Probabilistic Padding for Restoration of Blur Image for Removing Inconsistency

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Abstract: *In modern science and technology, digital images gaining popularity due to increasing requirement in many fields like medical research, astronomy, remote sensing, graphical use etc. Therefore, the quality of images matters in such fields. There are many ways by which the quality of images can be improved. Image restoration is one of the emerging methodologies among various existing techniques. Image restoration is the process of simply obtaining an estimated original image from the blurred, degraded or corrupted image. The primary goal of the image restoration is the original image is recovered from degraded or blurred image. This paper proposed a probabilistic hybrid model to recover these images in order to improve the quality. This work uses the basic concept of kernel and padding. This work also applies the Haar wavelet Transform for filtering the image in order to reconstruct image which have the noise and blur. Proposed methodology use linear regression and Bayesian classification probabilistic approximation for compute the degree of blur for image restoration. The results of this dissertation show that the proposed method gives the better result from the previous methods. It seems to be that the PSNR, Mean Square Rate and execution time is batter in the proposed scheme.*

Keywords: *Image Enhancement, DCT, DWT, Digital Image, Brightness Preservation, Histogram.*

1. INTRODUCTION

Over Recent trends show that the usage of image processing has becoming more and more prominent in our daily life. In addition to television, camera, camcorder, and personal computer, many high-tech electronic products, such as hand-phone, or even refrigerator, nowadays are being equipped with capabilities to display digital images. Unfortunately, the input images that are provided to (or captured by) these devices are sometimes not really in good brightness and contrast. Therefore, a process known as digital image enhancement is normally required to increase the quality of these low brightness images.

Image enhancement produces an output image that subjectively looks better than the original image by changing the pixel's intensity of the input image. The purpose of image enhancement is to improve the interpretability or perception of information contained in the image for human viewers, or to provide a "better" input for other automated image processing systems as shown in figure 1.

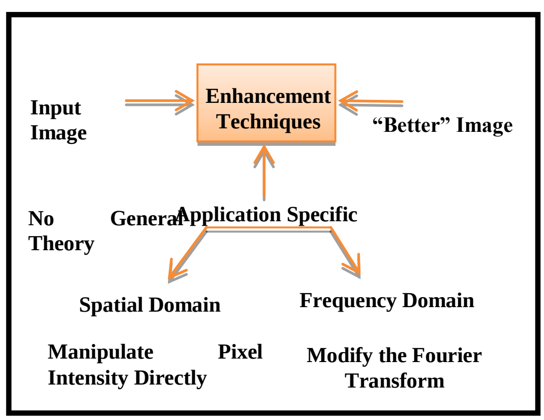

Figure 1: Image Enhancement Process

It plays an important role in the use of images in various applications like cancer tumor detection, medical image processing, radar image processing. There are many image enhancement techniques that have been proposed and developed, the most popular method being Histogram Equalization. This technique is one of the most popular methods for image enhancement due to its simplicity and efficiency. It usually increases the global contrast of the images mostly in cases where the important and useful data of the image is shown by low contrast values.

The rapid development of digital image processing Researchers used huge volume of data like medical image, satellite image, video image, digital image etc these data are retrieve through digital and electronic media. Many techniques and algorithm are developed using these data and perform different operation for enhanced feature, removal or reducing noise etc. and give result as better visual quality. These factor lead to researchers introduced hybrid model for preserving brightness, enhance quality of image and reducing noise.

2. IMAGE ENHANCEMENT TECHNIQUES

Image enhancement techniques improves a quality of an image such that enhanced image is better than the original image. Image Brightness preservation and contrast enhancement is one of the most important issue in low-level image processing. It is quite easy, for example, to make an image lighter or darker, to increase contrast, preserve brightness. For the last few decades, researchers have been working on image enhancement processes and two types of promising techniques have been developed such as, spatial domain image enhancement and frequency or spectral domain image enhancement.

Several image enhancement techniques have been proposed in both spatial and Frequency domains. Frequency domain enhancement techniques involve transforming the image intensity data into a specific domain by using such methods as the Discrete Cosine, Fourier, and Wavelet transforms. These frequencies are used to alter the frequency content of an image to improve desired traits, such as high frequency content. Most spatial domain enhancement methods are based on histogram modification .

