An Efficient Noise Removal Technique for Hybrid Images Using Directional Weighted Median Filter

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Abstract-

Visual information transmitted in the form of digital images is becoming a major method of communication in the modern age, but the image obtained after transmission is often corrupted with noise. The received image needs processing before it can be used in applications. Image denoising involves the manipulation of the image data to produce a visually high quality image. This thesis reviews the existing denoising algorithms. Different noise models including additive and multiplicative types are used. They include Gaussian noise, salt and pepper noise, speckle noise. The selection of denoising algorithm is application dependent. Hence, it is necessary to have knowledge about the noise present in the image so as to select the appropriate denoising algorithm. The filtering approach has been proved to be the best when the image is corrupted. A quantitative measure of comparison is provided by the peak signal to noise ratio of the image.

Keywords- Noise,Filtering,DWMF,Image,PSNR,MSE.

1. INTRODUCTION

Image is a pictorial representation of a person, scene or object. An image is a realistic or semi-realistic representation of a variety of subjects produced by a number of methods and in a number of different styles. The term "picture" is also frequently used in the literature; therefore, the terms "picture" and "image" are both used in appropriate contexts. In other words we can say that an image as described here is any object that could be considered graphical in nature. This includes, but is not limited to, photographs, slides, digital images and any object that is not textual in nature.

An image is an artifact that depicts or records visual perception, for example a two-dimensional picture, that has a similar appearance to some subject–usually a physical object or a person, thus providing a depiction of it.

Multilevel security or multiple levels of security (MLS) is the application of a computer system to process information with different sensitivities (i.e., at different security levels), permit simultaneous access by users with different security clearances and needs-to-know and prevent users from obtaining access to information for which they lack authorization.

2. RELATED WORKS

Esakkirajan et al. [1] proposed a modified decision based unsymmetrical trimmed median filter algorithm for the restoration of gray scale and colour images that are highly corrupted by salt and pepper noise. The proposed algorithm replaces the noisy pixel by trimmed median value when other pixel values, 0's and 255's are present in the selected window and when all the pixel values are 0's and 255's then the noise pixel is replaced by mean value of all the elements present in the selected window.

Hwang et al. [2] proposed two new algorithms for adaptive median filters. The algorithms had variable window size for removal of impulses while preserving sharpness. The first one, called the ranked-order based adaptive median filter (RAMF), is based on a test for the presence of impulses in the centre pixel itself followed by the test for the presence of residual impulses in the median filter output. The second one, called the impulse size based adaptive median filter (SAMF), is based on the detection of the size of the impulse noise.

Shuqun Zhang et al. [3] proposed a new impulse noise detection technique for switching median filters which was based on the minimum absolute value of four convolutions obtained using one dimensional Laplacian operators. In particular, the proposed filter is directed toward improved line preservation.

Srinivasan et al. [4] proposed a new decision-based algorithm for restoration of images that are highly corrupted by impulse noise. The proposed method, unlike other nonlinear filters, removes only corrupted pixel by the median value or by its neighboring pixel value.

Jayaraj et al. [5] proposed new switching-based median filtering scheme for restoration of images based on a new scheme introducing the concept of substitution of noisy pixels by linear prediction prior to estimation. Ben Hamza et al. [6] developed nonlinear filtering techniques based on the theory of robust estimation. Some deterministic and asymptotic properties were derived. Their proposed denoising methods are optimal over the Huber e-contaminated normal neighbourhood are highly resistant to outliers.

Zhou Wang et al. [7] discussed the objective methods for assessing perceptual image quality traditionally attempted to quantify the visibility of errors (differences) between a distorted image and a reference image using a variety of known properties of the human visual system. Under the assumption that human visual perception is highly adapted for extracting structural information from a scene, they introduced an alternative complementary framework for quality assessment based on the degradation of structural information.

Abreu et al. [8] discussed a new framework for removing impulse noise from images in which the nature of the filtering operation is conditioned on a state variable defined as the output of a classifier that operates on the differences between the input pixel and the remaining rank-ordered pixels in a sliding window.

