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Implementing Canny Edge Detection Algorithm for Different Blurred and Noisy Images

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***Abstract*—In the field of image processing, edge detection of visual data is one of the most important operations of image processing research. This operation is very useful in many applications like object recognition, feature detection of image, motion analysis in computer vision field, etc. Canny detector is an algorithm of these operations of edge detection which constitutes more information about object to other edge detection algorithms. This work consists of a comparison study of image edge detection methods by focusing on the Canny algorithm to present the efficiency and perfection of this methods compared to other. Moreover an improved execution of this methods for blurred and noisy images.**

***Index Terms*—Image, Blur, Noise, Restoration, Edge Detection, Canny Detector, Features of images.**

I. Introduction

FEatures detectors of any object of different scenes have been an essential part of many computer vision systems. The edge detection process serves to simplify the analysis of images by drastically reducing the amount of data to be processed, while at the same time preserving useful structural information about object boundaries. There is certainly a great deal of diversity in the applications of edge detection that can be to used on many types of images. In [1] a principal description of edge detector that define the detection criteria for extraction and localization of object. Among edge detection techniques that are studied in many works citing, Roberts Detector, Sobel Detector, Prewitt Detector, Laplician of Gaussian (LOG) Detector and Canny Detector, etc [7], [13], [15], [17], [18] and [19]. So in [19] the proposed edge detector based on the Laplacian Operator (LOG) is applied on the satellite images, but in [18] all these edge detection methods are applied on images X-ray. But in [7] ,[13], [15] and [17] these operators of edge extraction were applied on the digital images. Based on these works and our results Canny Detector is the good detector so in [16] authors proposed improved method of Canny Detector based on intensity and the mean of image gradient. Other improved methods based on genetic algorithm [20], and in [8] an improved method of Canny Detector used as an application of image processing for an automatic monitoring realized with vision based monitoring Robot for crack extraction by detection the edges of cracks inside a pipe, but these all methods no robust to noise.However, in this work we works on digital images captured by a digital camera. But these all images may suffer from different degradation during acquisition occur due to camera shake, slow shutter speed causes even slight camera motion to cause blurry photos and fast shutter speed freezes motion despite camera shake when shooting hand-held camera. That results we got a degraded images [3], which can be classified into three families blurred images that degraded by any type of blur like a Simple Blur, Average blur, Motion blur, Defocus blur, Gaussian blur, etc [4], [6], [10] or noisy images produced by many type of noises like Gaussian Noise, Poisson Noise, Speckle Noise and Salt and Pepper Noise etc [11], [12], [14], and blurred and noisy images that combined by these tow degradation [2], [9] These all problems can be eliminated by different method of image restoration for reduce the blur and noise, in [5] an description of Blind Deconvolution Algorithm using to reduce the Gaussian Noise, the Median Algorithm illustrated in many works in [11] ,[22] and [23] it is using to eliminate the blur and noise, Weiner Algorithm was proposed in [2], [23], [24] and [25] to remove specially the blur and additive Noise.So all visual data restoration and remove blur and noise is associated with edge detection of object, in our work we tried to eliminate four type of blur and two type

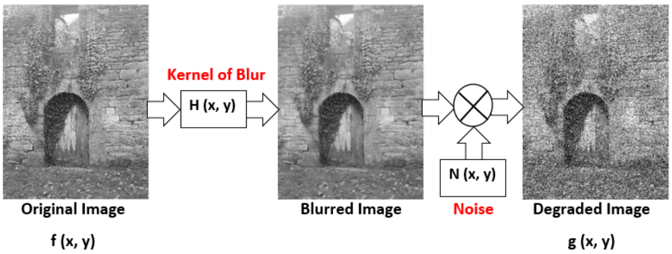

Fig. 1. Image Degradation Process: f(x,y): original image, H (x,y): Degraded Function: represents the types of blur, Blurred Image : an image degraded by a blur, N(x,y): Noise and g(x,y): Blurred and Noisy Image: Image that Degraded by blur and noise.