Traditionally, classical histogram equalization has presented challenges due to its inherent dynamic range expansion. Many images with data tightly clustered around certain intensity values can be over enhanced by standard histogram equalization, leading to artifacts and overall tonal change of the image, resulting in an undesired loss of visual data, of quality, and of intensity scale. In the Frequency domain, we have control over subtle image properties such as low and high frequency content with their respective magnitudes and phases.

Frequency domain-based techniques can embed high-resolution for enhancement. Curvelet transformation has been used most widely in many aspects of image processing. A wide range of wavelet-based transformation and ideas have been proposed and studied for noise removal from images, image compression, image reconstruction, and image retrieval.

The method Optimal Decomposition Level of Discrete Wavelet Transform for Pixel based Fusion of Multi-focused Images [30]. In this Kannan et al [30] development of digital image processing leads to the growth of feature extraction of images which leads to the development of Image fusion. Image enhancement in digital image processing aimed at better visual quality and noise free image of medical and satellite images. Image enhancement methods can be classified into two broad categories:

- Spatial domain methods
- Frequency domain methods

A. Spatial Domain Methods

Here, image processing functions can be expressed as in equation (1).

(x; y) = T (f(x; y))………………(1)

With f(x; y) the input image, g(x; y) the processed image (i.e. the result or output image) and T (●) an operator on f, defined over some neighbourhood N of (x; y). For N we mostly use a rectangular subimage that is cantered at (x; y).
Spatial domains methods further classify in to another technique are widely used for contrast enhancement like point processing, it is mostly used for contrast enhancement techniques using contrast starching, gray level slicing and bit plane slicing these techniques is used for enhancement of gray level images. Most applying technique for brightness preservation is HE and histogram specification is also part of point processing. Image subtraction, image averaging and spatial filtering are techniques of spatial domain. Spatial filtering is used low, median and high pass filleting techniques.

B. Frequency Domain Methods

These methods are principally based on the convolution theorem. It can be understood as follows:
Suppose $g(x, y)$is an image formed by the convolution of an image $f(x, y)$ and a Linear, position invariant operator$h(x, y)$as in equation (2):

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$\mathbf{g(x, y) = h(x, y) - f(x, y)}$.................. **(2)**

Applying the convolution theorem yields as in equation (3):

$$\mathbf{G(U, V) = H(U, V) - F(U, V)} \text{.............. } \mathbf{(3)}$$

In which F, G and H are the Fourier transforms off, g and h respectively.
Applying the inverse Fourier transforms onG(U,V) yields the output image as in equation (4):

$$g(x,y) = F_1(H(U,V) - F(U,V)) \quad \text{......(4)}$$

An example is $H(U, V)$ which emphasizes the high-frequency components of $F(U, V)$so that $g(x, y)$ becomes an image in which the edges are accentuated. Viewed from the theory of linear systems (see figure 2), some interesting features can be seen: $h(x, y)$is called a system whose function is to produce an output image $g(x, y)$from an input image $f(x, y)$.

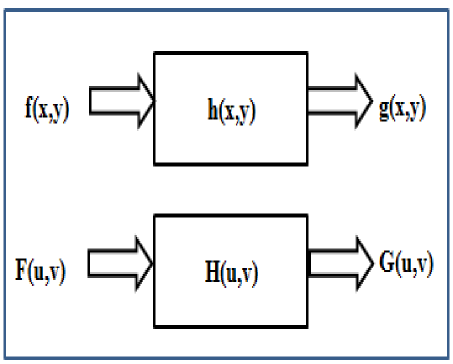

Figure 2: Linear Systems

Equivalent with this is the Fourier notation of this operation. Now suppose that $h(x, y)$is unknown and that we apply a unit impulse function δ (t) (this is the 1D-case) as in equation (5) and (6):

$\boldsymbol{\delta(t) = 0 \; if t \neq 0}$ .... **(5)**

$\boldsymbol{\delta(t) = +\infty if t = 0}$............................ **(6)**

Note that δ (t) is not a real function, it is only defined indirectly:

$\mathbf{x(t)\delta(t - t_0)dt = x(t_0) \text{ if } a < t_0 < \mathit{b}}$..................... **(7)**

Else: = 0

If we calculate its Fourier transform, we obtain 1 for $F(U, V)$. So in the Fourier system of equation (6), we multiply $H(U, V)$with the constant 1 which of course results in $H(U, V)$. From this we conclude that $G(U, V) = H(U, V)$). Applying equation (5), we obtain that $g(x, y) = h(x, y)$. Thus, the system is completely specified by its response to a unit impulse function. In the above derivation we call $h(x, y)$ the impulse response function and $H(U, V)$ the transfer function. Equation (7) describes a process called spatial convolution and $h(x, y)$is sometimes referred to as the spatial convolution mask (note that the mask must be symmetric about its origin because a convolution involves flipping an image about the origin).

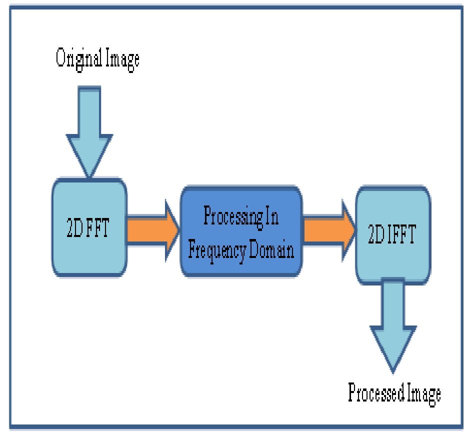

Figure 3: Frequency Domain Step

The frequency filters process, as shown in figure3, an image in the frequency domain. Application of this type of filtering is easy:

- Transform the image into the Fourier domain.
- Multiply the image by the filter.
- Take the inverse transform of the image.

All frequency filters can also be implemented in the spatial domain and, if there exists a simple kernel for the desired filter effect, it is computationally less expensive to perform the filtering in the spatial domain. Frequency filtering is more appropriate if no straight forward kernel can be found in the spatial domain, and may also be more efficient. To obtain the resulting image in the spatial domain, G (u,v) has to be retransformed using the inverse Fourier transform. There are basically three different kinds of filters: low-pass, high-pass and band-pass filters.

Frequency domain approaches are converting the signal in to frequency. This type of approaches used for reducing or removing noise for dynamic range of images or colour images. For noise detection using different filtering techniques like low pass and high pass filters. This approaches also used for transformation, colour image processing and image analysis.