Yli-Harja et al. [9] analyzed the deterministic properties of weighted median (WM) filters. Threshold decomposition and the stacking property together establish a unique relationship between integer and binary domain filtering. The authors presented a method to find the weighted median filter which is equivalent to a stack filter defined by a positive Boolean function. Because the cascade of WM filters can always be expressed as a single stack filter this allows expression of the cascade of WM filters as a single WM filter. A direct application is the computation of the output distribution of a cascade of WM filters. The same method was used to find a non recursive expansion of a recursive WM filter.

Pei-Eng et al. [10] proposed a novel switching median filter incorporating a powerful impulse noise detection method, called the boundary discriminative noise detection (BDND), for effectively denoising extremely corrupted images.

Aiswarya et al. [11] proposed a new algorithm to remove high-density salt and pepper noise using modified sheer sorting method. The new algorithm had lower computation time when compared to other standard algorithms. A result of this algorithm is compared with various existing algorithms and it was proved that the new method has better visual appearance and quantitative measures at higher noise densities as high.

Al-Araji et al. [12] presented an auto selection technique to reduce impulse noise presented an auto selection technique to reduce impulse noise in wireless communication systems. The selection of the appropriate reduction technique was based on an estimation of the rate of impulse noise present in the system. The impulse noise can be detected by comparing it with a fixed reference. The system used to subtraction-gating for low occurrence rate, conventional limiting for high occurrence rate and directly sends the incoming signal to the output if impulse noise is absent.

Chen et al. [13] proposed an adaptive pixel correlation filter (APCF) to remove impulse noise, with an adaptive threshold which was designed based on the correlations between a pixel and its neighbors. The filter was designed with a novel adaptive working window and weighted function for impulse noise detection and preserving noise-free pixels based on the fact that both horizontal and vertical correlations for a pixel are more significant than other orientations. Numerous simulations show that APCF is more robust and effective than other well known median filtering algorithms.

Chen et al. [14] proposed an adaptive working window to remove impulse noise. All pixels are correlated with its neighboring pixels, i.e. they have pixel correlation. The intensity of impulse noise was estimated with the value of pixel correlation. They developed a simple rule for impulse noise reduction for various median-based filters with adaptive working window. The switching median (SM) filter and multi-state median (MSM) filter were designed with this simple rule and the simulations showed that this method improves the reliability of MSM and SM filters in reducing impulse noise.

Divya Jothi et al. [15] proposed a new integrated fuzzy filter for the reduction of additive noise and impulse noise from digital color images. They used an impulse noise detector in the filter to detect the presence of impulse noise. The detector divides the set of pixels into impulse noise affected points and cleans points. A filter selection module was employed to select the appropriate filter to match the type of noise. The output of integrated filter contains the enhanced image after noise removal. This method combined the advantages of both additive noise and impulse noise filters.

3. IMAGE ENHANCEMENT

Images are captured at low contrast in a number of different scenarios. The main reason for this problem is poor lighting conditions (e.g., pictures taken at night or against the sun rays). As a result, the image is too dark or too bright and is inappropriate for visual inspection or simple observation. Image enhancement algorithms are used in a variety of image processing applications, primarily to improve or enhance the visual quality of an image by accentuating certain features.

Image processing modifies pictures to improve them (enhancement, restoration) to prepare suitable images for various applications from raw unprocessed images. Images can be processed by optical, photographic and electronic means, but image processing using digital computers is the most common method because digital methods are fast, flexible and precise. Image enhancement improves the quality (clarity) of images for human viewing. Increasing contrast and revealing details are examples of enhancement operations where as removing blurring and noise comes under the category Image restoration. Planetary scientists were the first users of enhancement techniques to enhance images of Mars, Venus and other planets. Radiologists, Doctors use this technology frequently to manipulate CAT scans, MRI and X-ray images. Areas like forensic science use image sharpening(enhancement) techniques for criminal detection.

