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Image Enhancement and Denoising Using Hybrid Filter

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Abstract*— Digital images are corrupted by various kinds of noise during the process of acquisition and/or transmission. The detection and removal of this noise plays a crucial role in restoration. Estimating the noise level from a single image seems like an impossible task, and due to this we need to recognize whether local image variations are dude to colour, texture, or lighting variations from the image itself or due to the noise. It might seem that accurate estimation of the noise level would require a very sophisticated prior model for images. The selection of the right denoising procedure plays a major role, it is important to experiment and compare the methods. This research will provide a platform to work further on the comparison of the denoising techniques. If the features of the denoised signal are fed into a neural network pattern recognizer, then the rate of successful classification should determine the ultimate measure by which to compare various denoising procedures. Besides, the complexity of the algorithms can be measured according to the CPU computing time flops. This can produce a time complexity standard for each algorithm. These two points would be considered as an extension to the present work done. The basic idea behind this research is the estimation of the uncorrupted image from the distorted or noisy image, and is also referred to as image "denoising". There are various methods to help restore an image from noisy distortions. Selecting the appropriate method plays a major role in getting the desired image. The denoising methods tend to be problem specific.

Keywords - Image Enhancement, Denoising, Hybrid Filtering.

I. INTRODUCTION

Image restoration technique aims at reversing the degradation undergone by an image to recover the true image. Images may be corrupted by degradation such as linear frequency distortion, noise, and blocking artefacts. The degradation consists of two distinct processes:

I) The deterministic blur
II) The random noise

The blur may be due to a number of reasons, such as motion, defocusing, and atmospheric turbulence. The noise may originate in the image-formation process, the transmission process, or a combination of them. Most restoration techniques model the degradation process and attempt to apply an inverse procedure to obtain an approximation of the original image. Many image restoration algorithms have their roots in well developed areas of mathematics such as estimation theory, the solution of ill-posed problems, linear algebra and numerical analysis. Iterative image restoration techniques often attempt to restore an image linearly or non-linearly by minimising some measures of degradation such as maximum likelihood, constrained least square, etc. Blind restoration techniques attempt to solve the restoration problem without knowing the blurring function. No general theory of image restoration has yet solved; however, some solutions have been developed for linear and planar invariant system.

Digital images are corrupted by various kinds of noise during the process of acquisition and/or transmission. The detection and removal of this noise plays a crucial role in restoration. Estimating the noise level from a single image seems like an impossible task, and due to this we need to recognize whether local image variations are dude to colour, texture, or lighting variations from the image itself or due to the noise. It might seem that accurate estimation of the noise level would require a very sophisticated prior model for images.

Image denoising is often used in the field of photography or publishing where an image was somehow degraded but needs to be improved before it can be printed. For this type of application we need to know something about the degradation process in order to develop a model for it. When we have a model for the degradation process, the inverse process can be applied to the image to restore it back to the original form. This type of image restoration is often used in space exploration to help eliminate artifacts generated by mechanical jitter in a spacecraft or to compensate for distortion in the optical system of a telescope. Image denoising finds applications in fields such as astronomy where the resolution limitations are severe, in medical imaging where the physical requirements for high quality imaging are needed for analyzing images of unique events, and in forensic science where potentially useful photographic evidence is sometimes of extremely bad quality [1].

Let us now consider the representation of a digital image. A 2-dimensional digital image can be represented as a 2-

dimensional array of data *s*(*x*,*y*), where (*x*,*y*) represent the pixel location. The pixel value corresponds to the brightness of the image at location (*x*,*y*). Some of the most frequently used image types are binary, gray-scale and color images [2].

Binary images are the simplest type of images and can take only two discrete values, black and white. Black is represented with the value '0' while white with '1'. Note that a binary image is generally created from a gray-scale image. A binary image finds applications in computer vision areas where the general shape or outline information of the image is needed. They are also referred to as 1 bit/pixel images.

