INTERNATIONAL JOURNAL OF INNOVATIVE TRENDS IN ENGINEERING (IJITE) ISSN: 2395-2946
ISSUE: 63, VOLUME 41, NUMBER 01, MAY 2018

An Extensive Survey on Image De-noising using Fuzzy and Wiener Filter in Wavelet domain

Pratik Sharma[1], Prof. Nikesh Tiwari[2]

[1]M-Tech Research Scholar, [2]Research Guide, Department of Computer Science & Engineering

Lakshmi Narain College of Technology and Science, Bhopal

Abstract- Digital image processing is a promising domain of research in the fields of modern electronics and communication engineering, customer and entertainment electronics, control and instrumentation, biomedical instrumentation, remote sensing, mechanical technology and computer vision and computer aided manufacturing (CAM). For an important and helpful processing, for example, image segmentation and protest acknowledgment, and to have great visual show in applications like TV, photograph telephone, and so on., the restored image signal must be deblurred and made noise free. In this investigation, the various noise conditions are studied and present an extensive survey of literature on Image de-noising using Fuzzy and Wiener filter in Wavelet domain.

Keywords- Image Processing, Image De-noising, Wiener filters, Wavelet, Image restoration.

I. INTRODUCTION

The need for image enhancement and restoration is encountered in many practical applications. For instance, distortion due to additive white Gaussian noise (AWGN) can be caused by poor quality image acquisition, images observed in a noisy environment or noise inherent in communication channels. Linear filtering and smoothing operations have been widely used for image restoration because of their relative simplicity. However, since these methods are based upon the assumption that the image signal is stationary and formed through a linear system, their effectiveness is generally acceptable but limited. In reality, real-world images have typically non-stationary statistical characteristics. They are formed through a nonlinear system process where the intensity distribution arriving at the imaging system is the product of the reflectance of the object or the scene of interest and the illumination distribution falling on the scene. There also exist various adaptive and nonlinear image restoration methods that account for the variations in the local statistical characteristics. These methods achieve better enhancement and restoration of the image while preserving high frequency features of the original image such as edges.

Another, seemingly unrelated, problem in signal processing is the need and desire to manipulate, communicate and store large amounts of digital information. This natural demand for data acquisition, coupled with the exponential growth of computer-based information, remote systems and media applications have created tremendous demand for storage. Data compression and more specifically, digital image compression is a viable method for reduction of storage, transmission and manipulation requirements of digital imagery. Digital image compression takes advantage of the relationships existing between pixel values to define a new set of coefficients or parameters which can be used to re-construct an estimate of the original image. In fact most real-world images contain some amount of redundancy that can be removed when the image is stored or transmitted and replaced when it is reconstructed without significant loss of information. Successful compression will result in this transformed image taking up less storage and requiring less time to transmit than the original image.

Recently, many research efforts in the literature have shown that the above two signal processing problems are indeed closely related and lossy image compression methods have been proposed for the purpose of image denoising in several works. The focus of this investigation is to extend the application of wavelet and fractal schemes, which are image compression methods, for the purpose of image denoising and restoration.

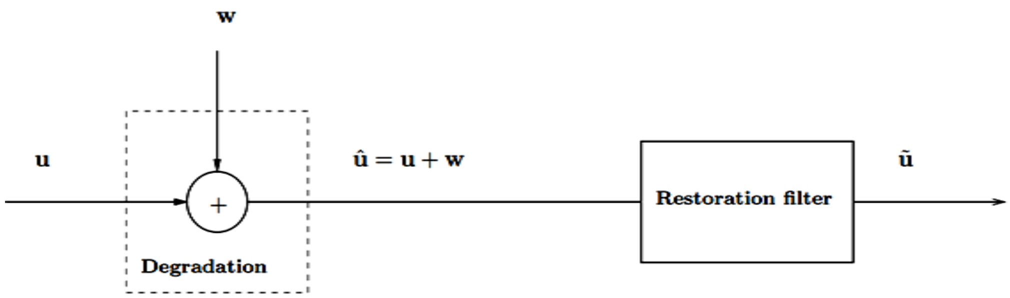

Figure 1.1 The Degradation and Restoration Model for an Additive Noise Process.

