Method & Implementation of Hybrid Filter Approach Based Image Restoration

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Abstract*— *Digital image processing techniques now are used to solve a variety of problems. One such important problem in image processing is restoration. The goal of the restoration approach is to improve the given image so that it is suitable for further processing. Image restoration is an inverse problem stated as the recovery of an image from its probably degraded version. Number of filters have been used for denoising digital images corrupted by mixed noise. Till now wiener filter and median filter have been used to reduce white Gaussian noise and impulse noise respectively.The main objective of this paper is the removal or reduction of degradations that are incurred while the image is being obtained using image restoration. For this it proposes an image restoration model using hybrid filter representation which will reduce the noise to a greater extent by improving PSNR value of image. All simulations will be done in MATLAB R2013a.

Keywords: Image Restoration, Hybrid Filter, Fuzzy Network etc.

I. INTRODUCTION

Image restoration is an important branch of image processing, dealing with the reconstruction of images by removing noise and blur from degraded images and making them suitable for human perception. Any image acquired by a device is susceptible of being degraded by the environment of acquisition and transmission. Therefore, a fundamental problem in the image processing is the improvement of their quality through the reduction of the noise that they can contain being often known as "cleaning of images". The goal of the restoration approach is to improve the given image so that it is suitable for further processing. Removal of noises from the images is a critical issue in the field of digital image processing.

Image restoration is a process used to restore the image information lost during blurring process. It use point source used to restore the image information lost during blurring process. It is different from image enhancement that makes the image more pleasing to the observer. Despite of various methods used for removal of noise and get enhanced image but due to relative motion the atmospheric turbulence is a severe limitation in remote sensing so to improve this problem sparse-based image restoration technique is used. To improve the sparse representation performance, it presents a non-locally centralized sparse representation model. For this the sparse code of reconstructed image should be as close as possible to the sparse code of the original image. For this, sparse noise must be minimum. So, PCA (Principal Component Analysis) method with K-Means algorithm for reduction of noise iteratively, is used.

Distortion is almost always involved in recorded images. Distortion is mainly due to imperfections in the imaging system. This problem can get complicated due to random noise involved in the imaging. Degradation process operates on at input image f(x, y) to produce a degraded image g(x, y). Given g(x, y), some knowledge about the degradation function H, and some knowledge about the additive noise term $\eta(x, y)$, the objective of restoration is to obtain an estimate f'(x, y) of the original image f(x, y) .

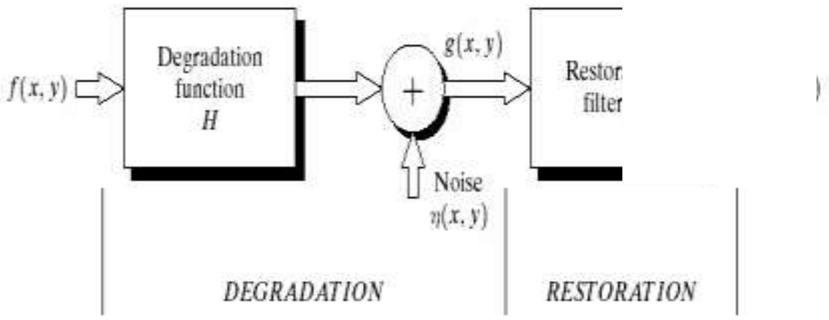

Figure1: A Model of the Degraded/Restoration Process

Degraded image given in the spatial domain

$$g(x, y) = h(x) * f(x, y) + \eta(x, y)$$

Model in an equivalent Frequency domain representation

$$G(u,v) = H(u,v)F(u,v) + N(u,v)$$

Where $H(u,v)$: Degradation functions

$\eta(x, y)$: Additive noise term

Noise is any undesired information that contaminates an image. The term noise in digital images refers to any pixel value of an image which does not match the reality quite exactly. The noise present in the images may significantly decrease the accuracy of the operations such as feature extraction and object recognition. Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera. Digital noise in images with digital cameras is random pixels scattered all over the photo. It is a similar effect as “grain" in film photography and it degrades the photo quality. The noise term is important because in practical imaging situations, additive noise is not negligible.

Common types of noise are:

1. Impulse Noise

Impulse noise is also known as salt and pepper noise. Impulse noise is typically caused by malfunctioning of the pixel elements in the camera sensors, faulty memory locations, or timing errors in the digitization process. For the images corrupted by impulse noise [10], the noisy pixels can take only the maximum and the minimum values in the dynamic range. An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions.

2. Gaussian 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. Gaussian noise has a root-mean-square value proportional to the square root of the image intensity, and the noises at different pixels are independent of one another.

3. Electronic Noise

It results from thermal motion of electrons in the electronic components of the imaging system.