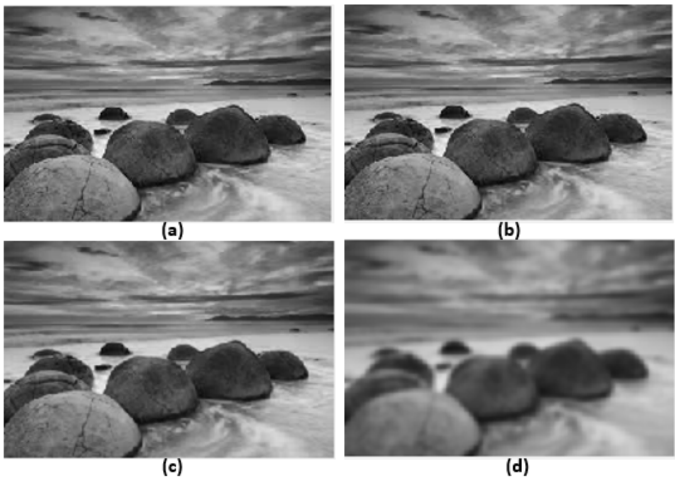

Fig. 2. Image degraded by a Simple Blur and Gaussian Blur : (a) Original image, (b) Image degraded by a Simple Blur, (c) Image degraded by a Gaussian Blur with σ = 0.5, (d) Image degraded by a Gaussian Blur with σ = 2.

of noise by an improved method based on the combination between Wiener and Median algorithms in addition to improve the Canny Detector to detect all edge of object by a estimated images without blur and noise. The present work divides into five sections; the first section an introduction. Second section presents all model and types of blurred an noisy images. All type of edge detector and analysis comparison of these detectors illustrated in the thirst section. all results obtained and comparative study between quality results of our proposed algorithm. In the end, a conclusion is presented in section five.

II. Blurred and noisy images

A. Blurring of image

Blur is a region or object or person shape which can't visible clearly. So this blur in images is an reduction of image quality [10], it is can be caused by visual sensors shake or object movement, or inaccurate focusing in time of taken, or motion of the scene [3], etc. Blur is an important cause of visual data degradation because it makes a improper quality of an image, such as digital images, Satellite Images, or X-ray images, and others. Noise also distorts the image [4], [6] and [24] so the model of degradation image it can be expressed by equation (1) :

$$g(x,y) = H(x,y) * f(x,y) + N(x,y) \tag{1}$$

Where, f(x,y) is the input original image, g(x,y) is the blurred and noisy image that degraded by H(x,y) function represents the blur model and by N(x,y) is an additive noise.

B. Blurring Types

There are several reasons that make a blurred images such as in visual sensors problems, atmospheric problems, move scene object, low intensity during acquisition...etc. So in these cases we get a blurred images with inexactly objects details. In processing image field, there are different types of blurring like Simple Blur, Gaussian Blur, Motion Blur, Average Blur, Defocus Blur, Selective Blur, etc. In this work, we based on four types of blur which are detailed below.

a) Simple Blur: It's a slight and low blur [6]. The effect of this type of blur is so slight in captured images, that it can be imperceptible and at times invisible. Also, this can be like a translation, a rotation in a light way [2].It can be represented by a model of blur in expression (2). This blur can be a combination of others types of blur but in a light way also. Sometimes it can be as a No Blur [2]. It is represented in picture (b) in Fig.2.

$$g(x,y) = (H * f)(x,y) \tag{2}$$

b) Gaussian Blur: This type of blur is the most used in image processing field, it works in the simplest way. In [6], [9] and [10] a Gaussian Blur as its name suggests, it is produced by a Gaussian function. This blur is high at the center and decreased at the edges of images depending on bell shaped curve [6] and [9]. The Gaussian kernel is represented by this equation (3) :

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{-x^2+y^2}{2\pi\sigma^2}} \tag{3}$$

This model of blur is shown in pictures (c) and (d) in Fig.2 with different values of σ, respectively σ = 0.5 and σ = 2.

c) Average Blur: Average blur distributes in a vertical and horizontal direction [6], [9] and [10]. It decreases quality of image by setting each pixel equal to the average pixel value of neighborhood. In [9] this type of blur can be occur on entire image. It's about a circular averaging can be represented by the expression (2). This type of blur is represented in picture (b) in Fig.3.

$$R(x,y) = \sqrt{F^2 + G^2} \tag{4}$$

Where, R is the radius size of the circular Average Blur, F is the horizontal size blurring direction and G is the vertical

