Develop of Mean Filter for Gaussian Image Noise Removal

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Abstract

Image can be corrupted during capturing, transmission or storing it. During this processes images are distorted due to different noises. There are many methods for reducing noise. Traditional mean filter considered as a linear filter, that simple, native and appropriates to removing an Additive noise such as Gaussian noise. Unfortunately, the mean filter suffer from inefficiency of reducing the noise. This paper proposed a new developed mean filter to speed up and enhance the competence of the traditional mean filter. The new filter use subset of pixels in the mask to find the new value of the pixel. The quality of the enhanced images is measured by the statistical quantity measures: Peak Signal-to-Noise Ratio (PSNR) and The Structural Similarity (SSIM) metrics. A time complexities comparison will be explained between developed and traditional filters.
Keywords : Additive Gaussian noise, mean filter, PSNR and SSIM Measures.

الخلاصة

يمكن ان تتعرض الصور الى تشويش خلال عملية التقاطها او انتقالها او خلال تخزينها. خلال هذه العمليات تفسد الصور ويؤدي ذلك الى ضوضاء مضافة. هنالك عدة طرق للتخلص من الضوضاء. ان مرشح المتوسط التقليدي هو مرشح خطي وبسيط ومناسب لإزالة الضوضاء المضافة كضوضاء كاوس. ولكن لسوء الحظ يعاني مرشح المتوسط من بعض المساوئ التي تجعله غير كفوء في تقليص الضوضاء. هذا البحث يطرح فكرة جديدة لمرشح المتوسط لتسريع ولتحسين كفاءة مرشح المتوسط. المرشح المقترح يستخدم مجموعة جزئية من بكسلات النافذة للحصول على سرعة وكفاءة للمرشح تفوق كفاءة مرشح المتوسط الاعتيادي. لقياس دقة تحسين الصور سنستخدم PSNR و SSIM كمقاييس دقة ونقارن بين الصورة الناتجة من مرشح المتوسط المقترح والمرشح الاعتيادي. كما يوضح البحث مقارنة تعقيدات الوقت لكلا الطريقتين.
الكلمات المفتاحية: ضوضاء كاوس المضافة, مرشح المتوسط, مقاييس الـ PSNR و MMIS.

1.Introduction

Noise may be supplement into images through capturing and transmission. The challenges of image processing is to effectually keeping the image features undamaged by remove the noise from it [Milin11]. Enhancement and noise removal is the more widespread and main image processing fields that procedures on image and video models. Linear filters were the elementary methods for processing of image and its applications, because of it provides a efficient theory for design and analysis. These filters show very good achievement with images that damaged by Gaussian noise. But, linear filters never achieve the nonlinearities of the image real sensitive resolution and the vision of the human eyes [Vija09]. Mean filter is one of more common important linear filters that is applied to treating the additive Gaussian noise.

There are many researches demonstrate the low quality of the mean filter on different types of noises. P. Patidar and et al. used mean filter to remove Gaussian, Salt and pepper, Poisson, Speckle noises and there results was not performed well with low resolution for the resulted image[Pawan10]. V.R.Vijaykumar and et al. applied the mean filter on additive Gaussian noise and explain that mean filter have not a good results compared with other types of removal noise filters [Vija10]. Rohit Verma and Jahid Ali discussed different types of noise that appeared in images and

compared the results of applying mean, order static and BM3D filters and mean filter get undesired effects on image[Rohit13].

Although the simplification and fast of mean filter, unfortunately, the week performance make it less used to remove the noise. This paper introduced a developed method to apply mean filter with improved and fast results by computed the mean of cross and plus form of the current window of the noisy image. This paper organized as follows: section 2 defines the noise and present main different types of noises that corrupted an image. Section 3 introduces the different types of filters to remove image noise. Section 4 focuses on the mean filter in details. Section 5 illustrates the quality measurements. Section 6 presents the proposed method of developed mean filter. Section 7 illustrates the results that obtained and section 8 presents the conclusions and discusses the results.

2.Image Noises

Noise can be defined as a mistaken information degraded an image. Noise betide an image from different sources. The basically cause of appears noise in images is the converting image from continuous electrical signal to digital form [Salem10]. There are several ways through which noise can be catch the image, depending on how the image is created.

