor smoothing filtering, symmetric nearest neighbor smoothing filtering, Sigoma smoothing filtering, and the like. Among denoising processes, Mean filtering and Median filtering are more basic and have the characteristics of being fast, accurate and stable, and the algorithms are also integrated with many mature software and tool kits. The idea of filtering is similar to the idea of convolution, both of which involve window proportion, except that convolution uses a convolution kernel to perform convolution proportion with the corresponding position in the image, while filtering does the corresponding proportion in the window. A filter is a circuit that can be equipped to pass or amplify some frequencies while reducing others. So, a filter can choose vital frequencies from signals that also include undesirable or dysregulated frequencies. So in the area of electronics, filters have lots of realistic applications.

### *2.2. software description.*

In this study, the exact and dependable scientific computing standard software Matlab is used as the tool. Matlab is a kind of high-performance numerical calculation and visualization commercial software launched by MathWorks in 1982. It is a literal translation language, based on matrix proportion, which integrates calculation, visualization, and programming into easy-to-use interactive working conditions. It can deal with engineering calculation, algorithm research, modeling and simulation, prototype development, information analysis, scientific engineering drawing, application program design, and graphical user interface design [4]. Matlab is an efficient engineering computing language, in data processing, image processing, neural networks, wavelet analysis, and other aspects that have a wide range of applications, so the author uses Matlab to run the code, and observe the Median filter and Mean filter denoising result comparison. Not only that, the Matlab language is similar to programming with C language, grammar is easy to learn, and easy to use, is simple, efficient and function is an extremely strong programming language, the image processing toolbox provides a variety of ways to reduce the noise of the image, use the toolbox provided abundant function, can conveniently analyze the digital image processing and research [5].

### *2.3. An Introduction to Noise.*

In a clear picture, the quality of the picture will be affected if it is infected by noise. Noise is usually expressed as an insular pixel or pixel block in an image that comes into being strong visual results. Noise can be divided into a variety of noises in different classification angles. For example, the common noise in digital noise is Gaussian noise, salt and pepper noise, Poisson noise, and multiplicative noise [6]. It is a sort of random noise, which is distributed according to the Gaussian probability law of N variables

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at any selected instant. Gaussian noise is entirely dependent on its time-varying average value and the covariance function of the two transients. If the noise is jarless, the average value is standalone of time, while the covariance function becomes a correlation function related only to the difference between the two transients considered, which is equivalent to the strength spectral density in sense. Gaussian noise can be produced by a good deal of standalone pulses in order to at any finite time interval, the value of pulses is inappreciable compared to the total number of the values of all pulses. There are two important indexes in Gaussian noise, one is the variance and the other is the mean. Because the noise obeys Gaussian distribution, the larger the variance, the more diffused the data, and the more noise, so in the code, the author will also calculate the SNR by the variance. The mean value determines the brightness of the whole picture. If the mean value is greater than 0, it means that the image is plus a noise that makes it bright, and if it is less than 0, it means that the image is plus a noise that makes it dark. Gaussian noise is caused by the image sensor when the market is not bright enough, the brightness is not uniform enough. It could also be due to circuit components of the own noise and interaction and image sensor long-term work; the temperature is too high. If the probability density function of noise follows Gaussian distribution, it is called Gaussian noise [6]. The amplitude of the Gaussian noise is very close to the normal distribution, but the noise is actually distributed on every pixel. Moreover, the mean of the normal distribution is 0, but when the mean is 0, the Mean filtering will replace that pixel with the mean, which is why the Gaussian noise is reduced after the processing of the Mean filtering.

### *2.4. Formulas and images*

The probability function of Gaussian noise is:

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{(x-u)^2}{2\sigma^2}\right) \tag{1}$$

Where, u represents the mean value, which determines the symmetry axis of the picture. σ is the standard deviation, which determines the height and width of the picture. And when u=0,σ=1, it's a standard normal distribution. This is a one-dimensional normal distribution, but the pictures people see in daily life are two-dimensional. So it is pretty important to understand the two-dimensional normal distribution:

$$f(\vec{x}) = \frac{1}{\sqrt{(2\pi)^n \det(\Sigma)}} \exp\left(-\frac{1}{2}(\vec{x}-\vec{u})^T \Sigma^{-1} \vec{x} - \vec{u}\right) \tag{2}$$

Its picture is shown below in Figure 1:

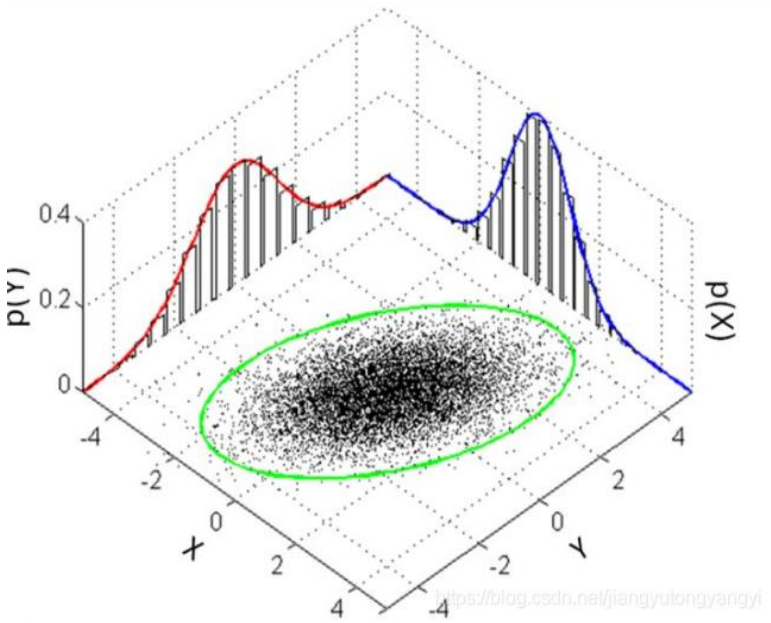


**Figure 1.** The two-dimensional normal distribution[6].

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Its visualization is shown below in Figure 2:

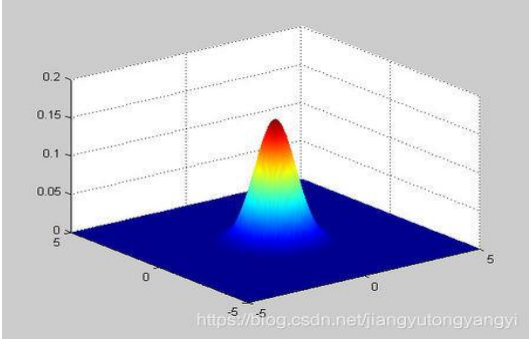


**Figure 2.** The two-dimensional normal distribution's visual picture[6].

*2.5. Image denoising method.*

The Median filter is a frequently used nonlinear smoothing filter [7]. Its filtering theory is pretty analogical to that of a Mean filter. The difference between the Mean filter and Median filter is that the output pixel value of the Median filter is contingent on the median value of adjacent pixels taking the place of the average value. Matlab image processing toolbox provides MedFILT2 function for Median filtering [8]. The essence of Median filtering is a sliding window filter. The filtering proportion is to make the sampled signal value at the center of the sliding window replace all sampled median values in the current window. Median filtering can reduce noise and maintain the image edge well. The theory of Median filtering is to classify the grayscale of all pixels in the window focusing on the current pixel from small to large and taking the median of the sorting result as the grayscale value of the pixel. It is a nonlinear denoising way widely used to reduce impulse noise. The benefits of the filter are easy proportion, convenient implementation, and speed is fast. Under certain circumstances, it can surmount the blur of image details caused by linear filters such as Mean filtering. However, this method should not be applied to pictures with many details, especially points, lines, spikes, and abrupt boundary changes, which will give rise to blurred edges [9]. The primary method used is the neighborhood averaging method of Mean filtering [10]. Mean filtering is a typical linear filtering algorithm, which refers to replacing the current pixel value with the average value of n×n pixel values close to the current pixel. By this means to traverse every pixel in the picture, the Mean filtering of the picture can be finished [10]. The fundamental theory of linear filtering is average takes the place of the intrinsical picture in every pixel value, not dispose of the present pixel (x, y). Select a form board, this form board is consist of the adjacent number of pixels, endeavors to the average of all pixels in the form board, then gives the average to the present point (x, y), as a gray-level picture at that point in g (x, y), That is, G (x, y) =∑ F (x, y) /m, where m is the sum of pixels in the form board containing the present pixel. The denoising result of Mean filtering on Gaussian noise is better than that of Median filtering mainly because the amplitude of Gaussian noise is close to normally distributed, but it is distributed at every point. In addition, Gaussian noise follows a normal distribution, so Mean filtering can be used to process noise when the mean noise is zero. The way of Mean filtering denoising is to treat the current pixel, choose a form board, it is consist of several pixels of its neighbors, and substitute the intrinsical pixel with the mean value of the pixel in the form board. Its advantage is the simple algorithm and its fast calculation speed. The signal-to-noise proportion refers to the proportion between the strength of the transmitted signal and the strength of the noise contained in the process of transmitting the signal. So the larger the signal-to-noise proportion, the better the capacity to decrease noise and the clearer the sound. Generally, this proportion is expressed in decibels (dB). The SNR is measured in dB and it is figured as 10lg(Ps/Pn), Ps and Pn are the resulting strength of signal and noise respectively, and that can be transformed into the proportion of voltage amplitude-20lg (Vs/Vn), Vs and Vn on behalf of the "resulting value" of signal and noise voltage. The amplifier does not append anything except amplifying the signal in the Audio amplifier, which is suitable for it.

