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Assessing the Efficacy of Blur Removal Methods in Image Denoising

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***Abstract* - Image denoising plays a prominent role in a variety of applications such as image instauration, visual tracking, image registration, image segmentation, and image displacement, where achieving pristine image content is critical for strong performance. A document image is in vogue in today's world and is used in digitized libraries and digitized organizations. These images are disseminated in the cyber world through emails, online announcements, and gregarious media/public channels. Image noise can be caused by various intrinsic (e.g., sensor) and extrinsic (e.g., environment) conditions that are often unavoidable in practice. An image denoising method proposed by implementing blurs abstraction techniques. This is based on Deep Learning methods to improve the various performance features.**

Keywords: Image noising, Image Denoising, Information Retrieval, Image Security, Blurring, De-Blurring, Deep Learning.

1. Introduction

Image Denoising

It is one of the fundamental challenges in the field of image processing and computer vision. Image denoising plays a prominent role in a variety of applications such as image instauration, visual tracking, image registration, image segmentation, and image displacement, where obtaining pristine image content is critical for strong performance.

Blurring effect in image processing

When an image is out of focus, colour transitions from one side of an edge in the image to the other become smooth rather than sudden. This compensates for rapid fluctuations in pixel intensity. The blur is a very common operation that we must perform before other tasks such as the threshold.

Blind image deblurring aims to produce a sharp image from a blurred image, where the blur kernel is unknown.

To solve this problem, numerous image priorities have been explored and employed in this field. From a mathematical point of view, image denoising is an inverse problem whose solution is not unique. Although many image denoising algorithms have been proposed, the problem of image noise suppression remains an open challenge, especially when the images are acquired under poor conditions and the noise level is very high.

The goal of the proposed work is noise reduction, i.e., reducing noise in natural images while minimizing the loss of original features and improving the signal- to-noise ratio (SNR).

Types of Blur

Channel Blur

Channel blur is used for color mixing, very often as a tool for color correction. It provides a set of sliders to increase and decrease the color values and transform the blur depending on the selected color.

Fig 1.3.1 Channel Blur

Bilateral Blur

Bilateral blur came as a "soft focus" effect with the beginning development of video effects. It is quite easy to use and gives your clip a "dreamy" atmosphere.

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Fig1.3.2 Bilateral Blur

Box Blur

Box Blur is great for slow zooms because it blurs the clip proportionally. We can often see it visually in TV series used in memory scenes.

Fig1.3.3 Box Blur

Radial Blur

Radial blur is practically always used for very sharp zooms. It looks best when you are trying to zoom in on something very far away, and creates a great transition.

Fig1.3.4 Radial Blur

Vector Blur

Extravagant vector blur useful for artistic effects, works perfectly with all kinds of motion.

Fig1.3.5 Vector Blur

Directional Blur

Directional blur or linear blue is one of the most popular types. You can easily transform the direction in the settings below and make it perfect for your transition.

Fig1.3.6 Directional Blur

Gaussian Blur

The simplest and easiest blur to use is the Gaussian blur. If you are not sure which blur to use, choose the one that is most commonly used and that any software supports.

Fig1.3.7 Gaussian Blur

Motion Blur

Motion blur should be your choice if you want your clips to look rough and the camera movement to be smoother. It's

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great for transitions and any kind of moving footage because it adapts to the image itself, making it look different and unique every time.

Motion blur is a photographic technique that uses a slow shutter speed to blur moving subjects in the image. You can significantly enhance motion blur with a faster moving subject and a slower shutter speed, or only slightly with a small amount of kineticism during a slightly faster shutter speed.

Kinetic blur intentionally captures out-of-focus images to convey kinetics. It mimics how the human eye perceives rapid movement as blurred objects passing by quickly. It is so appealing and captivating that it has evolved into its own genre of photography (i.e., kineticism blur photography).

Fig 1.2.8 Motion Blurr

Blurred image with low shutter speed

It has slower shutter speeds such as 1/60 second, and slower shutter speeds result in a blur effect. If you decide to use a slow shutter speed, mount the camera on a tripod and use image stabilization to reduce the risk of unwanted camera kineticism.

Blurred image with high shutter speed

A slower shutter speed with a higher ISO value can minimize or abstract motion blur, but if the ISO value is too high, there will be more noise in the image. If the ISO value is too high, the image may also be overexposed if the location has abundant light.

CC Force Motion Blur

CC Force motion blur that is impeccable when you need blur for clips for which you cannot normally get automatic blur. For example, clips that you have rendered in other animation video creation software packages and left without their natural motion blur.

2. Literature Review

Deblurring of an image is an important task in image processing. A large number of research papers on blurring have been published using various methods to improve the overall image quality. A number of techniques are used to achieve the best results.