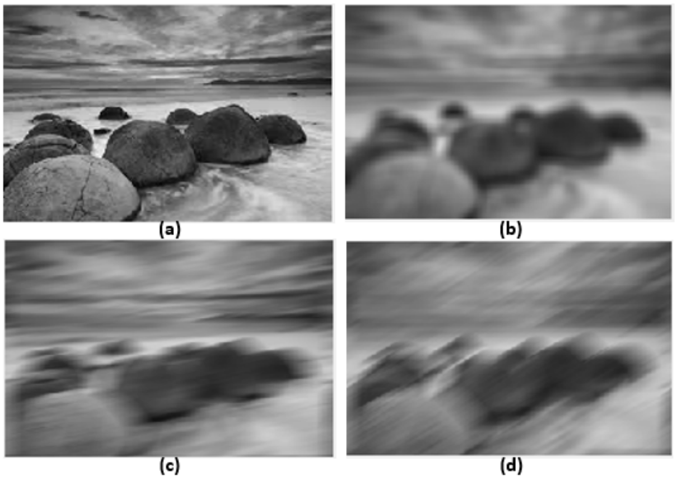

Fig. 3. Image degraded by Average Blur and Motion Blur : (a) Original image, (b) Image degraded by a Average Blur, (c) Image degraded by a Motion Blur with θ = 10, (d) Image degraded by a Motion Blur with θ = 30.

blurring size direction

d) Motion Blur: This blur caused by visual sensor like camera or movement of an object or a person of the 3D scene during the acquisition time [6]. It was giving a movement effect in output image, in [2] and [9] this movement can be a sudden change of scale, or a translation, or a rotation or a combination of these three causes. And it is characterized by angle theta or specific direction [5], [10] and [25], (0 to 360° or –90 to +90).

C. Types of Noise and Models

Generally, noise is all pests and degradation that undergo the image at the time of its acquisition. During image acquisition or transmission, many sources are let to get a noise in the image like stability and/or temperature of visual sensors (camera, thermal camera,...etc.), sensor lighting and/or 3D scene, and noises during data transmission. The main types of noise that are considered in image processing field; Additive noise, Multiplicative noise, Quantization noise, Periodic noise...etc. In this paper, noises that we will consider are :

a) Gaussian Noise: Gaussian Noise is an additive noise. In [2], [5] and [11] this type of noise has a Gaussian distribution with constant mean and a variance value σ. It has a Gaussian distribution can be given by the formula (5). This noise can be used a Gaussian kernel (3x3, 5x5, 7x7, etc.) [12]. It is given by the pictures (b), (c), (d), (e) and (f) in Fig.4 with different values of σ.

$$N_G = \frac{1}{2\pi\sigma^2} exp^{-}(\frac{-x^2+y^2}{2\pi\sigma^2}) \quad (5)$$

