Edge detection of noisy image using different mask filters

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Abstract

Operation based on second partial derivates are very useful in edge detection of image. in this research we have been used different mask filter such as (laplacian, sobel , Robert) applying on noisy and enhance image respectively. First; adaptive filter consist of duplicated of two filters (lee and Gaussian) have been apply to enhance the spkle noisy image, then mask filters have been used to develop the edge detection result, after that the comparison with original image has been achieved using statistical criteria.

Keywords: edge detection, lee filter, Gaussian filter, laplacian, sobel, Robert.

الكشف عن حافة الصورة الصاخبة باستخدام مرشحات قناع مختلفة

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المستخلص

التقنيات التي تعتمد على المشتقة الثانية تعتبر مهمة جدا لتحديد حافات الصور .في هذا البحث تم استخدام نوافذ مختلفة لتحديد حافات الصور تعتمد هذه النوافذ على طرق كلاسيكية معروفة مثل (لابلاس، سوبل، روبرت)، حيث تم تطبيق هذه التقنيات على الصورة الاصلية والصورة المشوشة بواسطة ضوضاء البقع ، واخيرا على الصورة المحسنة بأستخدام فلتر مركب من مرشحين (كاوسي ولي) ،ومن خلال استخدام الخصائص الاحصائية تم تحديد الطريقة المثلى لتحديد حواف الصورة المشوشة بضوضاء البقع.

Introduction

Edge detecting is a basic operation in image analysis. Edge points of items in an image hold much of the information in the image. The edge tell us where items are, their size, shape, and something about their texture. The detected edge gives a bright spot at the edge and dark areas everywhere else. Mathematically, edges are defined as a derivation process, this mean it is the slope or rate of change of the gray levels at boundary region, within an image, the gray variations is always positive or zero, it reaches its maximum values at the boundary points [1]. Also, it's an important operation in a number of image processing applications such as in scene analysis and character recognition. Edges are defined as large and sudden changes in some image attribute, usually the brightness. The usual aim of edge detection is to locate edges belonging to boundaries of objects of interest. Some of the difficulties in edge detection are caused by noise in the image but much more so by the fact that edges are often more so by the fact that edges are often blurred [2]. There are many techniques have been adopted to make edge detection of image such as (Robert operator, sobel gradient, Prwitt gradient, kirsch compass masks, robinson, etc,.). in this research we use classic laplacian filter which can be defined as a second differential operator, it convolving with the image, the sign of the result (positive or negative) from two adjacent pixel locations provides directional information, and it show which side of edge is bright, many edge detection techniques have been used in this paper the steps of the search can be summaries as follow:

- **Step (1)**: apply the edge detection techniques using different filters on the original image.
- **Step (2):** add rate of spkle noise to the original image.
- **Step (3):** enhance the noisy image using duplicated if two filters (lee and Gaussian filters).
- **Step (4):** apply the edge detection filters on the noisy image.
- **Step(5):** apply the edge detection filters on the enhance image.
- **Step (6):**compute the statistical properties using (mean, variance, stander deviation) for each result image as bellow equation:

$$m = \frac{1}{N*M}\sum_{i=1}^{N}\sum_{j=1}^{M} G(i,j) \tag{1}$$

$$V = \frac{1}{(N-1)*(M-1)}\sum_{i=1}^{N}\sum_{j=1}^{M} (G(i,j)-m)^2 \tag{2}$$

$$\sigma = \sqrt{V} \tag{3}$$

Where: m = mean, V =Variance, σ=Standard deviation, M=No. of row, N=no. of column, G(i,j) =original image .

Smoothing of noisy image:

Smoothing is a process by which data points are averaged with their neighbors in a series, such as a time series, or image. This (usually) has the effect of blurring the sharp edges in the smoothed data. Smoothing is sometimes referred to as filtering, because smoothing has the effect of suppressing high frequency signal and suppressing high frequency signal and enhancing low frequency signal. There are many different methods of smoothing, but here we use smoothing with duplicated filters (lee and Gaussian filters respectively) which it explanation below.

Lee's Filter:

Lee filter performs image smoothing by applying the lee filter algorithm this algorithm assumes that the sample mean and variance of a value is equal to the local mean and variance of all values within a fixed range surrounding it. Lee's filter is used to remove the additive signal noise by generating statistics in a local neighborhood and comparing them to the expected value [3].