In practice, an image may be degraded by various types and forms of noise. However, the most common type of noise is the additive one. As Figure 1.1 shows, the degradation process is modeled as an additive noise term, w, which operates on an input image, u, to produce a degraded image, U. Given this noisy observation, along with some knowledge of the additive noise term, the restoration technique yields an estimate, U, of the original image. The denoised estimate is desired to be as close as possible to original image.

II. SYSTEM MODEL

Image processing has got wide varieties of applications in computer vision, multimedia communication, television broadcasting, etc. that demand very good quality of images. The quality of an image degrades due to introduction of additive white Gaussian noise (AWGN) during acquisition, transmission/ reception and storage/ retrieval processes. It is very much essential to suppress the noise in an image and to preserve the edges and fine details as far as possible. In the present research work, efforts are made to develop efficient spatial-domain and transform-domain image filters that suppress noise quite effectively.

Amongst the various types of noise, the impulse noise may appear during image acquisition and transmission. Two types of impulse noise can be modeled: (i) Fixed valued impulse noise, also called, salt & pepper noise (SPN) and (ii) Random-valued impulse noise (RVIN). The absolute-average intensity of impulse noise could be very high for an RVIN under some circumstances. Thus, it could severely degrade the image quality and cause a great loss of information details in an image. For both SPN and RVIN, impulse noise density plays a great role. If the density is very high (normally > 50%), then it is very difficult to estimate the original pixel value from the neighborhood pixels.

Digital image processing generally refers to the processing of a 2-dimensional (2-D) picture signal by a digital hardware. An image is a 2-D function (signal), X(m, n), where m and n are the spatial (plane) coordinates. The magnitude of X at any pair of coordinates (m, n) is the intensity or gray level of the image at that point. In a digital image m, n and the magnitude of X are all finite and discrete quantities. Each element of this matrix (2-D array) is called a picture element or pixel.

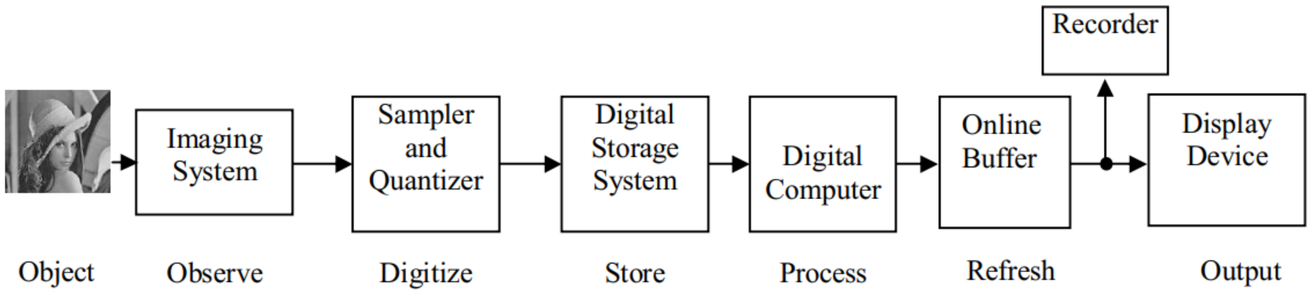

Figure 2.1 Typical Digital Image Processing System.

It is a hard task to distinguish between the domains of image processing and any other related area such as computer vision. Though, essentially not correct, image processing may be defined as a process where both input and output are images. At the high level of processing and after some preliminary processing, it is very common to perform some analysis, judgment or decision making or perform some mechanical operation (robot motion). These areas are the domains of artificial intelligence (AI), computer vision, robotics, etc.

Image processing may be performed in the spatial domain or in a transform domain. Depending on the application, a suitable transform is used that may be discrete Fourier transform (DFT), discrete cosine transform (DCT), discrete wavelet transform (DWT), etc.

Image restoration and filtering' is one of the prime areas of image processing and its objective is to recover the images from degraded observations. The techniques involved in image restoration and filtering are oriented towards modeling the degradations and then applying an inverse procedure to obtain an approximation of the original image. The use of color in image processing is motivated by two principal factors. First, color is a powerful descriptor that often simplifies object identification and extraction from scene. Second, humans can discern thousands of color shades and intensities, compared to shades of gray.