Enhancement algorithms are used extensively to enhance biometric (finger print, iris) images in airport, banking security systems. Palm print manuscripts contain religious texts and treaties on a host of subjects such as astronomy, astrology, architecture, law, medicine and music. Most of these palm-leaves are nearing the end of their natural lifetime or are facing destruction from elements such as dampness, fungus, ants and cockroaches. The enhancement algorithms are inevitable members of the preservation projects to protect these valuable historical documents.

Enhancement techniques are used to enhance the degraded documents so as to enable retrieval of the written text from these documents. Printing technology also uses extensively the enhancement schemes to produce high quality photographic prints. Acquisition of information of an object or phenomenon, by the use of sensing devices that is not in physical or intimate contact with the object i.e forest, vegetation, land utilization, sea changes etc. Various image processing techniques are involved in analyzing the acquired data. Image enhancement is one of the important image processing functions primarily done to improve the appearance of the imagery to assist in visual interpretation and analysis.

Image restoration and enhancement are used usually in synchronization rather than as an individual. These classes of image processing algorithms include image sharpening, contrast and edge enhancement. Among the enhancement algorithms contrast enhancement is most important because it plays a fundamental role in the overall appearance of an image to human being. A human being's perception is sensitive to contrast rather than the absolute values themselves. So it is justified to increase the contrast of an image for better perception. The noise removal algorithms which preserve edge details as well remove noise using selective filtering technique. It helps the enhancement schemes to be cascaded along with noise removal algorithm to produce better quality images with more edge details.

3.1 Contrast Enhancement

Image enhancement usually employs various contrast enhancement schemes to increase the amount of visual perception. Different enhancement schemes emphasize different properties or components of images. Contrast enhancement techniques can be broadly classified into two categories. For the first category, the gray value of each pixel is modified based on the statistical information of the image. Power law transform, log transform, histogram equalization belong to this category. In the second category the contrast is enhanced by first separating the high and low frequency components of the image, manipulating them separately and then recombining them together with the different weights. Unsharp Masking (UM) which emphasizes high frequency components of an image belongs to this category.

3.2 Image Restoration

The field of digital image restoration had its first encounter with the starting of space program by the scientists involved of United States of America and the former Soviet Union in the 1950s and early 1960s. The first images of the Earth, Moon (mainly of the opposite side), and planet Mars were, at that time, of unimaginable resolution which were obtained under big technical difficulties. These programs were responsible for producing many incredible images of our solar system, which were at that time unimaginable. However, the images obtained from the various planetary missions of the time were subject to much photographic degradation. The need to retrieve as much information as possible from such degraded images was the aim of the early efforts to adapt the one-dimensional signal processing algorithms to images, creating a new field that is today known as digital image restoration.

In astronomical imaging the ultimate goal is to recover the original celestial image from the degraded one. The degradations were as a result of relative motion between camera and the original scene, defocusing of the lens system because of vibration in machinery and spinning and tumbling of the spacecraft or because of substandard imaging environment. In addition to blurring the space images are also corrupted with additive random noise. Rapidly changing refractive index of the atmosphere was also one of the reasons for the degradation. Pictures from the manned space mission were also blurred due to the inability of the astronaut to steady him in gravitation less environment while taking photographs. Extraterrestrial observations were degraded by motion blur as a result of slow camera shutter speed, relative to rapid spacecraft motions. The degradation of images was no small problem. Any loss of information due to image degradation is devastating as it reduces the scientific value of these images. There is no surprise that astronomical imaging is still one of the primary applications of digital image restoration today.