Gray-scale images are known as monochrome or one-color images. The images used for experimentation purposes in this thesis are all gray-scale images. They contain no color information. They represent the brightness of the image. This image contains 8 bits/pixel data, which means it can have up to 256 (0-255) different brightness levels. A '0' represents black and '255' denotes white. In between values from 1 to 254 represent the different gray levels. As they contain the intensity information, they are also referred to as intensity images.

Color images are considered as three band monochrome images, where each band is of a different color. Each band provides the brightness information of the corresponding spectral band. Typical color images are red, green and blue images and are also referred to as RGB images. This is a 24 bits/pixel image.

II. BACKGROUND AND LITERATURE SURVEY

A. Fei Kou, Weihai Chen, et. Al, "Content Adaptive Image Detail Enhancement", 2015 [1] proposed a new norm based detail enhancement algorithm which generates the detail-enhanced image directly. The proposed algorithm preserves sharp edges better than an existing norm based algorithm. Experimental results show that the proposed algorithm reduces color distortion in the detail-enhanced image, especially around sharp edges.

B. Adin Ramirez Rivera, Byungyong Ryu, and Oksam Chae, "Content-Aware Dark Image Enhancement Through Channel Division", 2012[2] proposed a content-aware algorithm that enhances dark images, sharpens edges, reveals details in textured regions, and preserves the smoothness of flat regions. This algorithm produces an ad hoc transformation for each image, adapting the mapping functions to each image‟s characteristics to produce the maximum enhancement. They analyzed the contrast of the image in the boundary and textured regions, and group the information with common characteristics. These groups model the relations within the image, from which the transformation functions were extracted. The results were then adaptively mixed, by considering the human vision system characteristics, to boost the details in the image.

C. Deepak Ghimire and Joonwhoan Lee ," Nonlinear Transfer Function-Based Local Approach for Color Image Enhancement,"2011[3] proposed a method in which the image enhancement was applied only on the V (luminance value) component of the HSV color image and H and S component were kept unchanged to prevent the degradation of color balance between HSV components. The V channel was enhanced in two steps. First the V component image was divided into smaller overlapping blocks and for each pixel inside the block the luminance enhancement was carried out using nonlinear transfer function. In the second step, each pixel was further enhanced for the adjustment of the image contrast depending upon the center pixel value and its neighborhood pixel values. Finally, original H and S component image and enhanced V component image were converted back to RGB image.

D. Sudharsan Parthasarathy, Praveen Sankaran," Fusion Based Multi Scale RETINEX with Color Restoration for Image Enhancement,"2012[4] proposed that a fusion based approach on Multi Scale Retinex with Color Restoration(MSRCR) would give better image enhancement. Lower dynamic range of a camera as compared to human visual system causes images taken to be extremely dependent on illuminant conditions. MSRCR algorithm enhances images taken under a wide range of nonlinear illumination conditions to the level that a user would have perceived it in real time. One of the enhancement techniques that tries to achieve color constancy is Retinex. In Multi Scale Retinex(MSR),they average multiple SSR(Single Scale Retinex) images to obtain a net improved image.

E. S. Bronte, L. M. Bergasa, P. F. Alcantarilla, "Fog Detection System Based on Computer Vision Techniques", [5] proposed a real-time fog detection system using an on-board low cost b&w camera, for a driving application. This system was based on two clues: estimation of the visibility distance, which was calculated from the camera projection equations and the blurring due to the fog. Because of the water particles floating in the air, sky light gets diffuse and, focus on the road zone, which is one of the darkest zones on the image. The apparent effect is that some part of the sky introduces in the road. Also in foggy scenes, the border strength is reduced in the upper part of the image. These two sources of information were used to make the system more robust. The final purpose of this system was to develop an automatic vision-based diagnostic system for warning ADAS of possible wrong working conditions.

F. Zhang Chaofu, MA Li-ni, Jing Lu-na,“ Mixed Frequency domain and spatial of enhancement algorithm for infrared image”, 2012 [5] proposed a hybrid technique to enhance the image. It makes use of the Gauss filter processing to enhance image details in the frequency domain and smooth the contours of the image by the top-hat and bot-hat transforms in spatial domain. To enhance the infrared image, this algorithm did not enhanced only the details of the image, but the outline of the image had also been smooth.

