

A Review on Digital Image Enhancement by Noise Removal

Vinod Sharma¹, Deepika Bansal², Renu Bagoria³

Research Scholar, Department of Computer Science, Career Point University Rajasthan, Kota, Rajasthan, India¹

P.G. Student, Department of Computer Engineering, Jagannath University, Sitapura, Jaipur, India²

Assistant Professor, Department of Computer Engineering, Jagannath University, Sitapura, Jaipur, India³

ABSTRACT: Image processing is any type of signal processing for which we give an image as input. Digital image processing is the use of much type of computer algorithms to perform image processing on digital images. Images quality is often degraded by noises. Noise can occur during image capture, transmission or by film grain in it etc. Noise removal is an important task in image processing. In general, the results of the noise removal have a strong influence on the quality of the image processing technique. Many techniques are for noise removal as well established in color image processing. Noise removal problem the nature of this depends on the type of the noise corrupting the image. In the field of image noise reduction, several linear and nonlinear filtering methods have been proposed. Linear filters are not able to effectively eliminate impulse noise as they have a tendency to blur the edges of an image. On the other hand nonlinear filters are suited for dealing with impulse noise. Several nonlinear filters based on Classical and fuzzy techniques have emerged in the past years. Image edge detection is a process of locating the edge of an image which is important in finding the approximate absolute gradient magnitude in gray scale image.

KEYWORDS: Linear Filter, image processing, noise removal.

I. INTRODUCTION

Noise is the result of errors in the image acquisition process. That results in pixels value that do not reflect the true intensities of the real scene. Noise reduction is the process of removing noise from a signal or from an image. Noise reduction techniques are conceptually very similar regardless of the signal being processed. However, a priori knowledge of the characteristics of an expected signal can mean the implementations of these techniques vary greatly depending on the type of signal. The image captured by the sensors undergoes filtering by different smoothing filters and the resultant image. All recording devices, both analogue and digital have traits which make them susceptible to noise. The fundamental problems of image processing are to reduce noise from a digital color images. There are several ways that noise can be introduced into an image, depending on how the image is created. For example:

1. If the image is scanned from a photograph made on film, the film grain is a source of noise. Noise can also be the result of damage to the film, or be introduced by the scanner itself.
2. If the image is acquired directly in a digital format, the mechanism for gathering the data (such as a CCD detector) can introduce noise.
3. Electronic transmission of image data can introduce noise.

Edge detection from images is one of the most important concerns in video processing and digital images. With development in technology, edge detection has been greatly benefited and new avenues for research opened up. One such field being the image processing and real time video whose applications have allowed other video processing and digital image. It consists of the implementation of various image processing algorithms like edge detection using Prewitt, Laplacian, Sobels and Canny so on. Edge detection is difficult in noisy images, since both the edges and the noise contain high-frequency content. Attempts to reduce the noise result in distorted and blurred 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.

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The purpose of edge detection in general is to significantly reduce the amount of data in an image, while preserving the structural properties to be used for further image processing. Several algorithms exist, and this paper focuses on a particular one developed by John F. Canny (JFC) in 1986. This is used to remove noise from images. The Canny algorithm uses an optimal edge detector based on a set of criteria which include finding the most edges by minimizing the error rate, marking edges as closely as possible to the actual edges to maximize localization, and marking edges only once when a single edge exists for minimal response^[3]. It identifies strong edges, and preserving the relevant weak edges, in addition to maintaining some level of noise suppression.

II. TYPES OF NOISES

Noise can be any type of degradation in the image signal caused by external disturbance. If an image is being sent electronically from one place to another via satellite or wireless transmission or through networked cables. We may expect errors to occur in the image signals. These errors will appear on the image output in different ways this will depend on the type of disturbance in the signal. Usually we know that what type of errors to expect and the type of noise on the image. Hence, we investigate some of the standard noise for eliminating or reducing noise in color images. Image Noises that can be Amplifier noise (Gaussian noise), Salt-and-pepper noise (Impulse noise), Shot noise, Quantization noise (uniform noise), Film grain, on-isotropic noise, Speckle noise (Multiplicative noise) and Periodic noise.

