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Preprocessing of Handwritten Documents Using Various Filters - A Survey

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Abstract - In recent years, handwritten document recognition is the most challenging research area in the field of digital image processing and pattern recognition. Handwritten character recognition goes through numerous phases include, Preprocessing, feature extraction and classification. Since preprocessing is intended to control the suitability of results for successive stages, this is considered to be the most significant stage prior to feature extraction. The main objective of this preprocessing stage is to remove various noises from handwritten document. In this paper present a survey on how various filters can be used for removing various noises in the handwritten document. From the experimental results it is seen that median, average and wiener filters perform better compared to Laplacian.

Key words : image noise , filters , PSNR , MSE

1. INTRODUCTION

Pattern recognition has emerged due to applications which are not only challenging, but also they are more demanding in OCR, DC, Data Mining and Biometric authentication. The research in this area has been on-going for over a half century and outcome for printed character recognition exceed 99%. But hand written recognition significantly needs improvement, where the recognition rate has exceeded only to 90%. Hand written recognition system embraces with following phases: Data Acquisition, Pre-processing, Feature Extraction and Classification. Pre-processing is quite essential to prepare data for subsequent activities. The main task in pre-processing is to decrease the variations and increase the complexity, which leads to achieve high recognition rate. The pre-processing is the most indispensable stage prior to feature extraction, since it controls the suitability of result for successive stage. The key intention of this pre-processing stage is to normalize and to remove variation that would otherwise complicate the classification and reduce recognition rate.

1.1.Image affecting factors

There are number of factors that affect the quality of image like scanner quality, scanner resolution, paper quality and non-uniform illuminations.

II. NOISE REMOVAL

Noise in documents is classified based on the criteria if it is dependent on the underlying content or independent of the underlying content. Stray marks, marginal noise, ink blobs and salt-and-pepper noise are independent of size; location of the underlying content. Similarly the texture of the observed speckle pattern is independent of the underlying content. Blur, pixel-shift or bleed-through on other hand is dependent noise, as they manifest themselves differently depending on the content. Such content-dependent noise is comparatively more difficult to model, mathematically nonlinear and often multiplicative. Noise can also be classified based on its consistency in properties like periodicity of occurrence in the document, its shape, position and gray-values.

Types of Noise

1. Gaussian noise - Gaussian noise is statistical noise that has a probability density function of the normal distribution (also known as Gaussian distribution). In other words, the values that the noise can take on are Gaussian-distributed. It is most commonly used as additive white noise to yield additive white Gaussian noise (AWGN).
2. Poisson noise - Poisson noise has a probability density function of a Poisson distribution.
3. Salt & pepper noise - It represents itself as randomly occurring white and black pixels. An effective noise reduction method for this type of noise involves the usage of a median filter. Salt and pepper noise creeps into images in situations where quick transients, such as faulty switching, take place. The image after distortion from salt and pepper noise looks like the image attached.

4. Speckle noise - Speckle noise is a granular noise that inherently exists in and degrades the quality of images. Speckle noise is a multiplicative noise, i.e. it is in direct proportion to the local grey level in any area. The signal and the noise are statistically independent of each other.

III. METHODOLODY

3.1 Filters

Generally filters are used to filter unwanted things or object in a spatial domain or surface. In digital image processing, mostly the images are affected by various noises. The main objectives of the filters are to improve the quality of image by enhancing is to improve interoperability of the information present in the images for human visual.

3.1.1.Median Filter

Median filtering is one kind of smoothing technique. The performance is not that much better than Gaussian blur for high levels of noise, whereas, for speckle noise and salt and pepper noise (impulsive noise), it is particularly effective .Median filter is the one of the method to perform this noise reduction by performing neighborhood averaging, which can suppress isolated out of range noise but the side effect is it blurs sudden changes like sharp edges. The median filter is an effective method that can suppress isolated noise without blurring sharp edges. In Median Filtering, all the pixel values are first sorted into numerical order and then replaced with the middle pixel value. [8]Let y represent a pixel location and w represent a neighborhood centered around location (m, n) in the image, then the working of median filter is given by

y [m, n]=median{x[i ,j],(i , j) belongs to w}

Since the pixel y[m ,n] represents the location of the pixel y ,m and n represents the x and y co-ordinates of y. W represents the neighborhood pixels surrounding the pixel position at (m, n).(i , j) belongs to the same neighborhood centered around (m, n).Thus the median method will take the median of all the pixels within the range of (i , j) represented by x[i, j].