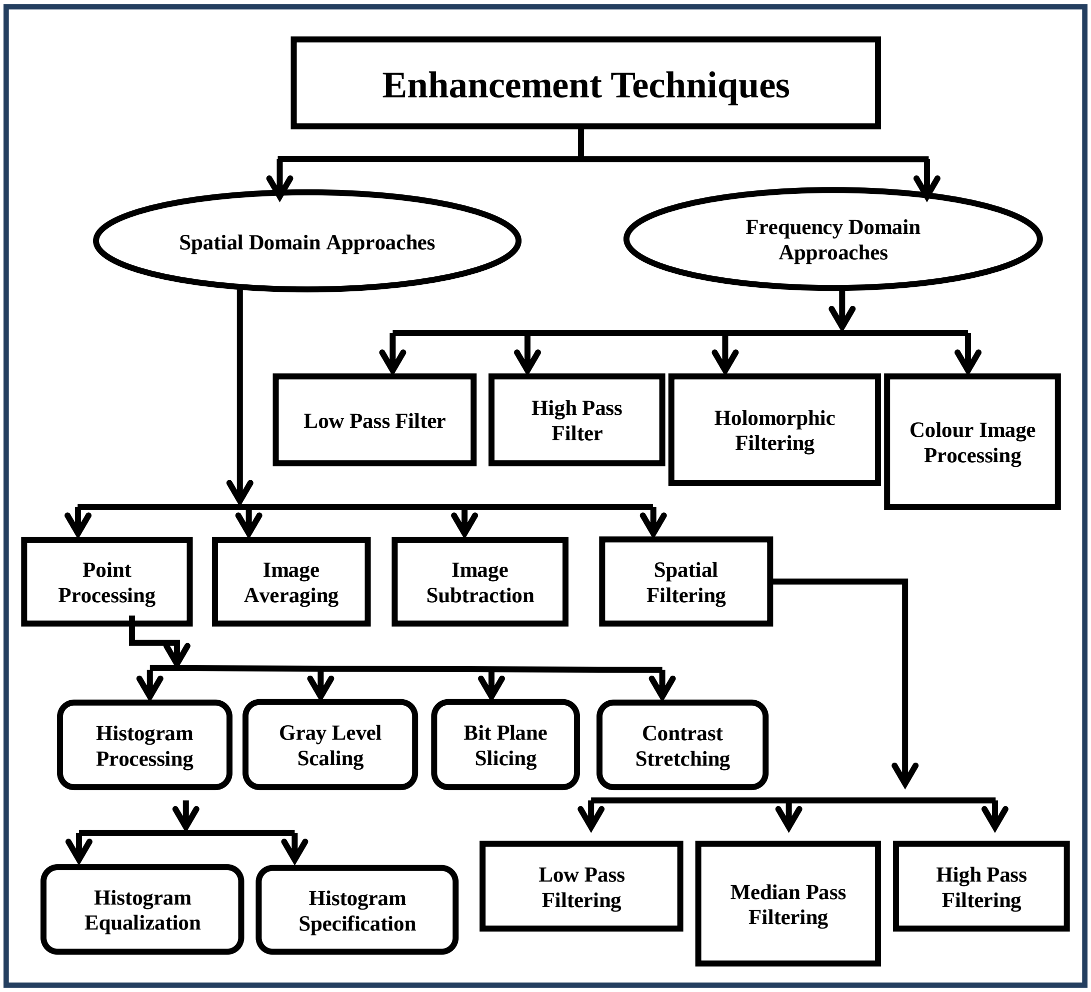

Figure 4: Classification of Image Enhancement Techniques

Classification of Image enhancement techniques as shown in figure 4, the goal of image enhancement techniques is to improve a quality of an image such that enhanced image is better than the original image.

3. PROPOSED APPROACH

The main aim of presented paper is restoring the original image from blur and noisy effected image. Firstly we create noisy and blur image by using noise function and Gaussian blur kernel. After obtaining noisy and blur image Here, we perform linear regression and Bayesian classification probabilistic approximation for estimation of blur distribution, point spread function (PSF). This PSF works as the deblurring parameter in wiener filter to find the noise free and deblur image.

In proposed methodology for image restoration linear regression and Bayesian classification probabilistic approximation is applied to compute the degree of blur by using

$$p\left(R_{image}^{degraded}/k\right) = \prod_i q(q_{i,x}(x))q(q_{i,y}(x))\prod_j q(y_j)$$

Where x and y shows the distance from horizontal and vertical axis respectively and k is approximate Gaussian Blur Kernel that has been added in degradation phase. Here Belief theory is used to compute the probability of blur distribution which gives the PSF.

Then Wiener filter is used for deblurring of blur image as we have already approximated the value of blur kernel (point-spread function).

$F = (G/H) * (|H|^2 / (k+|H|^2))$

Where,

G = Fourier transform of original blurry image

H = Fourier transform of blur kernel

k = Deblurring parameter ($k \geq 0$).