A. Amplifier Noise (Gaussian noise)

The standard model of amplifier noise is Gaussian or additive dependent of the signal intensity and dependent at each pixel, caused primarily by Johnson–Nyquist noise (thermal noise), including that which comes from the reset noise of capacitors ("kTC noise"). It is an idealized form of white noise, which is caused by random variations in the signal^[4]. In color cameras where more amplification is used in the blue color channel than in the red or green channel, there can be more noise in the blue channel. Amplifier noise is a major part of the noise in an image sensor, that is of the constant noise level in dark areas of the image. In Gaussian noise, each pixel in the image will be changed from its original value by a (small) usually amount. A histogram, a plot of the amount of distortion of a pixel value against the frequency with which it occurs, shows a normal distribution of noise

B. Salt-and-Pepper Noise (Impulse Noise)

Salt and pepper noise is sometimes called spike noise, impulse noise, random noise or independent noise. In salt and pepper noise (sparse light and dark disturbances), pixels in the image are very different in intensity and color unlike their surrounding pixels. Salt and pepper abatement can be caused by sudden and sharp disturbance in the image signal. Generally this noise will only affect small number pixels in an image. When viewed, the image contains dark and white dots. Hence, the term salt and pepper noise^[5]. Typical sources include flecks of dust inside the camera and overheated CCD (Charge-coupled device) elements. An image containing salt-and-pepper noise will have dark pixels in bright regions and white pixels in dark region. This type of noise can be caused by dead pixels or analog-to-digital converter errors and bit errors in transmission.

C. Speckle Noise (Multiplicative Noise)

While Gaussian noise can be modeled by random values added to an image, speckle noise can be modeled by random values multiplied by pixel values. Hence, it is also called multiplicative noise. Speckle noise can be a big problem in some radar applications. The speckle noise is commonly found in the ultrasound medical images. It is a granular noise that inherently exists in and degrades the quality of the Synthetic Aperture Radar (SAR) images and Active Radar images. It increases the mean grey level of local area. Speckle noise in SAR is generally more serious, causing difficulties for image interpretation. It is done by coherent processing of backscattered signals from multiple distributed targets. In SAR oceanography for example, speckle noise is caused by signals from elementary scatters, the gravity-capillary ripples and manifests as a pedestal image, beneath the image of the sea waves.

D. Shot Noise

The dominant noise in the lighter parts of an image from an image sensor is typically that caused by statistical quantum fluctuations that is, variation in the number of photons sensed at a given exposure level. This noise is known as photon shot noise. Shot noise has a root mean-square value proportional to the square root of the image intensity, and the

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noises at different pixels are independent of one another. Shot noise follows a Poisson distribution, which is usually not very different from Gaussian. In addition to photon shot noise, there can be additional shot noise from the dark leakage current in the image sensor. This noise is otherwise known as "dark-current shot noise" or "dark shot noise".

III. THE CANNY EDGE DETECTION ALGORITHM

The algorithm runs in 5 separate steps:

1. Smoothing: Blurring of the image to remove noise.
2. Finding gradients: The edges should be marked where the gradients of the image has large magnitudes.
3. Non-maximum suppression: Only local maxima should be marked as edges.
4. Double thresholding: Potential edges are determined by thresholding.
5. Edge tracking by hysteresis: Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.

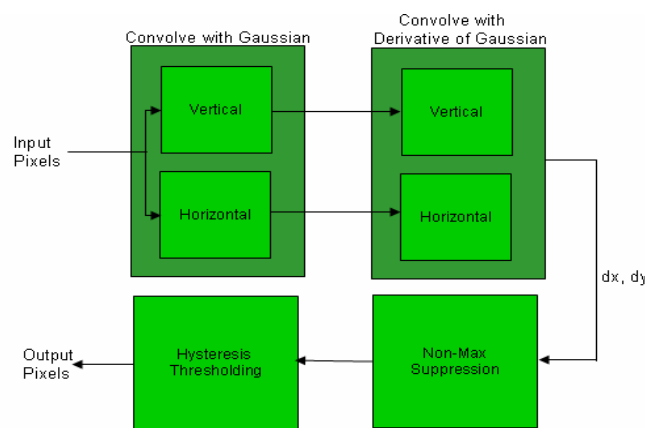


Fig 1: Canny edge detection algorithm process

A. Smoothing

The fact is that all images taken from a camera will contain some amount of noise by different sources. To prevent that noise, mistaken for edges noise must be reduced. Therefore the image is first smoothed by applying a Gaussian filter. The effect of smoothing on image will show in figure by giving original image as input shown in Figure:

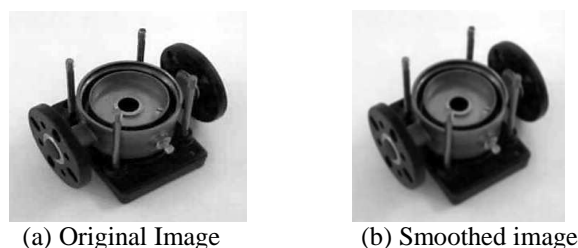


Fig 2: smoothing process

B. Finding gradients

The Canny algorithm basically finds edges where mostly the gray scale intensity of the image changes. These areas are determined by finding gradients of the image. Gradients at each pixel in the smoothed image are found by applying what is known as the Sobel-operator. First step is to find the near value of the gradient in the x-direction and y-direction respectively by applying the kernels.

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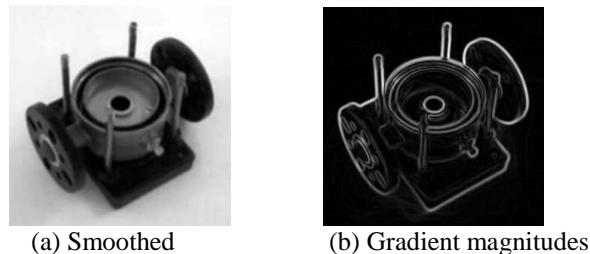


Fig 3: gradient finding process

C. Non-maximum suppression

The main aim of this step is to convert the “blurred” edges in the image of the gradient magnitudes to “sharp” edges. Basically this is done by preserving all local maxima in the gradient image and after that deleting everything else.^[7] The algorithm for each pixel in the gradient image:

1. Round the gradient direction to nearest 45° , corresponding to the use of an 8-connected neighborhood.
2. Compare the edge strength of the current pixel with the edge strength of the pixel in the positive and negative gradient direction. i.e. if the gradient direction is north ($\theta = 90^\circ$), compare with the pixels to the north and south.
3. If the edge strength of the current pixel is largest preserve the value of the edge strength. If not, suppress (i.e. remove) the value.

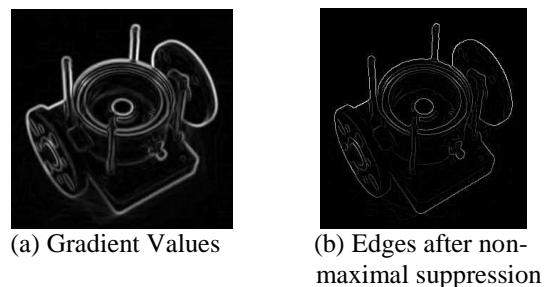


Fig 4: non maximum suppression

C. Double thresholding

The edge-pixels remaining after the non-maximum suppression step are (still) marked with their effectiveness pixel-by-pixel. Many of these will probably be true edges in the image, but some may be caused by noise or color fluctuations for instance due to rough surfaces. The simplest way to discern between these would be to use a threshold, so that only edges stronger than a certain value would be maintained. The Canny edge detection algorithm uses double thresholding. Edge pixels stronger than the high threshold are marked as strong, edge pixels weaker than the low threshold are inhibited and edge pixels between the two thresholds are marked as weak.