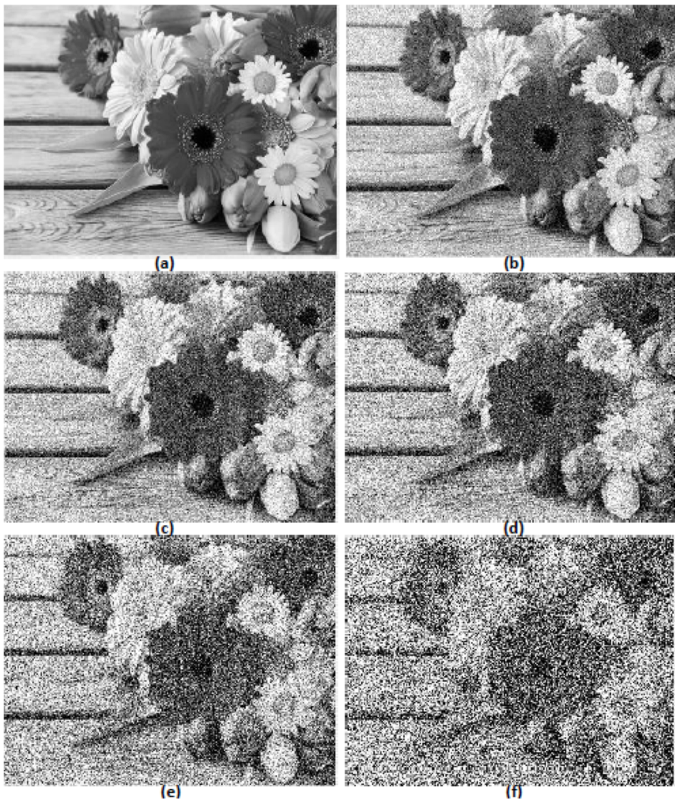

Fig. 4. Image degraded by Gaussian Noise with zero mean : (a) Original image, (b) Gaussian Noise with σ = 0.01, (c) Gaussian Noise with σ = 0.03, (d) Gaussian Noise with σ = 0.05, (e) Gaussian Noise with σ = 0.1, (f) Gaussian Noise with σ = 0.3.

where, x is the distance from the origin in the horizontal axis, y is the distance from the origin in the vertical axis, and is the standard deviation of N_G.

b) Salt and Pepper Noise: It is an impulsive noise [11] and [2]. It's about an image degradation in the form of black and white pixels (Salt and Pepper pixels) [9]. This type of noise is introduced for example by the visual sensor malfunction or by data transmission errors. Fig.5 presents this type of noise that effected the original image (a) with 5%, 10%, 20%, 30% and 40 % Salt and Pepper noise, that were represented respectively in pictures (b), (c), (d), (e) and (f).

III. Edge detection

Edge detection is an essential step for object detection and features extraction in image processing field. This step is important task which represent important object features of digital image, and all shapes which describe the edge of image in a good definite way. Several studies have been presented in [13], [15], [17], [18] and [19] about edge detection methods.

A. Traditional methods of edge detection

a) Roberts Detector: In this operator the vertical and horizontal edges are detected individually, after that its

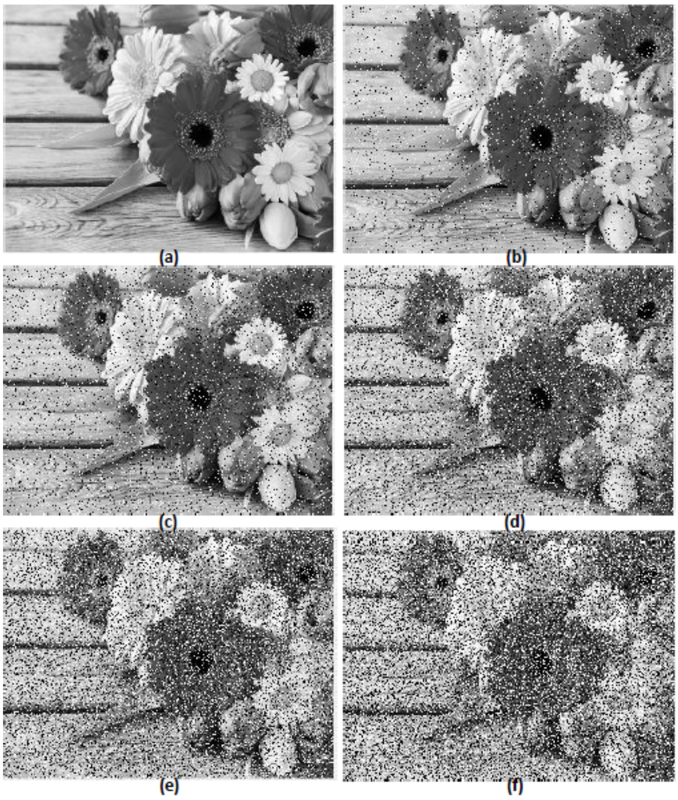

Fig. 5. Image degraded by Salt & Pepper Noise : (a) Original image, (b) Image degraded with 5% Salt & Pepper noise, (c)Image degraded with 10% Salt & Pepper noise, (d)Image degraded with 20% Salt & Pepper noise, (e) Image degraded with 30 % Salt& Pepper noise, (f) Image degraded with 40% Salt & Pepper noise.