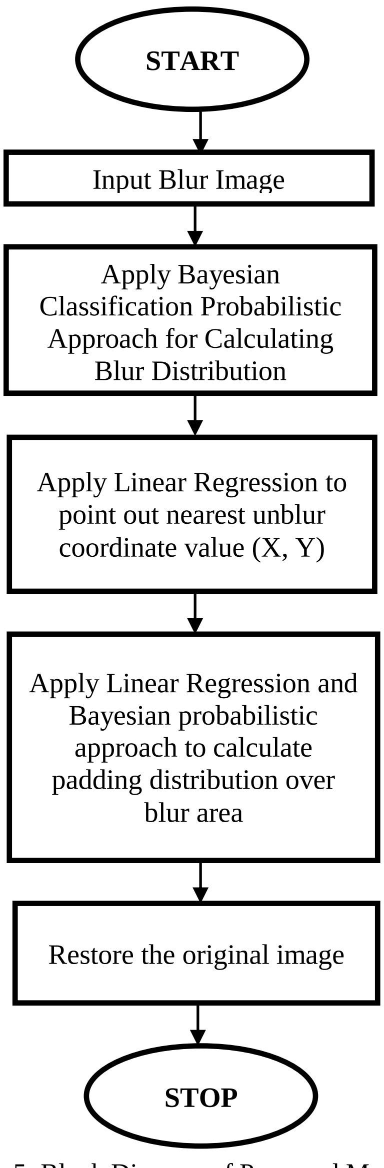

Figure 5: Block Diagram of Proposed Methodology

Then padding is applied on the resulting image with the size of the original image so that the effect of blurring could be minimized. Before padding process, noise is reduced with the help of Wiener filter. In this way both blur and noise degrades tends to reduce. In order to get the deblur image, next Inverse DWT is perform on the image.

Proposed Algorithm (Image Restoration Process)

Assumptions:

R^{image} = Raw image

O = Original Image

|Image| = size of Image

N_{image} = Noisy Image

K_{image} = Kernel Image

Algo (Degradation)

Step 1:- load the real original image R_{image}

Step 2:- Apply DWT over noisy image N_{image}

$$DWT(N_{image}, Haar) = N_{image}^{Discrete}$$

Step 3:-Apply DWT over Kernal image Kimage

$$DWT(K_{image}, Haar) = K_{image}^{Discrete}$$

Step 4:- Degraded image $R_{image}^{degraded} = N_{image}^{discrete} * K_{image}^{discrete}$

Algo (Restoring)

Step 1:- Apply Bayesian classification probabilistic approach for blur distribution

$$p\left(R_{image}^{degraded}/k\right) = \prod_i q(q_{i,x}(x))q(q_{i,y}(x)) \prod_j q(k_j)$$

Step 2:-Apply Linear Regression

$$yp\left(R_{image}^{degraded}/k\right) = a + b\left\{p\left(R_{image}^{degraded}/k\right)\right\}$$

Where

$$a = \sum y_i - b \sum p\left(R_{image}^{degraded}/k\right)$$

And

$$b = \frac{\sum x_i y_i - \frac{\sum x_i \sum y_i}{n}}{\sum x_i^2 - \frac{(\sum x_i^2)}{n}}$$

$$X = p\left(R_{image}^{degraded}/k\right)$$

Step 3:- Apply padding over $p\left(R_{image}^{degraded}, k\right)$

$$pad(p\left(R_{image}^{degraded}, k\right)$$

$$= pad\ image\ (p\left(R_{image}^{degraded}, k\right), SR_{image})$$

Step 4:- Restoring of original de-blur image

$$IDWT\left(pad(p\left(R_{image}^{degraded}, k\right), Haar\right) = Original\ image$$

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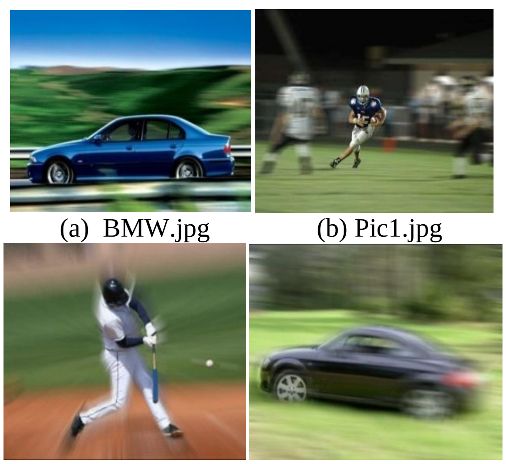
4. SIMULATION DETAIL & RESULT ANALYSIS

The proposed system is implemented using MATLAB R2014a. This work has simulated with the machine having configuration of Intel core i3 CPU with 2.53 GHz, having 4 GB of RAM and 500 GB HDD. The work has been done on 32 bit OS (Windows 7). Experimental analysis of proposed work is perform over MATLAB 14 with normal photography image then performing degradation process in which we have added noise to image. For that Salt and pepper noise here is added to the image by taking a default noise density with the value d=0.05.This is followed by blurring of image which is done by applying DWT, through selected the value of variance as s=3 and as we have also selected k_{size}=31so, the value of m becomes 15.5. After that Gaussian mean is selected in such a way that mean should just be in the center of the kernel image and resultant generate blur image. After that proposed approach have to take this blur image as our input and main focus of our work is to estimate blur, then as per proposed algorithms and apply probability estimation to estimate the value of blur and Bayesian classification method estimate the value of blur distribution (PSF). Then wiener filter is applied to get noise free and deblurred image.