The work presented by Saini and Himral [1] is mainly concerned with the concept of image restoration to obtain a true image from a noisy and unaltered image. In it, the blind deconvolution strategy is used to recover a sharp image using image restoration technique. A true image provides valuable information.

Mane and Pawar [2] presented their approach in the field of edge detection by using the blind deconvolution method with the edge detection method. This method is used to reduce the ringing effect of a blurred image. It is mainly used for motion blurred images where there is no information about the blur kernel. First, the image is degraded using a degradation model and then the original image is recovered.

Kanjar De and Masilamani [3] presented a new method concerning NR-IQA (No-reference Image Quality assessment). In this paper, the standard deviation of the Gaussian filter kernel is used for different images. This concept is used to deblur the images. As the blur in the image increases, the frequency component decreases. So it is a measure of the image quality of an image. The image quality measure is determined after the central Fourier transform to detect the sharpness in an image.

Saleh Al-amri, Kalyankar, and Khamitkar S.D. [4] studied the method of recovering Gaussian blur images when there is no information about PSF. In this paper, different deblurring methods are compared and different experiments are performed using different techniques such as Wiener filter, Lucy-Richardson algorithm method, Blind Deconvolution Algorithm method, Regularized Filter Deblurring method etc.

Gavilan, R. Arahal and Ierardi [5] presented their work on the estimation of roll angles. Plane angle estimation is used to remove blur in an image. A gradient algorithm is also used in this technique. Basically, these are methods to improve the image processing of aerial images. They are related to automatic landing methods.

Singh and Sahu [6] have developed a method for deblurring images using transform spread functions (TSFs). Parameters for quality measurement are also computed in this process. HDR images are derived using PSFs. Deblurring is referred to as a method for sharpening and clarifying the image. In this work, PSF is estimated for blurred images.

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Henawy, Amin, Ahmed, Adel [7] dealt with both the blur kernel and the deblurred image. They also presented the type of blur, noise model and different deblurring techniques. The blurring of an image can occur for many reasons, such as camera shake, object movement, etc. After that, the obtained image deteriorates and we cannot see it clearly. According to this paper, all captured images are more or less blurred. And there are many factors that deteriorate the quality of an image.

Madghe and Kasturiwala [8] discussed the methodology of image enhancement to improve the quality of an image using the GLAS algorithm. Image enhancement is basically a process where the original image is free from blur and noise. The two methods of image enhancement are: Spatial Domain and Transform Domain. The quality of an image enhanced through these methods. Image enhancement is the requirement of today's world to improve the quality of an image.

Kamboj and Moudgil [9] worked on Hybrid Median Filter to remove noise or blur from an image. They considered different filtering techniques to sharpen an image, but the suitable technique proposed by them is the hybrid median filter, with which we can get a better result on a blurred image. By using different filters, the PSNR value is calculated and the hybrid filter gives a better result than the median filter.

Tyagi and Singh [10] have been concerned with detecting areas to be inpainting in an image and then fill the holes and scratches by reconstructing them to get a good image. There are two approaches to image deblurring: texture synthesis and inpainting to restore the image. Two types of algorithms are used to fill the pixel values, namely the Boundary Fill and Flood Fill algorithms.

Bhawre and Ingle [11] presented an approach based on Group based sparse representation (GSR). The technique used in this approach is self-adaptive dictionary learning. In this paper, the three image restoration problem such as inpainting, deblurring and compressive sensing recovery are addressed. The inpainting method is used to fill the discontinuities of a blurred image.

3. Methodology

Methods used to Capture Motion Blur

Adjust Shutter Speed

When creating motion blur by slowing the shutter speed, you need to adjust the speed depending on how fast your subject is moving. Photographers may find it advantageous to shoot in aperture priority mode for easy adjustments.

Fast-Moving Subject

A fast-moving subject, such as an action or sports subject, will appear as a blur at a much faster shutter speed. If your subject is moving fast enough, you can achieve blur at shutter speeds such as 1/200, 1/125, 1/100, or 1/60.

Slower Subject

If your subject is moving much slower, such as a person walking around or a slow-moving river, you'll need a much slower shutter speed to capture the motion as a blur. In this case, you need slow shutter speeds of half a second, a full second, or even longer.

Move the Camera

You can also create kineticism blur by moving the camera with the shutter open. For example, you can create a motion blur effect by zooming in or out with the shutter open. With this technique, the camera causes the blur, not the subject. Make sure you use a tripod to avoid camera shake.

Panning

Another way to capture kineticism blur is the technique of panning, in which the photographer moves the camera from side to side with the shutter open. Panning generally results in an unmoving subject and a blurred background.