III. RELATED WORK

A. Kethwas and B. Jharia,[1] Nowadays images are very fundamental type data for transmission. In this exploration, a mixed domain image denoising method based on the wavelet transform median filter and nonlinear diffusion are proposed. The wavelet transform is used to convert the spatial domain image to wavelet domain coefficients. Wavelet transform produces approximation, horizontal, vertical and diagonal detailed coefficient which represents the various spatial frequency bands. These coefficients may be filtered by wiener filter or fuzzy filter separately. One is based on median and moving average, while other one used on probabilistic way, respectively. Exploration presents the two different techniques for image denoising, first technique is ATMAV (Asymmetrical Triangular Moving Average Filter) with HAAR wavelet transform and second is ATMED (Asymmetrical Triangular Median Filter) with HAAR wavelet transform. Both techniques are based on fuzzy logic based filters. Comparative analytical study based on PSNR and mean square error shows that HAAR with ATMED wavelet is better technique for image denoising.

S. Anissa, S. Hassene and B. b. Ezzedine,[2] mage enhancement and restoration in a noisy environment are fundamental problems in image processing. Various filtering techniques have been developed to suppress noise in order to improve the quality of images. Among diverse de-noising techniques, median filter is a well-known filter to deal with impulse noise in digitals images. However, due to some limitations associated with the standard median filtering approach, several new improved versions of the median filtering method have been proposed by researchers. In this study, a new approach based on adaptive neuro-fuzzy inference system (ANFIS) was presented for restoring digital images corrupted by salt and pepper noise by a dynamic median filter that will adapt itself to the local noise intensity. Simulation results indicate that the reported approach shows a high-quality restoration of filtered images than those using static median filter or others filters, in terms of peak signal-to-noise ratio (PSNR).

M. Duraisamy and F. M. M. Jane,[3] Magnetic Resonance Imaging (MRI) has become an efficient instrument for clinical diagnoses and research in recent years. It has become a very useful medical modality for the detection of various diseases through segmentation methods. In this exploration, an effective CNN based segmentation method with lung and brain MRI images have presented. This approach hits the target with the aid of the following major steps, which includes, 1) Preprocessing of the brain and lung images, 2) Segmentation using cellular neural network. Initially, the MRI image is pre-processed to make it fit for segmentation. Here, in the pre-processing step, image de-noising is done using the linear smoothing filters, such as Gaussian Filter. Then, the pre-processed image is segmented according to our proposed technique, CNN-based image segmentation. Finally, the different MRI images (brain and lung) are given to the proposed approach to evaluate the performance of the proposed approach in segmentation process. The Comparative analysis is carried out Fuzzy C-means (FCM) and K-means classification. From the comparative analysis, the accuracy of proposed segmentation approach produces better results (83.7% for lung and 93% for brain images) than that of existing Fuzzy C-means (FCM) and K-means classification.

M. H. F. Zarandi and M. Zarinbal,[4] Images and visual understandings are basis in everyday life and are very important tool for decision making. However, for improving the image appearance to a human viewer, or to convert an image to a format better suited to machine processing, enhancing methods should be used. There are wide varieties of techniques for this purpose including, contrast and histogram modification, de-noising, statistical methods, and clustering. Among these techniques, clustering especially fuzzy clustering methods are among the most efficient methods that classifies each data into more than one cluster. In the literature, many fuzzy clustering methods have been presented such as Fuzzy C-Mean (FCM) and Possibilistic C-Mean (PCM), which uses Type-1 fuzzy logic. However, Type-2 fuzzy logic can provide better performance, especially when many uncertainties are presented. In this exploration, applied Type-2 fuzzy clustering method for enhancing the images and proposed a new fuzzy Type-2 Possibilistic c-means clustering (PCM) method. The performance of the proposed method in having good results is evaluated by using 6 images.

T. Wilkin,[5] Image reduction is a crucial task in image processing, underpinning many practical applications. This work proposes novel image reduction operators based on non-monotonic averaging aggregation functions. The technique of penalty function minimization is used to derive a novel mode-like estimator capable of identifying the most appropriate pixel value for representing a subset of the original image. Performance of this aggregation function and several traditional robust estimators of location are objectively assessed by applying image reduction within a facial recognition task. The FERET evaluation protocol is applied to confirm that these non-monotonic functions are able to sustain task performance compared to recognition using non-reduced images, as well as significantly improve performance on query images corrupted by noise. These results extend the state of the art in image reduction based on aggregation functions and provide a basis for efficiency and accuracy improvements in practical computer vision applications.