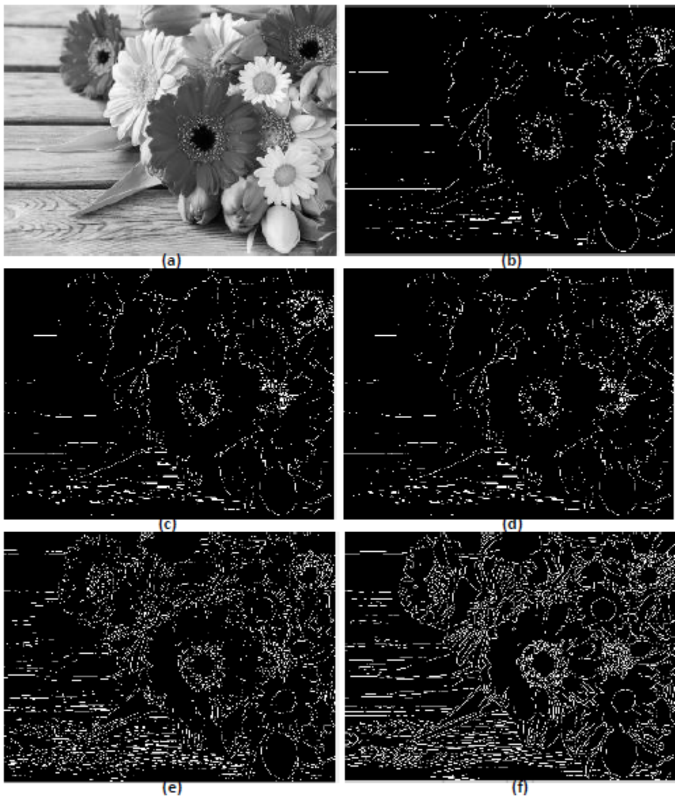

Fig. 6. Edge extraction by using the traditional methods of edge detection : (a) Original image, (b) Roberts Detector, (c) Sobel Detector, (d)Prewitt Detector, (e) Laplician of Gaussian (LOG), (f) Canny Detector.

combined all two for edge detection of output result [17]. It takes input image as gray scale image and produces edges involving in that image. In [17] this operator needs 22 convolution masks and based on the gradient of an input image by calculating the sum of squares of the differences between neighbouring pixels [18]. This detector produces the position of edges more accurately, also it is a simple and efficient approach, it is represented in picture (b) of Fig.6.

b) Sobel Detector: The Sobel detector used also to extract the edges of an image. This is almost similar to the Roberts detector, and among of classical operators allowed to detect edges and their orientations [15]. It is used to make detection of gradients in horizontal and vertical direction respectively X and Y [17] and [18]. The picture (c) of Fig.6 shows the result of this detector.

c) Prewitt Detector: Prewitt algorithm is a classical method for edge detection and one of fast and easy methods [17]. It is an operator used to compute an approximation of the gradient of intensity of image in both horizontal and vertical direction [18]. The result of Prewitt Detector is shown in picture (d) of Fig.6.

d) Laplician of Gaussian (LOG): This technique is a combination of the Gaussian filter with the Laplician filter [13]and [15], so it is applied on two steps for detection object edge. It is used to find areas of fast edges in digital images [17]. In [19] this operator can be detected edges after suppression the noise in an image, but in [18] it is sensitive to noisy images. The picture (e) of Fig.6 shows the result of this detector (LOG).

e) Canny Detector: Canny algorithm is another different method of edge detection because in which can be used different steps to facilitate the edges detection in image. It is the best to simplify the analysis of images by keeping the most parts information about object extraction [1]. Also it has an ability to detect true weak edges in a wide range of pixels in visual data. Canny operator is based on three criteria and is not sensitive to noise [17], Canny operator is one of the optimal edge detector and edge detection is done in multiple stages illustrated in [13], [18]. So in picture (f) on Fig.6 we got obtain a good object detection by Canny Detector.