G. A. Poljicak, L. Mandic, M. Strgar Kurecic, “Improvement of the Watermark Detector Performance Using Image Enhancement Filters,”2012[6] considered the influence of some image processing techniques on the watermark detection rate. Watermarking methods are still very sensitive to complex degradation attacks such are JPEG compression, or printscan process, so the detection rate of a watermark method decreases considerably after such attacks on a watermarked image. To improve the detection rate they reduced the degradation of the image by using unsharp, Laplacian or deconvolution filter. For the experiment dataset of 1000 images were watermarked and then compressed or printed and scanned. Degraded images were enhanced using unsharp, Laplacian and blind deconvolution filter. The watermark detection rate before and after enhancement was measured and compared.

H. Seung-Won Jung, Jae-Yun Jeong, and Sung-Jea Ko ,“ Sharpness Enhancement of Stereo Images Using Binocular Just-Noticeable Difference,”2012 [7] proposed a new sharpness enhancement algorithm for stereo images.. They introduced a novel application of the BJND model for the sharpness enhancement of stereo images. An efficient soliution for reducing the overenhancement problem in the sharpness enhancement of stereo images was proposed. The solution was found within an optimization framework with additional constraint terms to suppress the unnecessary increase in luminance values. In addition, the reliability of the BJND model was taken into account by estimating the accuracy of stereo matching.

I. Hong Zhang，Qian Zhao，Lu Li, Yue-cheng Li，Yu-hu You , “ Muti-scale Image Enhancement Based on Properties of Human Visual System,”2011[8] utilized the LIP(logarithmic image processing) model and considered the characteristics of the human visual system (HVS) to propose a new multi-scale enhancement algorithm. Then a new measure of enhancement based on JND model (Just Noticeable Difference, JND) of human visual system was proposed and used as a tool for evaluating the performance of the enhancement technique.

J. Rajib Kumar Jha, Rajlaxmi Chouhan, P. K. Biswas,“ Noise-induced Contrast Enhancement of Dark Images using Non-dynamic Stochastic Resonance,” 2012 [9] proposed a nonlinear non-dynamic stochastic resonance-based technique for enhancement of dark and low contrast images. A low contrast image was treated as a subthreshold signal and noise-enhanced signal processing was applied to improve its contrast. The proposed technique uniquely utilized the addition of external noise to neutralize the effect of internal noise (due to insufficient illumination) of a low contrast image. Random noise was added repeatedly to an image and was successively hard-thresholded followed by overall averaging. By varying the noise intensities, noise induced resonance was obtained at a particular optimum noise intensity. Performance of the proposed technique had been investigated for four types of noise distributions - gaussian, uniform, poisson and gamma. Quantitative evaluation of their performances had been done in terms of contrast enhancement factor, color enhancement and perceptual quality measure.

K. Khairunnisa Hasikin, Nor Ashidi Mat Isa, “Enhancement of the low contrast image using fuzzy set theory,” 2012[10] proposed a fuzzy grayscale enhancement technique for low contrast image. This technique was proposed by maximizing fuzzy measures contained in the image. The membership function was then modified to enhance the image by using power-law transformation and saturation operator.

L. Mussarat Yasmin, Muhammad Sharif, Saleha Masood, Mudassar Raza and Sajjad Mohsin ,“ Brain Image Enhancement - A Survey,”2011 [11] The basic purpose of enhancement operation is to analyze the brain images precisely in order to effectively diagnose and examine the diseases and problems. Brain imaging provides a way to investigate and determine brain related diseases in an efficient and effective manner. The basic objective of this study was to evaluate and discuss different techniques and approaches proposed in order to handle different brain imaging types. The paper provided a short overview of different methods presented in the prospect of brain image enhancement.