Gaussian Filter:

A Gaussian is an ideal filter in the sense that it reduces the magnitude of high spatial frequency in an image proportional to the frequency. That is it reduces magnitudes of higher frequencies more.

$$G(X,Y)=\frac{1}{2\pi\sigma}e^{\frac{-(X^2+Y^2)}{2\sigma^2}} \qquad (4)$$

Where x&y are the pixel coordinates, σ is the standard division

Edge Detection

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. There is an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges. Variables involved in the selection of an edge detection operator include,[4]:

- **Edge orientation:** The geometry of the operator determines a characteristic direction in which it is most sensitive to edges. Operators can be optimized to look for horizontal, vertical, or diagonal edges.
- **Noise environment:** Edge detection is difficult in noisy images, since both the noise and the edges contain high-frequency content. Attempts to reduce the noise result in blurred and distorted edges. Operators used on noisy images are typically larger in scope, so they can average enough data to discount localized noisy pixels. This results in less accurate localization of the detected edges.

Laplacian Filter:

When we consider laplacian filters we actually mean a discrete approximation to the math evnatical laplacian operator:

$$\nabla^2 f(x,y) = \frac{\partial^2 f(x,y)}{\partial \chi^2} + \frac{\partial^2 f(x,y)}{\partial y^2} \qquad (5)$$

Note that the 2- dimensional laplacian given by equation (1), is the second order partial derivative in the orthogonal directions of a continuous space. The Laplacian filter is frequently used in digital image processing, it a crude approximation of its mathematical equivalent defined in eq. (2) :

$$\nabla^2 \mathrm{I}(\chi, y) \approx \mathrm{I}(\chi+1, y) + (\chi-1, y) + \mathrm{I}(\chi, y+1) + \mathrm{I}(\chi, y-1) - 4\mathrm{I}(\chi, y) \qquad (6)$$

Alternatively, this digital filter can be viewed as the following 3 x 3 set of filter coefficients [5]:

0	1	0
1	-4	1
0	1	0

The advantage of laplacian is that "the high spatial frequencies in all orientations are equally enhanced", but the laplacian being doubly enhances any noise in the image [6].

Sobel Operator

The Sobel operator is used in image processing, particularly within edge detection algorithms. Technically, it is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Sobel operator is either the corresponding gradient vector or the norm of this vector. The Sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations. On the other hand, the gradient approximation which it produces is relatively crude, in particular for high frequency variations in the image.

Mathematically, the operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical. If we define **A** as the source image, and $\mathbf{G}_x$ and $\mathbf{G}_y$ are two images which at each point contain the horizontal and vertical derivative approximations, the computations are as follows:

$$\mathbf{G}_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * \mathbf{A} \quad \text{and} \quad \mathbf{G}_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * \mathbf{A} \qquad (7)$$

where * here denotes the 2-dimensional convolution operation.

The x-coordinate is here defined as increasing in the "right"-direction, and the y-coordinate is defined as increasing in the "down"-direction. At each point in the image, the resulting gradient approximations can be combined to give the gradient magnitude, using:

$$\mathbf{G} = \sqrt{\mathbf{G}_x^2 + \mathbf{G}_y^2} \qquad (8)$$

Using this information, we can also calculate the gradient's direction:

$$\mathbf{\Theta} = \mathbf{atan2}(\mathbf{G}_y, \mathbf{G}_x) \qquad (9)$$

where, for example, $\mathbf{\Theta}$ is 0 for a vertical edge which is darker on the right side.[7,8].

Robert’s Cross Operator:

The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. The operator consists of a pair of 2×2 convolution kernels as shown in Figure. One kernel is simply the other rotated by 90°. This is very similar to the Sobel operator.