TABLE I
COMPARISON TABLE ON DIFFERENT EDGE DETECTORS

Operator	Advantages	Disadvantage
Roberts	Simplicity and easy to implement	Losing some shape of object and sensitive to noise
Sobel	Simple operator, faster to compute and easy to find the correct of some corners	Bad edge detection and sensitivity to noise.
Prewitt	Quick to compute and extraction of object edges and their orientations	Sensitivity to noise and inaccurate in some region detection
Laplician of Gaussian (LOG)	Good detection, Finding the object edges and allows to test the small kernels around the pixel	Very sensitive to noisy images and fail to detect some edges
Canny	Optimal edge detector, enables to extract true weak edges, very good detection in noise conditions	Complicated, complex computations, and sensitive to noise also

B. Improved of edge Canny Detector

In this paper and in our case, we have a many degraded visual data by a blur or / and noise. So the use of the different detectors that quoted in the paragraph III is very difficult. In this situation it should to improve degraded images to better apply edge detectors. The classical edge detection algorithms in paragraph III are more used in image processing field, each of them has advantages and disadvantages that are classed in TABLE I . So according to this table, our research, the last works and our our experimental results, Canny detector is widely utilized in generally because it can be detected all the features for an image. It is simple to implement whatever the nature of the captured image. In this work, we studied tow problems, noise problems and blur problems. However, Canny Detector can't be simulated rightly for these problems exist again in blurred and noisy images. So that we have to remove all blur and noise to properly extract the edges of the image.

a) Median Algorithm: Median operator is an image processing operator very widely used for reduce a different type of noise [22]. It is used in particular in digital image processing under certain conditions because it allows to reduce the noise while preserving features of the image like the edge of an image. This operator is a nonlinear filter [11] and [23]. It is an averaging operator [11] allows to decrease noise in images for improving the results of edge detection. In [23] an improved method of Median Operator to remove impulse noise Salt & Pepper . This algorithm allows for enhance the detection of objects of image estimated. It is simple and much faster [23] for reduce a Gaussian and Salt & Pepper noise.

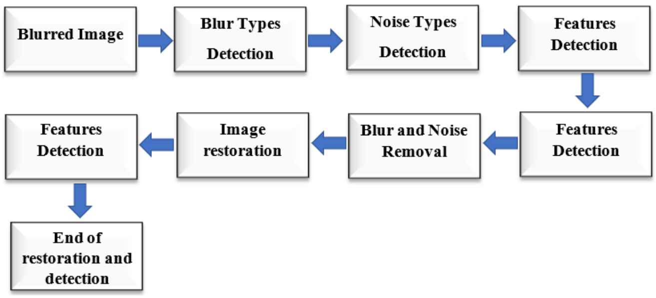

Fig. 7. Restoration image and edge detection Process: Proposed Algorithm.

b) Wiener Algorithm: Generally, in image processing the augmentation in quality of estimated image after restoration is measured by some settings of measurement of image quality like the Signal-to-Noise Ratio improvement [2], [15], [23] and [24], Peak Signal to Noise Ratio, Mean Square Error and Maximum Difference , etc [4], [9], [10], [11] [21]. Also with the visual judgement of the estimated result image can be used [2] and [21]. So, many algorithm can be applied to eliminate blur and noise in different captured images. Wiener can be reinstate the exact image which was corrupted by motion blur effect , and eliminates the additive noise at the same time [2], [24] and [25]. Like the other operators in restoration, the input to these operators is blurred and noisy image. Weiner Operator can be expressed by this expression:

$$G' = W * (f + N) \tag{6}$$

Where, f is the original image, G' is the output estimated image, N is the noise and W is the Weiner operator response. In [6] this algorithm was enabled to eliminate the simple blur, but in our case we are used all types of blur illus traded in Fig.4 and Fig.5 we got a bad results in Gaussian and motion blur.

C. Proposed Algorithm

In this approach, based of the improve Canny detector the image restoration with the proposed combination process works to eliminate the blur and noisy at the same time. This process in Fig.7 is a four step process. First step used both the degraded images (blur and noisy) to find an exact blur kernel. Second step is to detect features of blurred and noisy images. In the third step the restoration images to reduce a blur and noisy which are present in the non-sharp images . In the end, our process proposed detected all object features using the estimated images. Advantage of this proposed method is that it will use both blurred an noisy images blurred an noisy and produce a high quality reconstructed image as a result.