The nature of the problem depends on the type of noise added to the image. Mainly, there are two types of noises that are additive Gaussian noise and Impulse noise [C.Myth11].

Additive Gaussian noise is a statistical noise includes the adding of a zero-mean Gaussian values to the image pixels in particular rate. That is, for each pixel with intensity value $A_{x,y}$ where ($1 \leq x \leq m$, $1 \leq y \leq n$ for an m x n image), the resultant pixel of the corrupted image $B_{x,y}$ is denoted by:

$$B_{x,y} = A_{x,y} + N_{x,y} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where $N_{x,y}$ is denoted by the zero-mean value of Gaussian distribution. Such noise is usually introduced during image gaining. This type of noise can be reformed by finding the average of the pixel neighbors values (traditional mean filter)[Vija10][G.Ilango11].

Impulse noise is introduced by changing some pixels in image with random quantity. This noise can be introduced due to broadcast process. This type of noise can classified in to two main types: 1) Salt and Pepper noise and 2) Random valued impulse noise. The different between them is the value of the impulse noise that have 0 or 1 values in the first type, whereas, ranged between [0-255] in the second one. This work adopt the Additive Gaussian noise to apply the developed mean filter.

3.Filters

There are many ways to remove noise from image. It's aimed to eliminate noise as far as possible with a good enhanced resulted image. Conventionally, the remove noise methods, generally, can be divided in to two main types linear and non-linear methods.

In a linear method the value of an output pixel is a linear combination of the values of the pixels in the input pixel's neighbors. The advantages of linear noise removing method is the speed and simplified, but it suffer from ability to preserve edges. One of popular linear methods is mean filter. Whereas, in nonlinear method passes in a two phases, first decides if that data is noise or original pixel then replace

it with appropriate value depends on pixel's neighbors if it was a noise or leaves it without change if not. Although, the nonlinear method is have a better results in preserves the edges than linear method, more difficult to applied and time customized. One common nonlinear denoising filters is the median filter [Pawan10].

4.Mean filter

Traditional mean filter is considered as a low pass linear average filter that calculates the average (mean) of the values in the filter window that size can be in 3x3 or 5x5. In this filter, the pixel intensity value is replaced by that average value of the current window pixels. This procedure is repeated for all pixel image intensity. This filter can be used to remove noise and emphasize general brightness trends[Micro14][Rohit13]. The mean filter formula can be described in equation (2):

$$Mean\ Filter = \frac{1}{N^2} \times \sum_i^N \sum_j^N a_{ij} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, N^2 is the size of filter window (3x3 or 5x5).
(a) is the intensity pixel in that window.

5.Quality Measurements

There are two type of a quality measures are used to evaluate the enhancement of images there are Peak Signal-to-Noise Ratio (PSNR) and The Structural Similarity (SSIM) metrics.

The PSNR term is an statistical quality measure for the ratio between the maximum possible power of a signal and same content [M.Rouse08] . This measure's result is a real number greater than 0, that as increased as the similarity will be better. The equation of PSNR is denoted as:

$$PSNR = 10log_{10}\left[\frac{255^2}{\frac{1}{MN}\sum_i\sum_j(y_{ij}-x_{ij})^2}\right] \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where,the value y_{ij} denoted to the reconstructed image pixels and the value x_{ij} denoted to the original image value. M x N is the size of image [Vija09].

The structural similarity (SSIM) evaluate visual quality with a modified local measure of spatial correlation including of three values: mean, variance, and cross-correlation. This measure's result ranged between 0-1, that as increased as the similarity will be better. The SSIM measure can be described as:

$$SSIM(x,y) = \left(\frac{2\mu_x\mu_y+d_1}{\mu_x^2+\mu_y^2+d_1}\right) \times \left(\frac{2\sigma_{xy}+d_2}{\sigma_x^2+\sigma_y^2+d_2}\right) \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where x is the window of X image, y is the window of the image Y. μ_x and μ_y are represented the mean values of the windows x and y respectively. σ_x , σ_y are denoted to the standard deviation of x and y respectively. σ_{xy} is the cross-correlation (inner product) of the mean shifted images $x - \mu_x$ and $y - \mu_y$, and the d_i for i = 1, 2 are small positive constants. These constants avoid divided by zero issues when either $(\mu_x^2+\mu_y^2)$, $(\sigma_x^2+\sigma_y^2)$ or $(\sigma_x\sigma_y)$ is close to zero. The global SSIM quality image that refer to the images *x* and *y* can be calculated by averaging the SSIM values computed for small spatial windows of the two images [M.Rouse08],[P.NDAJ10].