M. Xiaoying Fang, Jingao Liu, Wenquan Gu, Yiwen Tang ,“ A Method to Improve the Image Enhancement Result based on Image Fusion,”2011 [12] proposed a method to improve the enhancement result with image fusion method with evaluation on sharpness. Several different evaluation methods and fusion policies were discussed and compared**.**

III. SYSTEM DESCRIPTION

As we have already studied a number of noises and to remove them there is a quite good category of filters available as:

Pseudo Inverse Filter Filter

Wiener Filter

Inverse Filter

Weiner Filter and many more.

But to remove maximum possible noise from the signal is not possible with any single filter. So, we have found a new approach for de noising based on multi level filtering.

Our filter is a combination of:

PSEUDO-NOISE FILTER and WIENER FILTER

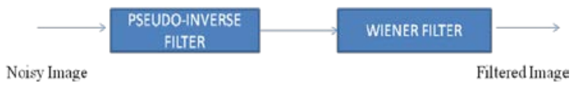


Fig 1 shows pseudo noise filter and filtered image

We are arranging these filters in series to get desired output.

3.1 PSEUDO INVERSE FILTERS

Suppose we have a known image function f(x,y) and a blurring function h(x , y), so we need to recover f(x,y) from the convolution

$$g(x,y)=f(x,y)*h(x,y) \quad (1)$$

A very easy possible solution for this is INVERSE FILTERING.

EQ (1) can be written in frequency domain as:

$$G(u,v)=F(u,v) \times H(u,v) \quad (2)$$

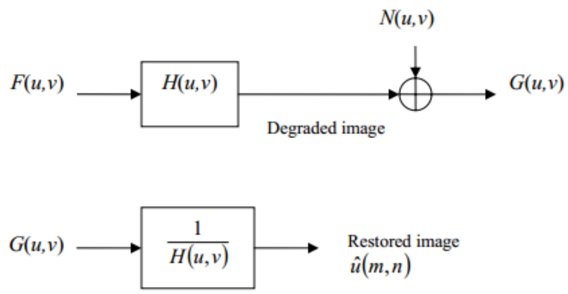
Now we divide eq (2) by H(u,v) and so is referred to as Inverse Filtering.

$$G(u,v)/H(u,v)=\{F(u,v) \times H(u,v)\}/H(u,v) \quad (3)$$

This can be written as:

$$G(u,v)/H(u,v)=F(u,v) \quad (4)$$

These filters are very effective on removing White Gaussian Noise.



3.2 WIENER FILTER

These filters reduces the amount of noise present in the signal by comparison with an estimation of a desired noiseless signal.

It is based on Statistical Approach. Here, we assume to have knowledge of the spectral properties of the original signal and the noise and seek the Linear Time Invariant Filter whose output would be as close to the original signal as possible.

Algorithm for Proposed work

1. Enter the image
2. Resize the image into 256 x 256 size.
3. Initialize the sigma, gamma, alpha variable.
4. If noise ==0
   Add the noise
   Else
      Goto step 4
   End
5. Enter the size off mask or window
6. Calculate fft of the input image, called y.
7. Calculate the fft of the input mask with the level = size of mask.
8. Initialize the point spread function based on the value of row and column of mask
9. Determine the frequency response by Calculating the fft of the point spread function.
10. Perform the Inverse filtering of the frequency response obtained by step 8.
11. Calculate the Inverse fft of the result obtained from step 9 with only considering real part.
12. Calculate the fft of the result obtained from step 10.
13. Calculate the power of function retrieved from step 11.
14. Calculate the S- frequency response using gamma function.
15. Calculate the i- frequency response using gamma function.

16. Calculate the power in consideration with sigma.
17. Calculate the frequency response of the result obtained from step 16, called freqh.
18. Determine the element by multiplication of y and freqh.
19. Determine the inverse fft of the result obtained from step 18 with only considering real part, called final de-noised image.
20. Calculate the SNR of the de-noised image.