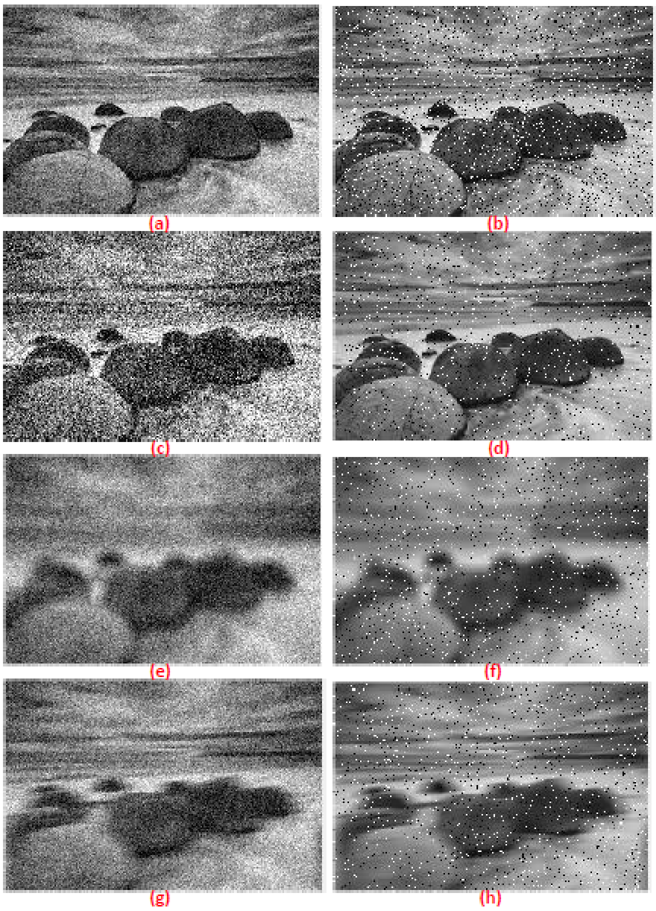

Fig. 8. Blurred and noisy images : (a) Original image, (b) Image degraded by a Simple Blur and with 10% of salt & pepper noise, (c) Image degraded by a Gaussian blur and Gaussian noise, (d) Image degraded by a Gaussian blur with 5% of salt & pepper noise, (e) Image degraded by an Average Blur and Gaussian noise, (f) Image degraded by an Average Blur with 5% of salt & pepper noise, (g) Image degraded by a Motion blur and Gaussian noise, (h) Image degraded by a Motion blur with 5% of salt & pepper noise.