6.Proposed method

This paper presents a developed mean filter that remove the image noise with best quality than the traditional mean filter. The developed filter considers that the filter convoluted on a window with size 5x5 illustrated in figure (1). In this method, for each pixel in the image that will be the center of window, find S vector that consists of the pixels in main and secondary diagonals of the current window that illustrated in figure (1) with green color and the pixels in horizontal and vertical form in current window that colored with yellow. Then, find the mean (average) value for S that represent the filtered value of the current pixel.

X11	X12	X13	X14	X15
X21	X22	X23	X24	X25
X31	X32	X33	X34	X35
X41	X42	X43	X44	X45
X51	X52	X53	X54	X55

Figure (1) filtering window with size 5x5

The white pixel in filtered window that illustrated in figure (1) will not be computed in filter because it less important than the pixels located in the horizontal, vertical and two diagonals of the window. The later contains edges information and important details of the window. The ignored eight white pixels are reduced the time that required to enhance the image as illustrated in results section.

7.Results

The proposed method is applied on 512 by 512,that is 8 bits per pixel standard gray images, for example House, Lena and Boat. The performance of the proposed method is tested for default Gaussian noise corruption and compared with traditional mean filter. The filters are implemented using filtering window is of size 5x5. Figures (2) illustrate the original image for House, Lena and Boat, respectively.

(a) House original image **(b) Lena original image** **(c) Boat original image**

Figure (2) Original standard images

Figures (3) illustrate the noisy images by Additive Gaussian noise with default mean and variance values. Figures (4) illustrate the filtered images using traditional mean filter. Figures (5) illustrate the filtered images using developed mean filter.

In addition to the visual quality, Table (1) illustrated the performance of the proposed method and traditional mean filter that are statistically measured by PSNR and SSIM measurements.

(a) House noisy image

(b) Lena noisy image

(c) Boat noisy image

Figure (3) the noisy images with Adaptive Gaussian noise

(a) apply traditional mean on noisy House

(b) apply traditional mean on noisy Lena

(c)apply traditional mean on noisy Boat

Figure (4) applying traditional mean filter

(a) apply developed mean on noisy House

(b) apply developed mean on noisy Lena

(c) apply developed mean on noisy Boat

Figure (5) applying developed mean filter

The time consumed of the our manner is coupled with the traditional filter for the images samples with a size 512x512 are illustrated in table (2). Note the two methods are applied in Matlab 7.1 with computer specified in Intel Corei7 1.8 GHz CPU and 8 GB Ram memory .

Table (1)the results of PSNR and SSIM quality measures between the original image and removed noise image using traditional and developed mean filters on Lena, House, Boat images samples.

Images samples	Lena		House		Boat	
Quality Measure	PSNR	SSIM	PSNR	SSIM	PSNR	SSIM
Traditional mean filter	27.9928	0.623	26.8673	0.651	25.9174	0.636
Developed mean filter	28.1539	0.694	27.3802	0.671	26.7831	0.673

Table (2)the results of time complexities traditional and developed mean filters on Lena, House, Boat images samples.

Images samples	Lena	House	Boat
Traditional mean filter	7.7	7.1	7.3
Developed mean filter	6.7	6.3	6.5

8.Conclusions

This paper introduced a developed method to apply mean filter that's to increase the performance and ability of the traditional mean filter and speed up the computation time of it. This done by reducing the number of pixels that inherent in calculation of mean and abided a subset of pixels that have cross and plus form of 5x5 convolution window. The results presented and compared for these filters techniques. The obtaining results denoted that our developed mean filter is introduced quality of the image as well as the traditional mean. The time complexities of developed mean filter is less than the traditional mean that near to be one second. That make our method is faster than the traditional one, because our filter reduce the number of pixels that computed mean for it.

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