The rapid growth of medical imaging equipment which capture, record, and redisplay in a non-invasive manner the internal structure of living matter or patients, has composed a great challenge and opportunity to image processing tasks. Providing better diagnosis facility would have been a tedious job without image restoration. X-rays, mammograms, and digital angiographic images without filtering would have been of no use since the acquiring methods are usually associated with various degradation phenomenon like noise. Sophisticated imaging techniques like PET (Positron Emission Tomography) and SPECT (Single Photon Emission Computed Tomography) are two methods to obtain images noninvasively from the interior of a patient which extensively use restoration schemes to improve resolution in order to perform better diagnosis. Other than this it also finds its utility in Magnetic Resonance Imaging (MRI). Digital image restoration techniques can contribute significantly. A film reflects the culture from which it is stemmed and records our history, represent contemporary culture and have great artistic value. Thus, they are precious cultural assets which must be preserved. Unfortunately, because of aging, improper storage conditions and other reasons, old films are threaten with defects caused by decaying, dust, dirt, scratch and mold. Consequently, digital film restoration, repairing defects in films, has been recognized as an important issue by archives, content owners and film companies. Motion picture restoration is not limited to eliminate scratches and dust from old movies, but also to colorize black-and-white films. Only a small subset of the vast amount of work being done in this area can be classified under the category of image restoration. Much of this work belongs to the field of computer graphics and enhancement. Nonetheless, some very important work has been done recently in the area of digital restoration of films.

Image restoration has also received some notoriety in the media, and particularly in the movies of the last decades digital image restoration has been used in law enforcement and forensic science for a number of years. Complex problems like solving a crime often requires security video tapes, blurry photographs of license plates and crime scenes to be properly visualized for proper investigation. Image restoration helps in improving the quality of such images which are often needed when such photographs can provide the only link for solving a crime. Clearly, law enforcement agencies all over the world have made, and continue to make use of digital image restoration ideas in many forms.

Image and video coding is one of the exciting applications of image restoration. Even though coding efficiency has improved and bit rates of coded images have reduced, there is another problem of blocking artifacts which needs significant improvement. These are as a result of the coarse quantization of transform coefficients used in typical image and video compression techniques. Usually, a Discrete Cosine Transform (DCT) will be applied to prediction errors on blocks of 8× 8 pixels. Intensity transitions between these blocks become more and more apparent when the high-frequency data is eliminated due to heavy quantization.

Digital image restoration is being used in many other applications as well. Just to name a few, restoration has been used to restore blurry X-ray images of aircraft wings to improve aviation inspection procedures. It is used for restoring the motion induced effects present in still composite frames and more generally, for restoring uniformly blurred television pictures. Printing applications often require the use of restoration to ensure that halftone reproductions of continuous images are of high quality. In addition, restoration can improve the quality of continuous images generated from halftone images. Digital restoration is also used to restore images of electronic piece parts taken in assembly-line manufacturing environments. Many defense-oriented applications require restoration, such as that of guided missiles, which may obtained distorted images due to the effects of pressure differences around a camera mounted on the missile. All in all, it is clear that there is a very real and important place for image restoration technology today.

Image restoration is distinct from image enhancement techniques, which are designed to manipulate an image in order to produce results more pleasing to an observer, without making use of any particular degradation models. Image enhancement refers to the techniques by which try to improve an image such that it looks subjectively better by improving the visual appearance of the image. On the other hand restoration emphasizes on getting back the original image as far as possible from the degraded one.

3.3 Linear Filters

In the early development of image processing, linear filters were the primary tools. Their mathematical simplicity with satisfactory performance in many applications made them easy to design and implement. However, in the presence of noise the performance of linear filters is poor. In image processing applications they tend to blur edges, do not remove impulsive noise effectively, and do not perform well in the presence of signal dependent noise. If the filter evaluates the output image only with the input image, the filter is called non-recursive. On the other hand, if the evaluation process requires input image samples together with output image samples it is called recursive filter. The few main types of filters:

Low-pass filter: Smooths the image, reducing high spatial frequency noise components.

High-pass filter: Enhances very low contrast features, when superimposed on a very dark or very light background.

Band-pass filter: Tends to sharpen the edges and enhance the small details of the image.