T. Mu-Ling and Y. Jie-Ming,[6] Weighted Fuzzy C-Mean clustering algorithm by one-dimensional histogram can classify accurately pixels of coal flotation froth images into three kinds such as bubble vertex, the bubble surface and the background to increase the contrast of bubble edge and background, accurately positioning the bubble region for its fast convergence speed, real-time characteristics. After de-noised based on morphological filtering method of reconstruction opening and closing, clustered image can not only remove noises but retain more image detail and reflect accurately the true image information. So over-segmentation and under-segmentation will be avoided so as to be segmented more accurate when image clustered by these algorithms is processed using watershed segmentation based tags.

C. Chu, G. Li, Y. Lou and J. Li,[7] This exploration describes the classic total variation de-noising model and its improved models, and gives a simple comparison of the characteristics of each model. An adaptive spatial fidelity term is intended to ease the smoothing effect by the second-order nonlinear filtering over the details. An adaptive regularization term is used to reduce the "staircase effect", and to achieve a more stable and converged value. Two improvements, one is a new adaptive regularization term based on local information of the pre-image; the other is a double-entry adaptive model has reported. SNR to quantify the effect of de-noising, and residual images to evaluate the loss of details and texture of the images is used. The results show that the improved method can achieve good results in the case of high noise as well. Compared to the original method, the proposed has better noise robustness.

Table : Summary of Literature Review

SR. NO.	TITLE	AUTHORS	YEAR	METHODOLOGY
1	Image de-noising using fuzzy and wiener filter in wavelet domain,	A. Kethwas and B. Jharia,	2015	ATMAV (Asymmetrical Triangular Moving Average Filter) with HAAR wavelet transform and second is ATMED (Asymmetrical Triangular Median Filter)
2	Adaptive median filter based on ANFIS for impulse noise suppression,	S. Anissa, S. Hassene and B. b. Ezzedine,	2014	A new approach based on adaptive neuro-fuzzy inference system (ANFIS)
3	cellular neural network based medical image segmentation using artificial bee colony algorithm,	M. Duraisamy and F. M. M. Jane,	2014	Comparative analysis is carried out Fuzzy C-means (FCM) and K-means classification
4	A new image enhancement method Type-2 Possibilistic C-Mean Approach,	M. H. F. Zarandi and M. Zarinbal,	2013	Fuzzy C-Mean (FCM) and Possibilistic C-Mean (PCM)
5	Image reduction operators based on non-monotonic averaging functions,	T. Wilkin,	2013	Novel image reduction operators based on non-monotonic averaging aggregation functions
6	Pre-processing of Froth Image of Coal Flotation Based on Weighted Fuzzy C-Mean Clustering by One-Dimensional Histogram,	T. Mu-Ling and Y. Jie-Ming	2012	based on morphological filtering method of reconstruction opening and closing
7	An improved model of double-entry adaptive TV,	C. Chu, G. Li, Y. Lou and J. Li,	2012	Use SNR to quantify the effect of de-noising, and residual images to evaluate the loss

IV. THE PROBLEM STATEMENT

In the last two decades, many researchers have attempted to develop filters to suppress the impact of noise from images. But that are not adaptive in nature, so the performance of that filter is not good in many occasion. Some filters are not able to preserve image detail and also many filters are quite efficient at high noise levels but don't perform so well at low noise levels. Therefore, it is very important to design and develop highly efficient adaptive nonlinear image filters that suppress impact of noise quite effectively and preserve image detail. . The current trends of the image denoising research are the evolution of mixed domain methods. The better expansible proportion of wavelet coefficients in order to get better denoising effects using fuzzy filters.

V. CONCLUSION

In this investigation an extensive survey of literature has presented on image denoising and digital image filtering. Today digital imaging is required in numerous applications e.g., object identification, remote sensing, biomedical instrumentation, digital multimedia, web and so forth. The quality of an image corrupts because of tainting of different sorts of noise. Noise degrades the image qality during the procedure of restoration, transmission, storage and so on. For an important and helpful processing, for example, image segmentation and object identification, and to have great visual display in applications like TV, photograph telephone, and so forth., the acquired image signal must be sans noise and made deblurre. Both the noise concealment (filtering) and the deblurring go under a typical class of image processing tasks known as image restoration.

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