4. Photoelectric Noise

It is due to statistical nature of light and photoelectric conversion process in the imaging sensor.

5. Film Grain Noise

It is due to randomness of silver halide grains in the film used for recording.

6. Thermal Noise

An additional, stochastic source of electrons in a CCD well is thermal energy. Electrons can be freed from the CCD material itself through thermal vibration and then, trapped in the CCD well, be indistinguishable from "true" photoelectrons. By cooling the CCD chip it is possible to reduce significantly the number of "thermal electrons" that give rise to thermal noise or *dark current*. As the integration time *T* increases, the number of thermal electrons increases.

The paper is ordered as follows. In Section II, It defines image restoration, their methods. The section III defines the proposed system. Results are explained in section IV. Finally, conclusion is explained in Section V.

II. IMAGE RESTORATION

Any image acquired by a device is susceptible of being degraded by the environment of acquisition and transmission. The restoration of images tries to minimize the effects of these degradations by means of a filter. Therefore, a fundamental problem in the image processing is the improvement of their quality through the reduction of the noise that they can contain being often known as "cleaning of images". A great variety of techniques dedicated to carry out this task exist. Each of them depends on the types of the noise in images. During image acquisition, the photoelectric sensor induces the White Gaussian noise due to the thermal motion of the electron. Many filters can be used to remove this type of noise; the most famous one is Wiener filter. On the other hand, with the unstable transferring of network some image data may be lost and impulse noise is combined into the image. To remove the impulse noise, many filters are designed; a simple and effective one is Median filter. Gaussian and Impulse noise together named as mixed noise. Neither Wiener filter nor Median filter alone can efficiently reduce this mixed noise. This in turn insists the need for the investigation of new filters. So, hybrid filter is designed.

Hybrid filter combines the advantages of median filter, wiener filter, edge detector and fuzzy network. This filter is designed to remove both impulse noise (salt and pepper noise) and gaussian noise. Thus, hybrid filter is able to reduce the mixed noise. Hybrid filter is also able to reduce the blurring effects in the image by using the edge detector.

1. Hybrid Filter

Hybrid filter is obtained by appropriately combining a noise filter, an edge detector with fuzzy network. The neuro fuzzy network utilizes the information from the noise filter, as well as from the edge detector as the current input, and the uncorrupted image as the reference output to compute the error function of the system, which is equal to the restored value of the noiseless input pixel

Hybrid filter is composed of four modules: wiener filter, median filter, edge detector and fuzzy network. Wiener filter or median filter is selected to remove the respective Gaussian noise and impulse noise. Edge detector is selected to extract the edges of the images so that the blurring effect is reduced. Image contaminated by mixed noise can be modelled by

$$g(x,y) = f(x,y) + n_G(x,y) + n_I(x,y)$$

where $f(x, y)$ and $g(x, y)$ are the gray value of original image and polluted image located at the pixel (x, y), $n_G(x,y)$ and $n_I(x,y)$ *I* are the Gaussian and Impulse noise positioned at the pixel (x, y) respectively.

2. Median filter

The median filter is a simple rank selection filter that outputs the median of the pixels contained in its filtering window. The median filter is also a spatial filter, but it replaces the center value in the window with the median of all the pixel values in the window. The kernel is usually square but can be any shape. An example of median filtering of a single 3x3 window of values is shown below. [62],[65]

Unfiltered values		
6	**2**	**0**
3	**97**	**4**
19	**3**	**10**

Figure 2: 3*3 unfiltered pixels kernel

3. Wiener filter

Images can be corrupted with different kinds of noises. The observed image is a nonlinear combination of the true image signal and noise. The noise could be described by the combination of many different distributions depending on the source of corruption. In image processing, the common source of noise can be described using Gaussian and/or impulsive noise distributions. [6]

Wiener filter is best to remove Gaussian noise. The Wiener filter is the Mean Square Error (MSE)-optimal stationary linear filter for images degraded by additive noise and blurring. The Mean-squared Methods uses the fact that the Wiener Filter is one that is based on the least-squared principle, i.e. the filter minimizes the error between the actual output and the desired output.

4. Edge Detector

Edges characterize boundaries and are therefore a problem of fundamental importance in image processing. Edges in images are areas with strong intensity contrasts – a jump in intensity from one pixel to the next. Edge detecting an image significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. The Canny edge detection algorithm is known to many as the optimal edge detector. The canny edge detection algorithm smoothes the image to eliminate the noise. It then finds the image gradient to highlight regions with high spatial derivatives. The algorithm then tracks along these regions and suppresses any pixel that is not at the maximum (non maximum suppression).