3.4 Nonlinear Filters

Nonlinear filters also follow the same mathematical formulation the operator L( ) is not linear in this case. Convolution of the input with its impulse response does not generate the output of a nonlinear filter. These types of gray level transform are extensively used for enhancing the subjective quality of the images as per the need of the application. Histogram modification is another form of intensity mapping where the relative frequency of gray level occurrence in the image is depicted. An image may be given a specified histogram by transforming the gray level of the image into another. Histogram equalization is one such method that is used for this purpose. The need for it arises when comparing two images taken under different lighting conditions. The two images must be referred to the same base, if meaningful comparisons are to be made. The base that is used as standard has a uniformly distributed histogram. Of course, a uniform histogram signifies maximum information content of the image. Histogram based approaches as discussed above are used as simple image enhancement techniques in various applications.

Order statistic filters for noise removal are the most popular class nonlinear filters. A number of filters belong to this class of filters, e.g., the median filter, the stack filter, the median hybrid filter etc. Nonlinear filters based on order statistics have excellent robustness properties in the presence of impulsive noise. They tend to preserve edge information, which is very important for human perception.

Even there computation is relatively easy and fast as compared to some linear filters. Such properties of those filters have created numerous applications in digital image processing. Adaptive filtering has also taken advantage of nonlinear filtering techniques. Non-adaptive nonlinear filters are usually optimized for a specific type of noise and signal. When the filter is required to operate in an environment of unknown statistics or a non stationary environment, an adaptive filter provides an elegant solution to this more difficult problem. Images can be modeled as two-dimensional stochastic processes, whose statistics vary in the various image regions and also from applications to applications.

3.5 Adaptive Center-Weighted Median Filter

The Adaptive Center-Weighted Median Filter (ACWM) has devises a novel adaptive operator, which forms estimates based on the differences between the current pixel and the outputs of center-weighted median (CWM) filters with varied center weights. It employs the switching scheme based on the impulse detection mechanisms. It utilizes the center-weighted median filter that have varied center weights to define a more general operator, which realizes the impulse detection by using the differences defined between the outputs of CWM filters and the current pixel of concern. The ultimate output is switched between the median and the current pixel itself.

4. Proposed Methodology

In the proposed filtering technique the Directional Weighted Median Filter is applied on the input finger print image. The process flow of the proposed filter is presented below.

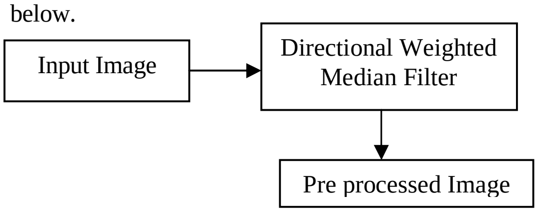

Fig. 3.2 Preprocessing flow Diagram

From above diagram shows the process flow of the proposed preprocessing. Median filter, the most prominently used impulse noise removing filter, provides better removal of impulse noise from corrupted images by replacing the individual pixels of the image as the name suggests by the median value of the gray level The median of a set of values is such that half of its values in the set are below the median value and half of them are above it and so is the most acceptable value than any other image statistics value for replacing the impulse corrupted pixel of a noisy image for if there is an impulse in the set chosen to determine the median it will strictly lie at the ends of the set and the chance of identifying an impulse as a median to replace the image pixel is very less.

Directional Weighted Median Filter (DWM) has method is used for removal of random-valued impulse noise is directional weighted median filter (DWM). This filter uses a new impulse detector, which is based on the differences between the current pixel and its neighbours aligned with four main directions. After impulse detection, it does not simply replace noisy pixels identified by outputs of median filter but continue to use the information of the four directions to weight the pixels in the window in order to preserve the details as removing noise. The New Directional Weighted Median Filter (NDWMF) uses a new impulse detector, which is based on the differences between the current pixel and its neighbours aligned with four main directions. First it considers a 5X5 window. Now, it considers the four directions: horizontal, vertical and two diagonal. Each direction there is 5 pixel points. It then calculates the weighted difference in each direction and takes the minimum of them. The minimum value is compared with a threshold value and if it is greater than the threshold value then it is a noisy pixel otherwise not.