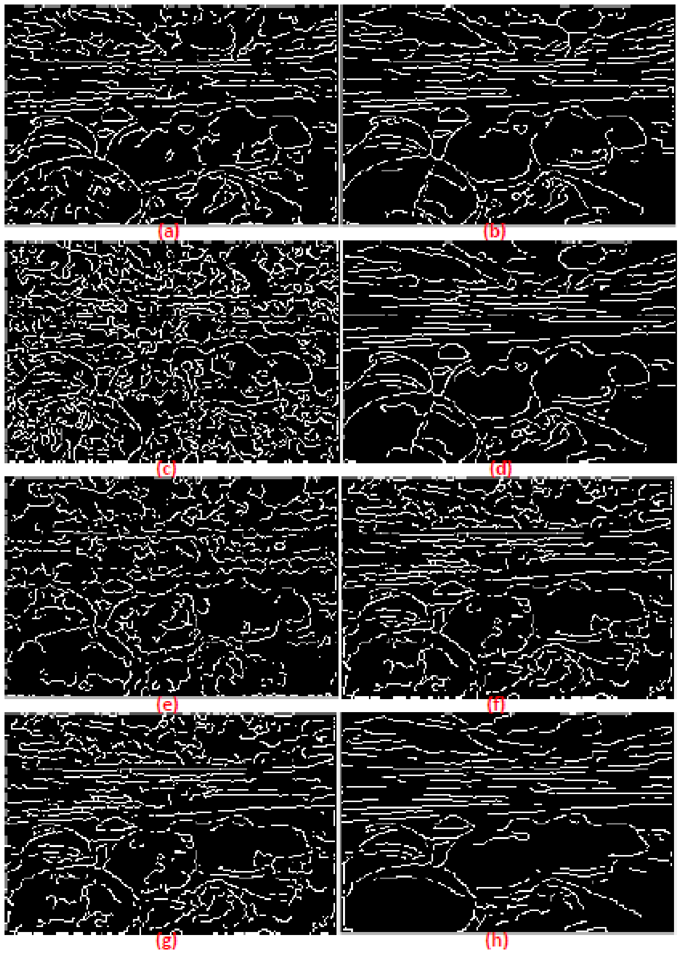

Fig. 9. Final results of our proposed algorithm: Process of restoration and edge extraction about reduce blur an noise: (a) Original image, (b) Final image estimated that degraded by a Simple Blur and with 10% of salt & pepper noise, (c) Final Image estimated that degraded by a Gaussian blur and Gaussian noise, (d) Final image estimated that degraded by a Gaussian blur with 5% of salt & pepper noise, (e) Final image estimated that degraded by an Average Blur and Gaussian noise, (f) Final image estimated that degraded by an Average Blur with 5% of salt & pepper noise, (g) Final image estimated that degraded by a Motion blur and Gaussian noise, (h) Final image estimated that degraded by a Motion blur with 5% of salt & pepper noise.

IV. Results and Discussion

The simulations in this wok are effected by MATLAB software. So the results of our algorithm proposed are display in Fig. 8. The results show that the improvement Canny algorithm by a combination of Median and Wiener techniques has improved edge detection results closer to the edge of the original image compared with the classical algorithm. From the result in Fig.9, Picture (a) represented the original image of dimension (277×182), picture (b) represented the image degraded by a Simple Blur and with 10% of salt & pepper noise, (c) represented the image degraded by a Gaussian blur and Gaussian noise, picture (d) represented image degraded by a Gaussian blur with 5% of salt & pepper noise, the picture (e) represented the image degraded by an Average Blur and Gaussian noise, (f) represented the image degraded by an Average Blur with 5% of salt & pepper noise, (g) Image degraded by a Motion blur and Gaussian noise, and picture (h) illustrated the image degraded by a Motion blur with 5% of salt & pepper noise.In general, our proposed algorithm show the better results in case of Salt & Pepper noise in TABLE II the PSNR is higher then the PSNR in case of Gaussian noise, also this method show a good image quality to eliminate the blur an noise with the good precision except that in case of motion blur with a bad performs.

V. Conclusion

This work study of the classical edge detectors and in case of two problems, blur and noise problems that degraded an digital image captured, we tried to do a full analyses of methods of edge detector to select the right and good algorithms. And the combination of Median and Wiener methods proposed with the good edge detector is an

TABLE II
PERFORMANCE AND PRECISION OF ANALYSIS OF USED RESTORATION METHODS

Algorithms Name	Types of Blur	Types of Noise	PSNR	Precision
Wiener	Simple Blur	Gaussian	87	✓
	Simple Blur	Salt & Pepper	102	✓
	Gaussian Blur	Gaussian	65	X
	Gaussian Blur	Salt & Pepper	78	✓
	Average Blur	Gaussian	51	X
	Average Blur	Salt & Pepper	68	✓
	Motion Blur	Gaussian	64	X
	Motion Blur	Salt & Pepper	98	✓
Median	Simple Blur	Gaussian	88	X
	Simple Blur	Salt & Pepper	107	✓
	Gaussian Blur	Gaussian	55	X
	Gaussian Blur	Salt & Pepper	78	✓
	Average Blur	Gaussian	78	X
	Average Blur	Salt & Pepper	95	✓
	Motion Blur	Gaussian	33	X
	Motion Blur	Salt & Pepper	83	✓
Combination	Simple Blur	Gaussian	98	✓
	Simple Blur	Salt & Pepper	100	✓
	Gaussian Blur	Gaussian	45	✓
	Gaussian Blur	Salt & Pepper	65	✓
	Average Blur	Gaussian	49	✓
	Average Blur	Salt & Pepper	53	✓
	Motion Blur	Gaussian	39	X
	Motion Blur	Salt & Pepper	48	✓

Precision ; ✓ : Good and Acceptable , X : Unacceptable

improvement for more accurate features detection of image whatever on the type of blur and/or noise. So our proposed algorithm that combined Median and Wiener to eliminate blur and noise with and Canny operator with the principal aim of improving this edge detection algorithm. This improvement algorithm provides blur and noise removal and object feature detection more efficiently than the classical algorithms.

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