5. Fuzzy Network

The fuzzy network used in the structure of the proposed hybrid filter acts like a fusion operator and attempts to construct an enhanced output image by combining the information from the noise filter, the edge detector and the noisy input image. The fuzzy network is a first order Sugeno type fuzzy system with three inputs and one output. Sugeno-type fuzzy systems are popular general nonlinear modelling tools because they are very suitable for tuning by optimization and they employ polynomial type output membership functions. Let X_1, X_2, X_3 denote the inputs of the fuzzy network and *Y* denote its output. Each noisy pixel is independently processed by the median and by Gaussian filter, Edge detector preserved the edges and being applied to the fuzzy network as the second input.

III. DESCRIPTION OF PROPOSED SYSTEM

An image is a visual representation, reproduction, or imitation of something. In most cases the blurring of images is a spatially continuous process. The blur introduced by atmospheric turbulence depends on a variety of factors such as temperature, wind speed, exposure time etc. The sparse coding noise, which is defined as the difference between the sparse code of the degraded image and the sparse code of the unknown original image, should be minimized to improve the performance of sparse-based image restoration. Due to this, it proposes an image restoration model & presented hybrid filter approach that filters and restores an image by reducing mixed noise from the image. This cannot reduce 100 % noise but it removes noise by around 60%, as compared to the original image.

Edge detection is a terminology in image processing and computer vision, particularly in the areas of feature detection and feature extraction, to refer to algorithms which aim at identifying points in a digital image at which the image brightness changes sharply or more formally has discontinuities. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. There is an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges.

The edges extracted from a two-dimensional image of a three-dimensional scene can be classified as either viewpoint dependent or viewpoint independent. A viewpoint independent edge typically reflects inherent properties of the three-dimensional objects, such as surface markings and surface shape. A viewpoint dependent edge may change as the viewpoint changes, and typically reflects the geometry of the scene, such as objects occluding one another. The Canny Edge Detector is one of the most commonly used image processing tools, detecting edges in a very robust manner.

Development of the Canny Algorithm

Canny's aim was to discover the optimal edge detection algorithm. In this situation, an "optimal" edge detector means:

- Good detection - the algorithm should mark as many real edges in the image as possible.
- Good localization - edges marked should be as close as possible to the edge in the real image.
- Minimal response - a given edge in the image should only be marked once, and where possible, image noise should not create false edges.

$$\frac{1}{115}$$

2	4	5	4	2
4	9	12	9	4
5	12	15	12	5
4	9	12	9	4
2	4	5	4	2

Figure 3: Discrete Approximation to Gaussian Function

In order to implement the canny edge detector algorithm, a series of steps must be followed. The first step is to filter out any noise in the original image before trying to locate and detect any edges. And because the Gaussian filter can be computed using a simple mask, it is used exclusively in the Canny algorithm. Once a suitable mask has been calculated, the Gaussian smoothing can be performed using standard convolution methods. A convolution mask is usually much smaller than the actual image. As a result, the mask is slid over the image, manipulating a square of pixels at a time.

After smoothing the image and eliminating the noise, the next step is to find the edge strength by taking the gradient of the image. The Sobel operator performs a 2-D spatial gradient measurement on an image. Then, the approximate absolute gradient magnitude (edge strength) at each point can be found. The direction of the edge is computed using the gradient in the x and y directions. However, an error will be generated when sumX is equal to zero. So in the code there has to be a restriction set whenever this takes place. Whenever the gradient in the x direction is equal to zero, the edge direction has to be equal to 90 degrees or 0 degrees, depending on what the value of the gradient in the y-direction is equal to. If G_y has a value of zero, the edge direction will equal 0 degrees. Otherwise the edge direction will equal 90 degrees. Once the edge direction is known, the next step is to relate the edge direction to a direction that can be traced in an image. After the edge directions are known, non-maximum suppression now has to be applied. Non-maximum suppression is used to trace along the edge in the edge direction and suppress any pixel value (sets it equal to 0) that is not considered to be an edge. This will give a thin line in the output image.

Finally, hysteresis is used as a means of eliminating streaking. Streaking is the breaking up of an edge contour caused by the operator output fluctuating above and below the threshold.

Fuzzy System

A typical fuzzy system can be split up into four main parts, namely a fuzzifier, a knowledge base, an inference engine, and a defuzzifier. The fuzzifier maps a real crisp input to a fuzzy function, therefore determining the 'degree of membership' of the input to a vague concept. In a number of controllers, the values of the input variables are mapped to the range of values of the corresponding universe of discourse. The range and resolution of input fuzzy sets and their effect on the fuzzification process is considered as a factor affecting the overall performance of the controller. The knowledge base comprises the knowledge of the application domain and the attendant control goals. It can be split in a database of definitions used to express linguistic control rules in the controller, and a rule base that describes the knowledge held by the experts of the domain. Intuitively, the knowledge base is the core element of a fuzzy controller as it will contain all the information necessary to accomplish its execution tasks. The Inference Engine provides the decision making logic of the controller. It deduces the fuzzy control actions by employing fuzzy implication and fuzzy rules of inference. In many aspects, it can be viewed as an emulation of human decision making. The defuzzification process converts fuzzy control values into crisp quantities; that is, it links a single point to a fuzzy set, given that the point belongs to the support of the fuzzy set.