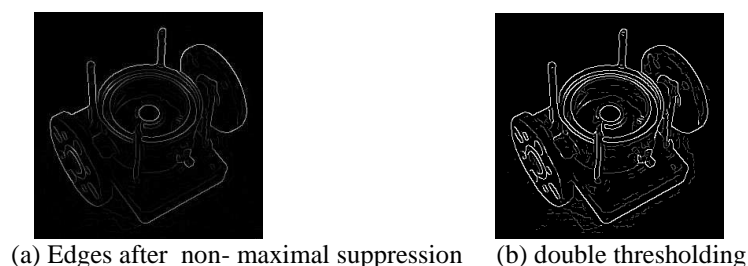


Fig 5: Double thresholding process

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D. Edge tracking by hysteresis

Strong edges are interpreted as “certain edges”, and can instantly be included in the final edge image. Weak edges are included if and only if they are linked to strong edges. The logic is of course that noise and other small fluctuations are unlikely to result in a strong edge (with proper adjustment of the threshold levels). Thus strong edges will almost be due to true edges in the original image. The weak edges can either be due to true edges or color/noise fluctuations. The latter type will likely be allotted independently of edges on the entire image, and thus only a small amount will be settled adjacent to strong edges. Weak edges due to true edges are much more likely to be linked directly to strong edges. Edge tracking can be followed out by BLOB-analysis (Binary Large Object). The edge pixels are divided into linked BLOB’s using 8-connected neighborhood. BLOB’s containing at least one strong edge pixel is then conserved, while other BLOB’s are inhibited.

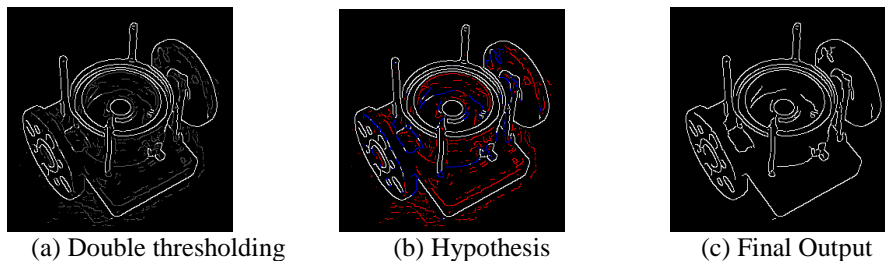


Fig 6: edge tracking by hysteresis

IV. FILTERS USED IN DEFILTERING/DENOISING

1. Mean Filter (MF)

Mean Filter (MF) is a simple linear filter, intuitive and easy to implement method of smoothing images i.e. it reduces the amount of intensity variation between one pixel and the next pixel. Mean filter is often used to reduce noise in images. The idea of mean filtering is simply to replace each pixel value in an image with the average or we can say mean value of its neighbors, including itself. This has the effect of removing pixel values which are unrepresentative of their surroundings.^[4] This filter is usually thought of as a convolution filter. Like other convolutions it is based around a kernel, which represents the shape and size of the neighborhood to be sampled when calculating the mean or average of the pixels.

2. Standard Median Filter (SMF)

Median filter is the non-linear filter which changes the image intensity average value if the spatial noise distribution in the image is not symmetrical within the window. Median filter reduces the variance of the intensities in the images. Median filter is a spatial filtering procedure, so it uses a 2-D mask that is applied to each pixel in the input image. To apply the mask means to center it in a pixel, calculating the covered pixel brightness and determining which brightness value is the median value.

3. Adaptive Wiener Filter (AWF)

Adaptive Wiener Filter (AWF) changes its behavior based on the statistical characteristics of the image present inside the filter window. Adaptive filter performance is usually master to non-adaptive counterparts. But the bettered performance is at the cost of added filter complexity. Mean and variance are two important statistical measures which are using in adaptive filters designing.

4. Gaussian Filter (GF)

Gaussian low pass filter is the filter which give impulse responsive and Gaussian filters are invented to give no overshoot to a step function input while minimizing the rise and fall time. Gaussian is smoothing filter in the 2D convolution process that is used to remove noise and blur from image.