IV. RESULT AND DISCUSSION

METHODS	SNR OUTPUT	NOISE, VARIANCE
Pseudo Inverse Filter	27.43	Salt and Pepper-0.05
Pseudo Inverse Filter	21.24	Gaussian-0.05
Wiener Filter	47.97	Salt and Pepper-0.05
Wiener Filter	22.79	Gaussian-0.05
PROPOSED FILTER	49.67	Salt and Pepper-0.05
PROPOSED FILTER	26.28	Gaussian-0.05
Speckle Remover	42.47	Speckle, 0.4
Speckle Remover	43.54	Speckle, 0.4

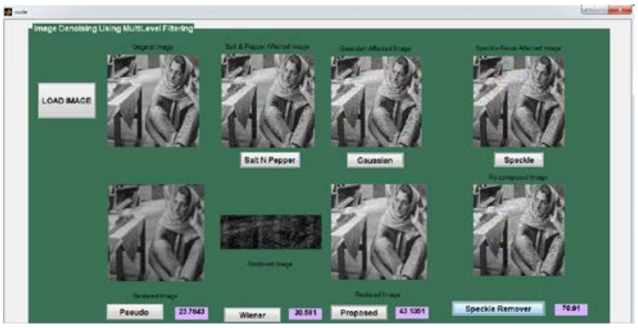


Fig 1. Result 1

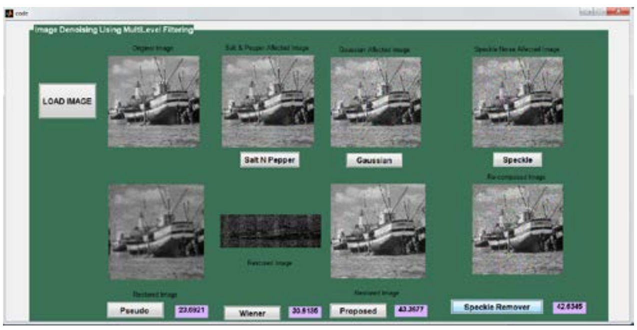


Fig 2 Result 2

Table 2 Comparison between SNR and MSE for Lena Image

Methods	Image Name	SNR	MSE
Mean Filter	Lena.jpg	34.28	
Median Filter	Lena.jpg	36.83	
Wiener Filter	Lena.jpg	47.97	
Proposed Filter	Lena.jpg	49.67	

V. CONCLUSIONS AND FUTURE WORK

From the experimental and mathematical results it can be concluded that for salt and pepper noise, the median filter is optimal compared to mean filter and LMS adaptive filter. It produces the maximum SNR for the output image compared to the linear filters considered. The LMS adaptive filter proves to be better than the mean filter but has more time complexity. From the output images shown in Chapter 3, the image obtained from the median filter has no noise present in it and is close to the high quality image. The sharpness of the image is retained unlike in the case of linear filtering. In the case where an image is corrupted with Gaussian noise, the wavelet shrinkage denoising has proved to be nearly optimal. SureShrink produces the best SNR compared to VisuShrink and BayesShrink. However, the output from BayesShrink method is much closer to the high quality image and there is no blurring in the output image unlike the other two methods. VisuShrink cannot denoise multiplicative noise unlike BayesShrink. It has been observed that BayesShrink is not effective for noise variance higher than 0.05. Denoising salt and pepper noise using VisuShrink and BayesShrink has proved to be inefficient. When the noise characteristics of the image are unknown, denoising by multifractal analysis has proved to be the best method. It does a good job in denoising images that are highly irregular and are corrupted with noise that has a complex nature. In the two methods considered, namely multifractal regularization and multifractal pumping, the second method produces visually high quality images.

Since selection of the right denoising procedure plays a major role, it is important to experiment and compare the methods. As future research, we would like to work further on the comparison of the denoising techniques. If the features of the denoised signal are fed into a neural network pattern recognizer, then the rate of successful classification should determine the ultimate measure by which to compare various denoising procedures [21]. Besides, the complexity of the algorithms can be measured according to the CPU computing time flops. This can produce a time complexity standard for each algorithm.

These two points would be considered as an extension to the present work done.

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