4.1 Algorithm

Input: Input image from IDB

Step 1: *Read an image from the image database (IDB)*
Step 2: *Add Noise to an input image.*
Step3: *Apply mean filter, median filter, ACWM filter, Proposed DWMF on the input image.*
Step 4: *Calculate PSNR values.*
Step 5: *Repeat step 2 and step 4 for all images in database (IDB).*

The following mathematical metrics are used for the evaluation of the quality of the image.

Peak Signal to Noise Ratio (PSNR)
Mean Squared Error (MSE)

4.2 Peak Signal to Noise Ratio (PSNR)

The phrase peak signal-to-noise ratio, often abbreviated PSNR, is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale. The PSNR is defined as:

$$PSNR = 10.\log_{10}\left(\frac{MAX_I^2}{MSE}\right) = 20.\log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \qquad \ldots 1$$

Here, MAXI is the maximum pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255. More generally, when samples are represented using linear PCM with B bits per sample, maximum possible value of MAXI is 2B-1.

4.3 Mean Squared Error (MSE)

The PSNR is most commonly used as a measure of quality of reconstruction in image compression etc. It is most easily defined via the mean squared error (MSE) which for two m×n monochrome images I and K where one of the images is considered a noisy approximation of the other is defined as:

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\|I(i,j) - K(i,j)\|^2 \qquad \ldots 2$$

For color images with three RGB values per pixel, the definition of PSNR is the same except the MSE is the sum over all squared value differences divided by image size and by three. In general, a good reconstructed image is one with low MSE and high PSNR. That means that the image has low error and high image fidelity.

5. Performance Evaluation

In order to evaluate the results from the data sets, measurements are necessary to rate the performance. The different classes of images are verified with the five image sets containing ten images of each class of same images are used for the testing. The proposed method is applied on the various classes of images are computed and compared with the existing model and are presented as follows.

Table 5.1 Performance Comparison

Denoising Filters	BARBARA	BOAT	LENA	LANDSAT	AGRICULTURE AREA	REMOTE SENSING	IRIS	FINGERPRINT	MRI
Mean Filter	22.73	21.15	21.22	18.50	25.68	32.13	26.58	19.14	24.44

Wiener Filter	20.64	21.20	21.29	21.93	27.26	35.91	22.13	21.32	23.08
ACWM Filter	21.99	22.44	22.56	22.33	32.37	36.79	26.58	23.84	28.13
Proposed Directional Weighted Median Filter	28.31	26.68	29.17	24.42	36.73	39.47	28.36	25.61	30.41

From the above table 5.1 shows the PSNR is computed and compared with the existing models. Similarly, the Peak signal to noise ratio of the existing method is low when compared to proposed directional weighted median filter. Compared with the existing methods the proposed hybrid method provides better enhancement in image noise removal. Hence, the proposed method is more efficient than the existing one. The pictorial representation of the compared values is presented in the following chart.

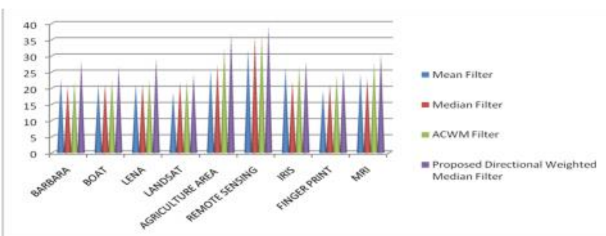

Fig.5.1 Comparison Chart

The above figure 5.1 shows the efficiency of the proposed method in compared with the existing methods for image noise removal. According to the chart of original image, noisy image and output image are compared to the existing method and proposed method is an efficient one.

6. CONCLUSION

Directional Weighted Median Filter also preserves edge information as compared to mean filter. The image gets preprocessed with the Directional Weighted Median filtering technique for the removal of noises and better enhancement. Initially, the median filter is applied on the different classes of image to filter the high frequency contents. Then directional weighted median filter is used to eliminate the noises present in the image. In order to increase the quality of the image the DWMF is used to enhance the noise free image with the constant amplitude factor. Finally a well preprocessed image has obtained with the proposed DWM filter. The performance is evaluated with PSNR and MSE estimations.

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