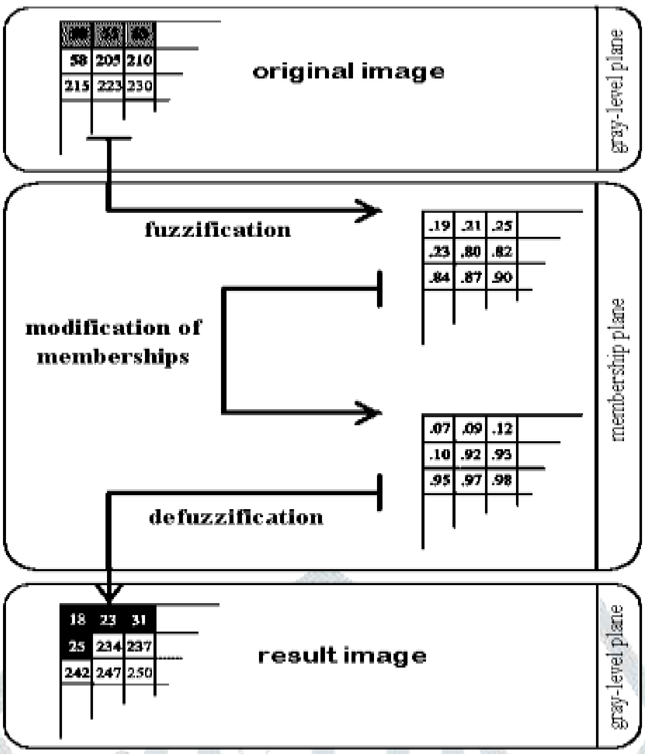

Figure 4: Steps of Fuzzy Image Processing

IV. RESULTS & DISCUSSION

Hybrid Filter is a filter to restore the image by removing noise from the image and making it suitable for human perception. This filter is designed by combining median filter, wiener filter, canny edge detector and fuzzy network. It is designed to remove mixed noise (i.e. both impulse noise and Gaussian noise). Output of hybrid filter can also be used to further processing (i.e. this output can be used by next step in image processing). Hybrid filter increase the quality of image by removing noise from the image. Noise can be any undesired information that can degrade the image.

Firstly noisy image is passing through median filter, wiener filter, and canny edge detector. Then output of these three act as an input to the fuzzy network and we get the restored image. Four modules are designed to develop the hybrid filter:

1. Median filter is used to reduce impulse noise (salt and pepper noise)
2. Wiener filter is used to reduce Gaussian noise.
3. Canny edge detector is used to preserve the feature of image and reducing the blurring effect in the image.
4. Fuzzy network is used to deal with uncertain, incomplete information of the image. It utilizes the information that comes from the median filter, wiener filter and canny edge detector. After processing the image by fuzzy network we get the enhanced or restored image.

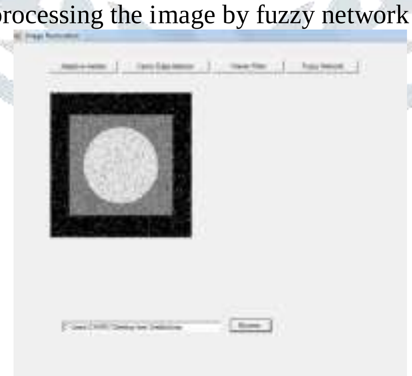

Figure 5: Input Image

Figure 6: Median Filter Output

Figure 7: Canny Edge Detection Output

Figure 8: Image Restoration Output

V. CONCLUSION

In this work, it proposes an image restoration method using hybrid filter concept and denoising the noisy image by iterative method. A novel hybrid filtering operator for removing mixed noise from digital images is presented. The fundamental superiority of the proposed operator over most other operators is that it efficiently removes Gaussian and impulse noise from digital images while preserving thin lines and edges in the original image. A new noise filter design methodology is introduced for cancellation of mixed noise with the added feature of the preservation of edges. An efficient method for the detection of impulse noise pixels, an improved Wiener filter (based on the result of impulse noise detection) for removing Gaussian noise and a adaptive median filter for removing impulse noise are all contributed to this scheme to effectively eliminate both types of noise. It presented hybrid filter approach that filters and restores an image by reducing mixed noise from the image. This cannot reduce 100 % noise but it removes noise by around 60%, as compared to the original image.

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