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2.6. *Experimental methods and code analysis.*

This experiment first adds Gaussian noise to the image, here is done with the IMnoise function, IMnoise is called the noise pollution image function, which is to add noise pollution to a graph, it is widely used in Gaussian noise. In our code, I1 is used as the input image, and the Gaussian noise with mean 0 and variance 0.02 is added to picture I1 by using the IMnoise function. The fSpecial function is then used to generate a predefined filter, and the filter2 function is used to filter the image, where h is the filtering parameter, J is the image to be processed, and the following medfilT2 function is used to filter the median image.The function H =fspecial(' average ',hsize) is used to generate the Mean filter. Hsize also specifies the filter size, in this case, 3*3. The next Subplot is used to typeset the image, with three numbers representing rows, columns, and specific locations. And mark their names accordingly. A subplot is a gear for drawing multitudinous photos onto a single plane. The m signifies the graph is scheduled in m rows, and n signifies the graph is scheduled in n columns. In other words, there are n graphs in the figure scheduled in a row, a sum of m rows, if m=2, it signifies 2 rows. P is the location of the picture, and p=1 means the first location from left to right and from top to bottom. It is used as a subplot (M,n,p) or subplot (M n P), and the author uses the former in this code. The function of imshow is to display images.MAXI is the maximum value on behalf of the color of picture points, which is 255 if each sampling point is represented by 8 bits. The double function returns a matrix of type double with the same value as the input. Next, the inverse of the total number of image pixels is used to average the variance of two images, and the formula PSNR = 10 * log10(L/MSE) is used to calculate the peak signal-to-noise proportion. After calculating the SNR, the author found that the SNR of the Mean filtering was 35.5489, and that of the Median filtering was 34.3531. The author knew that the higher the SNR, the preferable the denoising result of the filtering. PSNR is frequently used for testing the quality of signal reconstruction in picture contraction and other areas. It is often defined simply by MSE. Therefore, the author could conclude that the denoising result of the Mean filtering on Gaussian noise was better than that of the Median filtering, And the same result can be observed with pictures. The following image is the result of this experiment (see Figure 3):

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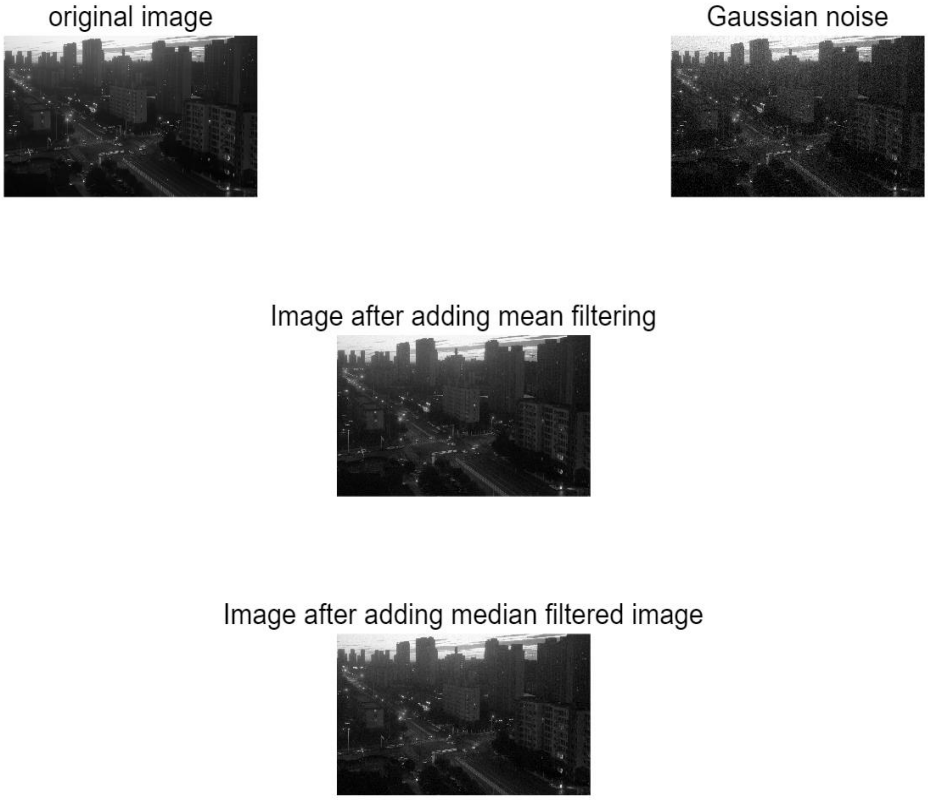


**Figure 3.** The result after treatment and the effect of two methods.

(Photo credit: Original)

## 3. Conclusion

Looking at the picture and comparing the size of the signal-to-noise proportion, shows that in this experiment, the average filtering of a higher signal-to-noise proportion than the value of Median filtering. Because the greater the values of SNR said filtering de-noising result is better, so dealing with gaussian noise with an average filtering result is more significant. When the image is processed under the influence of Gaussian noise, the result of Median filtering is obviously inferior to that of Mean filtering, and the image after processing is fuzzy. But when dealing with color images with the Median filtering may appear the phenomenon of image color becomes shallow, this will not have much impact on the experimental results, which can be ignored. Gaussian noise affects all pixels of the picture. If Median filtering is used to denoise Gaussian noise, all pixels will be replaced by the intermediate value of the pixel only, so the information of other pixels also affected by noise will be lost, and its result is not as good as the Mean filtering of the average value of all pixels.

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