+1	**0**
0	**−1**

Gx

0	**+1**
−1	**0**

Gy (10)

These kernels are designed to respond maximally to edges running at 45° to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these Gx and Gy). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is given by:

$$|G| = \sqrt{Gx^2 + Gy^2} \quad (11)$$

Although typically, an approximate magnitude is computed using:

$$|G| = |Gx| + |Gy| \quad (12)$$

Which is much faster to compute. The angle of orientation of the edge giving rise to the spatial gradient (relative to the pixel grid orientation) is given by:

$$\theta = \arctan(Gy / Gx) - 3\pi / 4 \quad (13)$$

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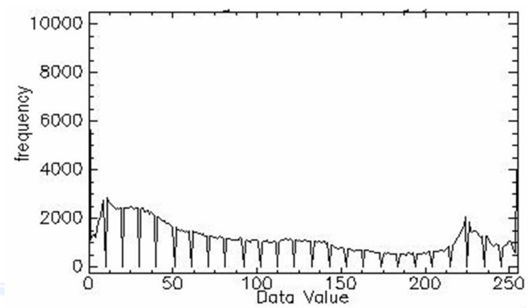
<tr><td></td><td>
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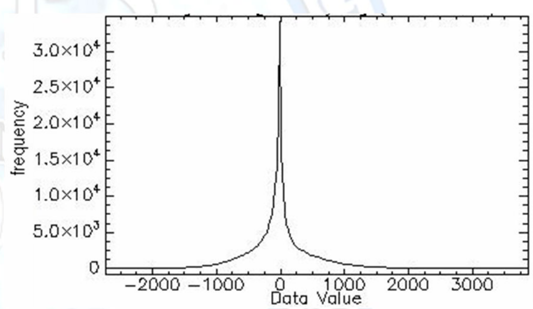
<tr><td>Original image</td><td>Histogram of original image</td></tr>
<tr><td></td><td>
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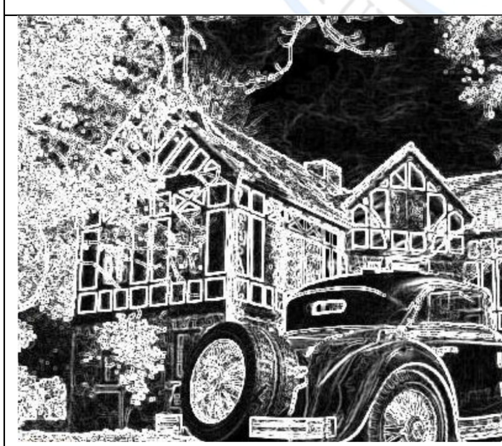
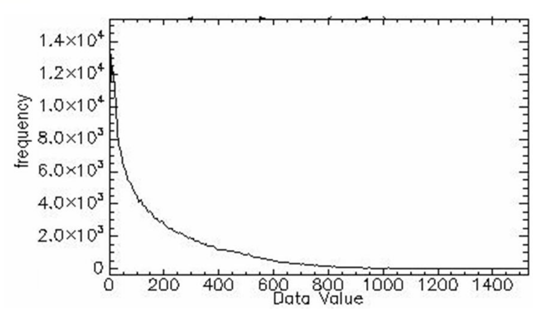
<tr><td>Edge image using Laplace filter</td><td>Histogram of edge image(laplace)</td></tr>
<tr><td></td><td>
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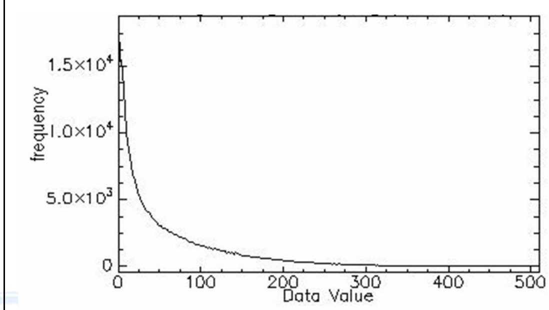
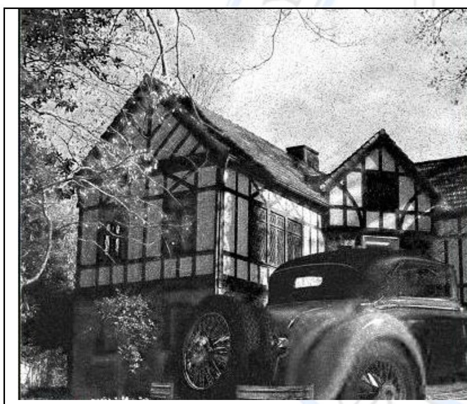
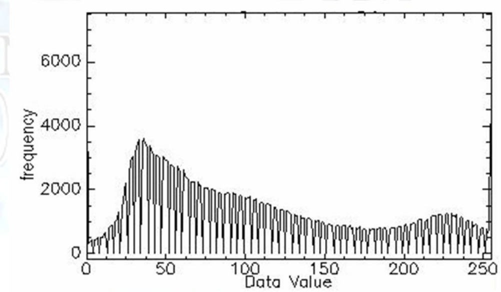
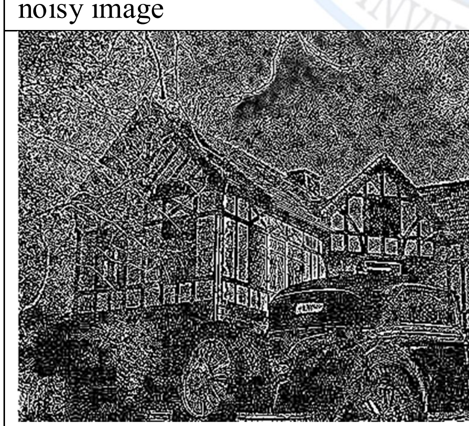
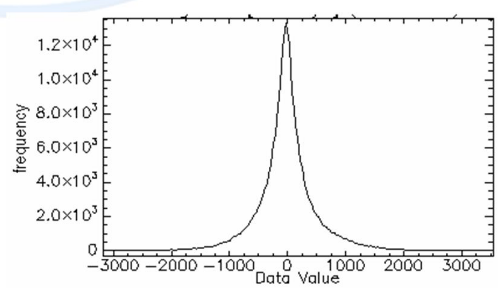
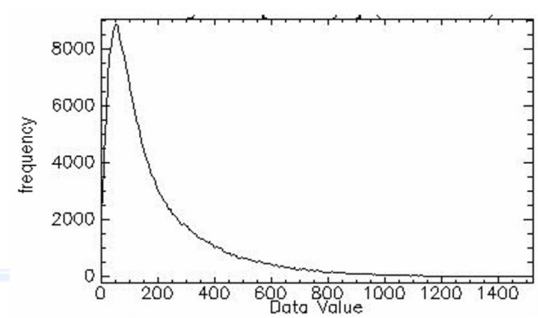
	