3.1.2. Wiener Filter

The inverse filtering is a restoration technique for deconvolution, i.e., when the image is blurred by a known low pass filter, it is possible to recover the image by inverse filtering or generalized inverse filtering. However, inverse filtering is very sensitive to additive noise. The approach of reducing degradation at a time allows us to develop a restoration algorithm for each type of degradation and simply combine them. The Wiener filtering executes an optimal trade-off between inverse filtering and noise smoothing. It removes the additive noise and inverts the blurring simultaneously.

The Wiener filtering is optimal in terms of the mean square error. In other words, it minimizes the overall mean square error in the process of inverse filtering and noise smoothing. The Wiener filtering is a linear estimation of the original image. The approach is based on a stochastic framework. The orthogonality principle implies that the Wiener filter in Fourier domain can be expressed as follows:

$$W(f_1, f_2)=\frac{H*(f_1,f_2\ )\ S_{xx}\ (f_1 f_2)}{|H(f_1 f_2)|^2 S_{xx}\ (f_1 f_2)+S_\eta\ (f_1 f_2)},$$

Where Sxx(f1,f2), Sηη(f1,f2) are respectively power spectra of the original image and the additive noise, andH(f1,f2) is the blurring filter. It is easy to see that the Wiener filter has two separate part, an inverse filtering part and a noise smoothing part. It not only performs the deconvolution by inverse filtering (high pass filtering) but also removes the noise with a compression operation (low pass filtering).

3.1.3 Average Filter

Mean filtering is a simple, intuitive and easy to implement method of smoothing images, and to reduce the amount of intensity variation between one pixel and the next. Average filtering replaces each pixel value in an image with the mean value of its neighbors, including itself. The simplest procedure would be to calculate the mask for all the pixels in the image. For all the pixels in the image which fall under this mask, it will be considered as the new pixel [7]. This has the effect of eliminating pixel values which are unrepresentative of their surroundings. Average filter is also considered to be a convolution filter or a mean filter. The average mean filter expression is follows

$$g(x,y) = \frac{\sum_{s=-a}^{a}\sum_{t=-b}^{b} w(s,t) f(x+s,y+t)}{\sum_{s=-a}^{a}\sum_{t=-b}^{b} w(s,t)}$$

3.1.4 Laplacian Filter

Detecting edges within an image can be done by the laplacian filter. It denotes areas where the intensity changes rapidly, hence producing an image with all the edges. The Laplacian is often applied to an image that has first been smoothed with something approximating a Gaussian smoothing filter, in order to reduce its sensitivity to noise. The operator normally takes a single gray level image as input and produces another grey level image as output. As radius of interest on the image is increased, this method will prove to be more computationally expensive. The lapacian filter expression is as follows

$$g(x,y) = f(x,y) + c[\nabla^2 f(x,y)]$$

3.1.5 Canny Filter

The canny filter is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. The canny edge filter satisfies the properties like good detection, good localization and minimal response. In canny edge detection, the structural details of the image will be maintained while the amount of data within an image will reduce An edge in an image may point in a variety of directions, so the Canny algorithm uses four filters to detect horizontal, vertical and diagonal edges in the blurred image. The edge detection operator (Roberts, Prewitt, Sobel for example) returns a value for the first derivative in the horizontal direction (G_x) and the vertical direction (G_y). From this the edge gradient and direction can be determined:

$$G = \sqrt{G_x^2 + G_y^2}$$

3.2 Algorithm

Input : *Original Image*
Output : *Preprocessed Image*

Step 1 : *Start the process.*

Step 2 : *Select an uncorrupted handwritten document image.*
Step 3 : *Convert the document image into binary image.*
Step 4 : *Different noises are added to the handwritten document image.*

1. *Apply median, average, Laplacian, wiener, canny filter on the input image and estimate the PSNR and MSE value.*
2. *Repeat Step 4 for all the noise.*

Step 5 *: Stop the process.*

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

A number of experiments have been conducted using Matlab R2009b version for evaluation of the filters on four different types of noise. Experiments were conducted using the handwritten document.

PSNR

For the image quality measures, if the value of the PSNR is very high for an image of a particular noise type then is best quality image. PSNR value results in high values for removal of both Gaussian noise and Salt-and-pepper noise by using the median filter. The average filter will remove the Gaussian Noise better followed with that of Poisson noise. According to the PSNR values, the wiener filter is best suited to remove the Gaussian Noise. According to performance comparison we see that median filter is more suited to remove the salt-and pepper noise and wiener filter is more suited to remove Gaussian and speckle noise.