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5. Adaptive Median Filter (AMF)

The Adaptive Median Filter (AMF) is designed to remove the problems faced with the Standard Median Filter. The basic difference among both the filters is that in the Adaptive Median Filter, the size of the window surrounding each pixel is variable. This fluctuation depends on the median of the pixels in the present window. If the median value is an impulse, then the size of the window is expanded.

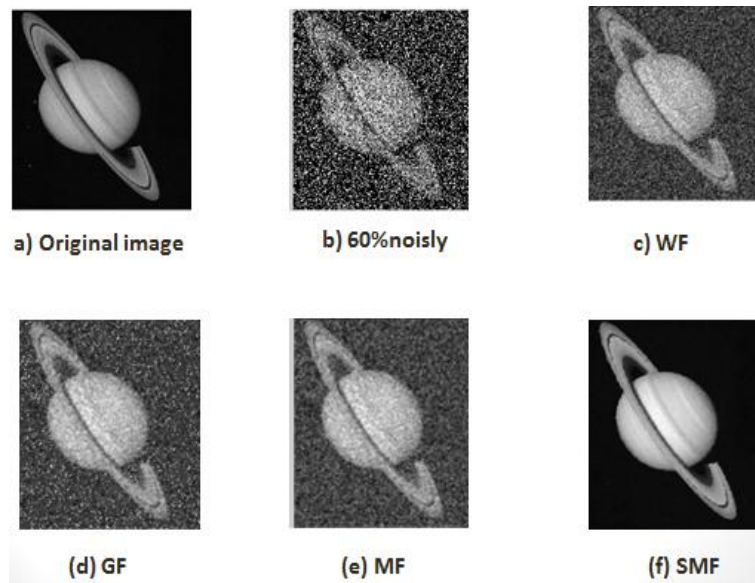


Fig 7: comparison of different filters result by an image

V. CONCLUSION

The study of noise removal is done. In this paper we discussed different types of noise that are present in the images. We can say noise is extra bits that are present in the image that make it blurred or can say make the visual of image low. Different types of noise have different visual artifacts on the image. By the image we can identify the type of noise present in image. Many filters apply on the image to remove the noise from the image. In final we have a comparative study of all the filters and we have results that which filter is better in removing the noise. In future, we can create a tool box or software that applies all the filters on a single image to remove all types of noise from that image and makes the image look good.

REFERENCES

- [1] Pietro Perona and Jitendra Malik (July 1990). "Scale-space and edge detection using anisotropic diffusion". IEEE Transactions on Pattern Analysis and Machine Intelligence, 629–639
- [2] Guillermo Sapiro (2001). Geometric partial differential equations and image analysis. Cambridge University Press. p. 223. ISBN 978-0-521-79075-8.
- [3] Md. Imrul Jubair, Md. Mizanur Rahman Syed Ashfaqueuddin, Imtiaz Masud Ziko "An Enhanced Decision Based Adaptive Median Filtering Technique to Remove Salt and Pepper Noise in Digital Images" International Conference on Computer and Information Technology (ICCIT 2011) 22-24 December, 2011, Dhaka, Bangladesh
- [4] Venkatasubramanian Adhinarayanan, S.P.Shebha, L. Sriraman, T. N. Prabakar, G. Seetharaman "A Modified algorithm for Removal of Salt and Pepper Noise in Color Images" 978-0-7695-4668-1/12 © 2012 IEEE DOI 10.1109/ISMS.2012.93
- [5] Sean C. Matz and Rui J.P. de Figueiredo "A NONLINEAR TECHNIQUE FOR IMAGE CONTRAST ENHANCEMENT AND SHARPENING" 0-7803-5471-0/99/\$10.00@1999 IEEE
- [6] Ma. Guadalupe Sánchez, Vicente Vidal, Gumersindo Verdú, Patricia Mayo and Francisco Rodenas "Medical Image Restoration with Different Types of Noise" 34th Annual International Conference of the IEEE EMBS San Diego, California USA, 28 August - 1 September, 2012
- [7] James C. Church, Yixin Chen, and Stephen V. Rice "A Spatial Median Filter for Noise Removal in Digital Images" 978-1-4244-1884-8/08/\$25.00 ©2008 IEE