Edge image using Robert filter	Histogram of edge image (Robert)

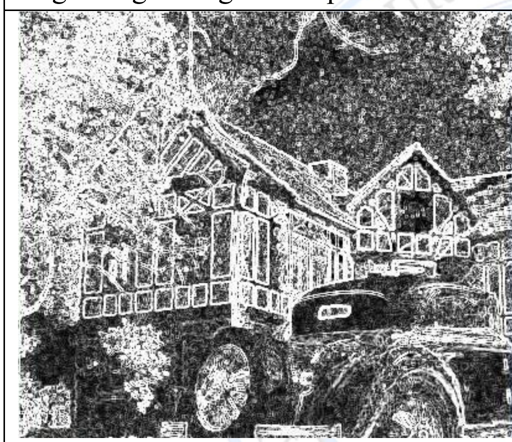
Figure (1) shows the result of edge detection of original image using different filters.

	
noisy image	Histogram of noisy image
	
Edge image using Laplace filter	Histogram of edge image(laplace)

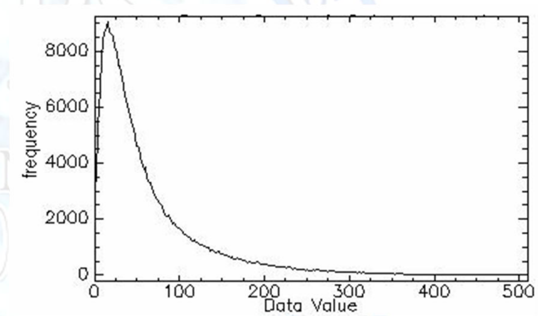
Edge image using sobel operator



Histogram of edge image(sobel)