MSE

The lowest mean square error represents the best quality image, thus median filter is best suited to remove the salt-and pepper noise according to this quality measure. The average and wiener filter are the best for removing Poisson noise and Gaussian noise respectively. Canny, Robert and Prewitt filter have lesser efficiency than the median, average and wiener filters but they have edge detection capability.

Image quality measures for Gaussian Noise

Filters	**PSNR**	**MSE**
Median	23.934	21.0019
Average	12.5	51.41
Laplacian	-15.14	252.59
Wiener	20.89	26.52
Canny	-17.6	254.99

Graphical Representation of Image Quality Measures for Gaussian Noise

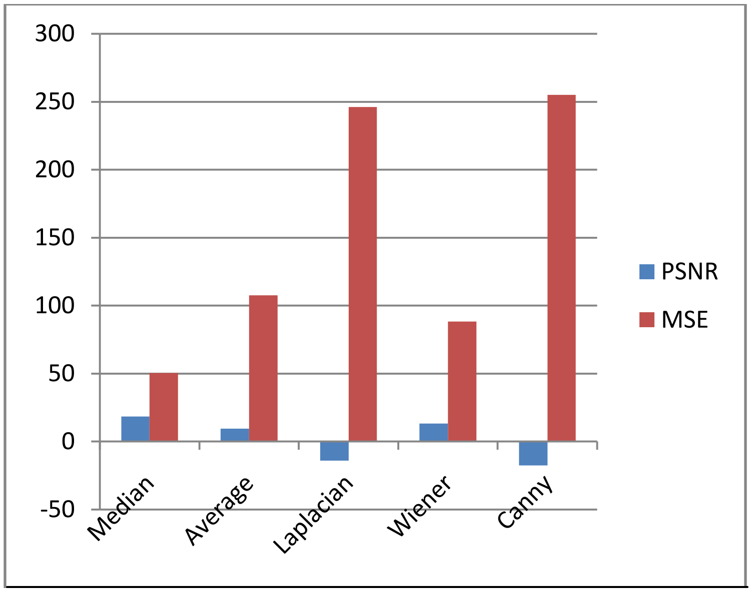


Image quality measures for Poisson Noise

Filters	PSNR	MSE
Median	22.17	27.01
Average	11.96	59.35
Laplacian	-14.95	252.29
Wiener	19.05	36.96
Canny	-17.7	255

Graphical Representation of Image Quality Measures for Poisson Noise

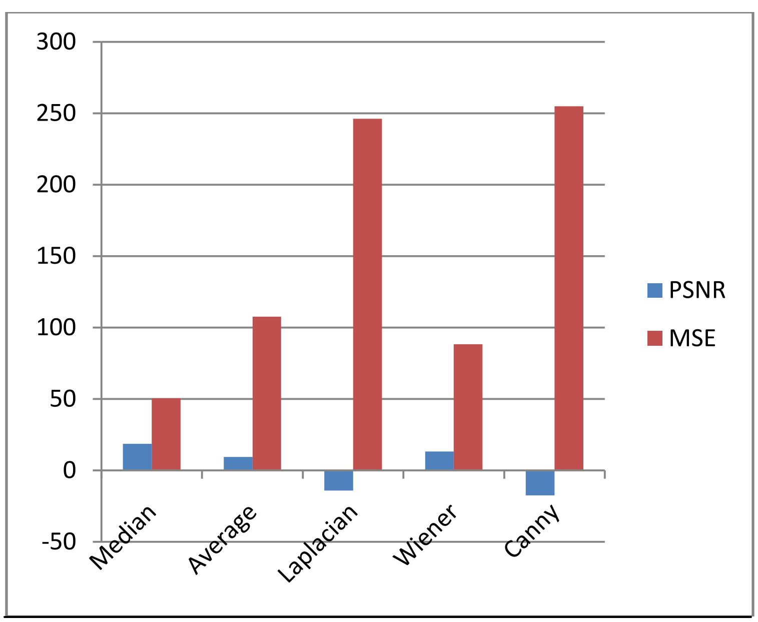


Image quality measures for Salt and Pepper Noise

Filters	PSNR	MSE
Median	23.11	9.66
Average	7.95	110.76
Laplacian	-15.17	241.78
Wiener	16.39	46.04
Canny	-17.5	243.75