(a) BMW.jpg (b) Pic1.jpg

(c) Pic2.jpg (d) Pic3.jpg

Figure 6: Input Data set (a)(b)(c)(d)

After reconstruction, for result comparison four different images has taken namely BMW, PIC 1, PIC 2 and PIC 3. Then, the proposed probabilistic kernel-padding algorithm is applied on these images and finds their final PSNR value as show in table1. The previous LDA algorithm for image restoration was performed with Gabor filter whereas for length of blur they utilize a RBF neural network . Their result and PSNR value also shows in table1. Here proposed approach is Probabilistic Padding and previous approach is RBFNN.

Table 1: Comparison of PSNR ratio

Image Name	Algorithm	PSNR (dB)
BMW.jpg	Probabilistic Padding (Proposed)	35.1576
	Linear Discriminant Analysis [9] (Existing)	28.9645
PIC1	Probabilistic Padding (Proposed)	32.3658
	Linear Discriminant Analysis [9] (Existing)	30.1307
PIC2	Probabilistic Padding (Proposed)	32.5781
	Linear Discriminant Analysis [9] (Existing)	31.3595
PIC3	Probabilistic Padding (Proposed)	34.7205
	Linear Discriminant Analysis [9] (Existing)	31.2589

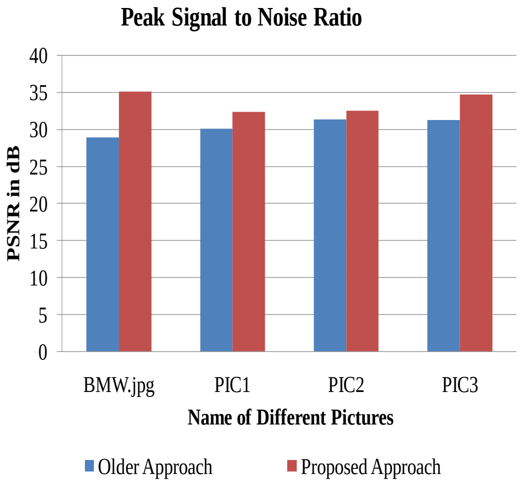


Figure 7: Comparison Graph of PSNR Ratio

PSNR is Factor of an image which is use to know the quality of the picture or image, it is calculated by using mean square error (MSE). The PSNR will be calculating between the original images and resulting image. Both parameters are calculated by the following formula.

$$PSNR = 10\log_{10}\left(\frac{MAX^2}{MSE}\right)$$

$$MSE = \frac{\sum_{M,N}[I_1(m,n) - I_2(m,n)]^2}{M * N}$$

The experimental results shows that the proposed algorithm gives the better performance with compared to previous approaches. The results are better for all the image data set. As shown in figure 6.

5. CONCLUSION

Image restoring is a mechanism to refine the original image from blur and noisy effected image. Motion blur occur due to relative motion between the camera and the object being imaged during an spotlight time. Basically in a scene, when the momentums of moving articles exceed the chronological resolution of the camera, then because of its technical limitation CCD camera lead to generate degraded picture affected by motion blurs. Degraded Image restoration is a procedure of restoring original non Blur and noise free image. In this dissertation a competent probabilistic based Kernel padding Wiener filter technique for the restoration of images is proposed. The result parameter shows that the efficiency of the proposed technique is improved. The Error rate of the techniques is less as compared to the previous techniques. Also the blurry and noise effect can be effectively reduced using our proposed work. In future try to develop a scheme having perform accurately even at the noisy conditions. This implicates the robustness of the proposed scheme. And working for video image also.

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