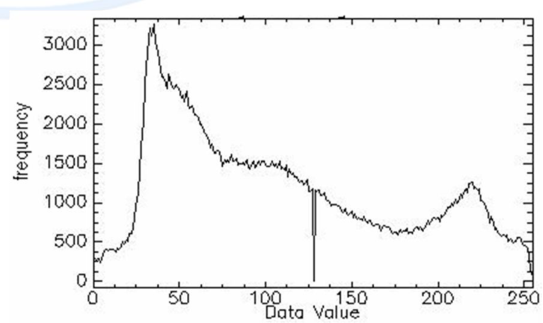
Edge image using robert operator



Histogram of edge image(robert)

Figure (2) shows the results of edge detection of spkle nose image using (laplacian,sobel, Robert)

Enhance image



Histogram of enhance image

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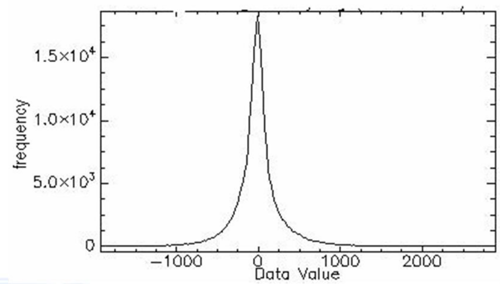
<tr><td></td><td>
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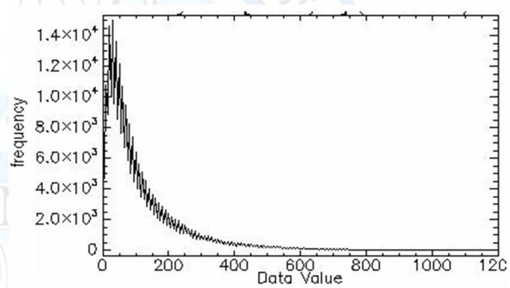
<tr><td></td><td>
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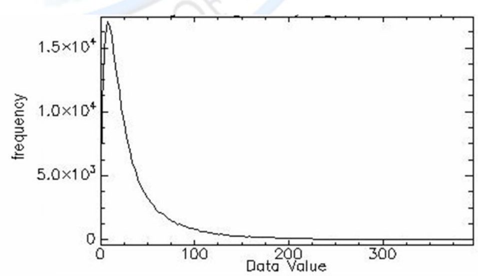
<tr><td>Edge image using sobel operator</td><td>Histogram of edge image(sobel)</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td>Edge image using robert operator</td><td>Histogram of edge image(robert)</td></tr>
</table>

Figure (3) shows the results of edge detection of enhancement image using duplicated filters (gauss and lee filters)

Table (1) shows the statistical properties of edge detection for original, noisy and enhance image.

	Min.	Max.	mean	Stdv.
Original image	0	255	103.125701	80.56354
Edge detection(laplace)	-2737	3874	0.002257	473.82929
Edge detection (sobel)	0	1530	191.37476	196.81467
Edge detection(Robert)	0	512	57.191699	66.121652
Noisy image	0	255	107.125701	72.4988
Edge detection(laplace)	-3184	3553	-0.033078	491.62092
Edge detection (sobel)	0	1 528	196.086485	192.17803
Edge detection(Robert)	0	510	61.748918	61.89112
Enhance image	0	255	107.237726	66.31654
Edge detection(laplace)	1933-	2907	0.029209	273.8894
Edge detection (sobel)	0	1202	121.412561	130.30837
Edge detection(Robert)	0	397	34.774141	38.68214

Result and Discussion:

Edge detection consider to be one of the most important technique for image processing, many classic edge detection filters such as (laplace, sobel, Robert) have been adopted in this research. These techniques were performing by convolving the give image with one selected mask. The effect of these masks have been obtained by corrupted the image with rate of spkle noise then remove the spkle noise and enhance it using duplicated filterers consist of two filters (lee and Gaussian) respectively. Edge detection filters applied on original, noisy and enhance image respectively. The statistical properties such as (minimum, maximum, mean and standard deviation) have been achieve to check the quality of performance of the edge detection filters, the statistical properties of original, noisy and smoothing image show that Robert technique is better than other classic technique for detect the edge of enhance spkle noisy image. For more details see table (1). The edge detection of the original image using different mask filters with their histogram can be shown in figure (1). While the noisy and enhance image using duplicated (Gaussian and lee) with their histogram can be showed in figure (2) and (3) respectively.

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