Graphical Representation of Image Quality Measures for Salt and Pepper Noise

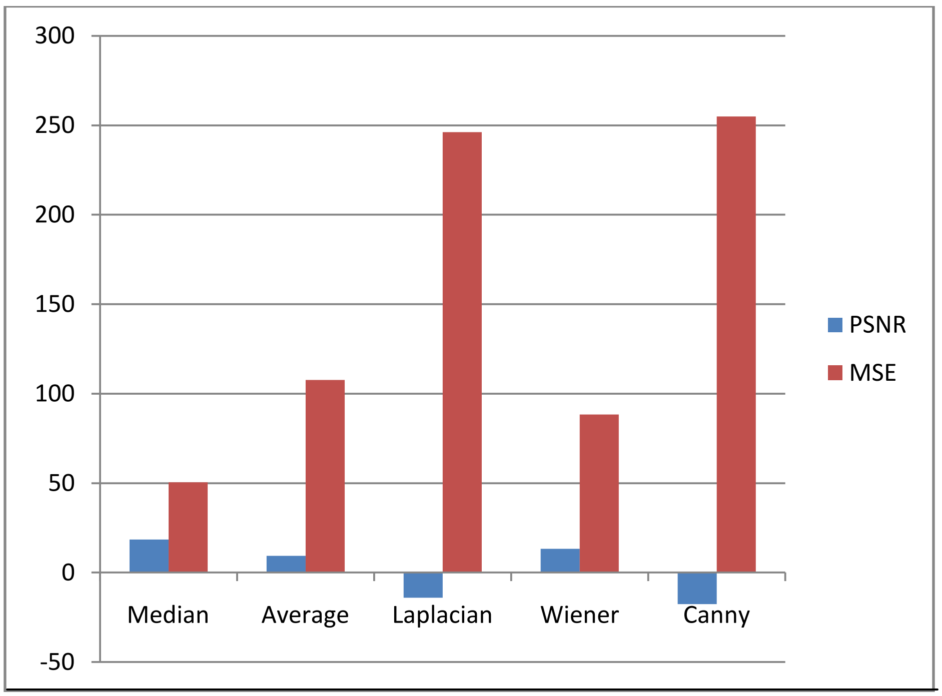
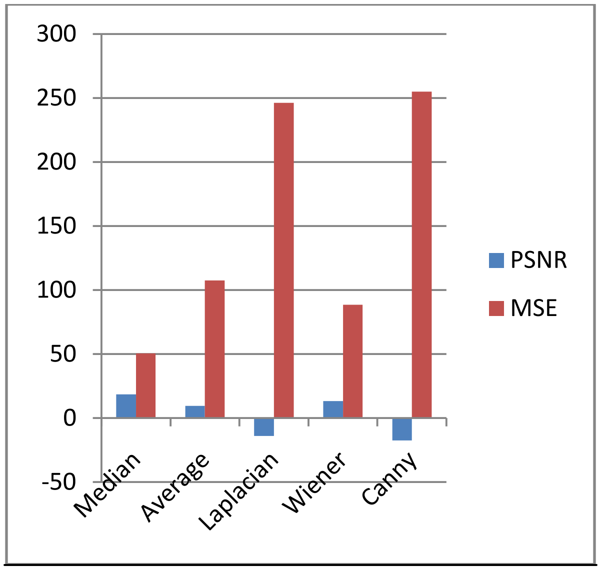


Image quality measures for Speckle Noise

Filters	PSNR	MSE
Median	18.55	50.39
Average	9.41	107.59
Laplacian	-14.03	246.24
Wiener	13.33	88.41
Canny	-17.59	255

Graphical Representation of Image Quality Measures for Speckle Noise



In this study we have observed that median, wiener and average filters performs much superior when compared to Laplacian for the handwritten document recognition. Median filter performs much better in removing salt and pepper noise in the handwritten document. To eliminate Gaussian and Poisson noise, Wiener and average filters are the preeminent filters, and speckle noise can be removed by Laplacian filter in the handwritten dcoument..

V. CONCLUSION

In this paper attempts to present a comprehensive survey of research on various filters that are used for preprocessing of handwritten document. Most frequently affected noises like: Impulse noise, speckle noise, Gaussian noise, Poisson noise, and salt and pepper noise are considered with their PSNR and MSE values. The performance of the median filter is better than all the filter. In order to achieve preeminent recognition rate, the noise removal is quite seems to be a demanding task.

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