Measuring units for Blur Accuracy

Motion Blur Evaluation Techniques

These techniques model human sensitivity to moving spatial patterns to evaluate and improve exhibit performance. Kineticism blur occurs when a moving edge travels across an exhibit such as a liquid crystal exhibit (LCD) that has limited temporal replication. It is therefore important to quantify this effect visually.

Human perception of motion blur

One of the major drawbacks of the current exhibits is an artifact called kineticism blur that occurs when viewing video with motion sequences. With this visual artifact, the viewer perceives the edges of moving objects as blurred edges. Kineticism blur is caused by an interaction between the lighting conditions of the exhibit and the human visual system.

Camera measurement method for motion blurs

Motion Picture Replication Time (MPRT) is used to characterize the kineticism artifacts of an exhibit. Kineticism blur is perceived as the result of the viewer's eye tracking a moving object. The perceived retinal image is obtained by

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spatiotemporal integration along the kineticism trajectory. This uniform tracking of the eye can be captured using a uniform tracking camera system to simulate the tracking of a moving edge and perform spatial- temporal integration with position shifts.

Motion blur from moving block width

As shown in the figure, when dynamic images are displayed, different exhibits lead to different perceived width in retinal coordinates. Therefore, perceived width can be used to characterize the kineticism blur (similar to the use of BEW). BEW measures the width of the blurred edge from 10% to 90% of the luminance transition, while our proposed perceived width is the width of the entire moving block. For example, a static pattern with a width of 500 pixels moves from left to right on the screen, resulting in a different perceived width than 500 pixels in kineticism. A relative luminance of 90% is an imperceptible threshold for a dark moving object, and a relative luminance of 10% is an imperceptible threshold for a bright moving object.

Blur Removal via Blurred-Noisy Image Pair The blur kernel cancels differences in adjacent pixel values. The Emboss kernel (which is related to and sometimes referred to as the Sobel kernel) creates the illusion of depth by emphasising differences between pixels in a particular direction.

The general expression of a convolution is

$$g(x,y) = \omega * f(x,y) = \sum_{dx=-a}^{a} \sum_{dy=-b}^{b} \omega(dx,dy) f(x-dx, y-dy)$$

Where g(x,y) is the filtered image, f(x,y) is the original image, ω is the filter kernel. Every element of the filter kernel is considered by $-a<dx<a$ and

$-b<dy<b$

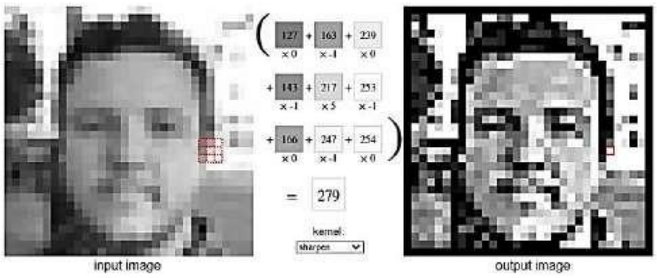
An image kernel is a tiny matrix used to apply effects such as those in Photoshop or Gimp, e.g., blurring, sharpening, contouring, or embossing. For 'Feature extraction', this technique for determining the most important parts of an image also used in machine learning. In this context, the process is commonly referred to as "convolution".

To see how they work, let us first look at an ebony- white image. The matrix on the left contains numbers between 0 and 255, each corresponding to the gloss of a pixel in an image of a face. The colossal, granular image has been enlarged to make it easier to perceive visually; the last image is the "genuine" size.

Let's walk through the following 3X3 sharpen kernel to the image of a face from above.

0	-1	0
-1	5	-1
0	-1	0

In the following, for each 3x3 pixel block of the left image, we multiply each pixel by the corresponding input of the kernel and then sum it. This sum becomes a starting pixel in the right image. Move the mouse pointer over a pixel in either image to visually see how its value is calculated.



One of the subtleties of this process is what to do on the edges of the image. For example, the input image has only three neighbors, at the upper left corner. One way to fine-tune this is to extend the edge values in the original image by one, while keeping the output image the same size. In this demo, we ignored these values by making them ebony.

Here is a playground where you can select different kernel matrices and visually see how they affect the original image, or create your own kernel. You can also upload your own image or use live video if your browser supports it.

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Let's walk through the following 3X3 sharpen kernel to the image from above.

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

Blur image performance Measures

Image quality can be assessed utilizing two methods.

a) Subjective methods are predicated on the perceptual assessment of a human viewer about the attributes of an image or set of images.
b) Objective methods are predicated on computational models that can prognosticate perceptual image quality.

The categories of blur measure operators analyzed in this work are:

Derivative-based operators [DER]

The blur measure operators in this category are predicated on the derivative of the image. These operators are predicated on the postulation that non- blurred images present sharp edges as compared to blurred images. First and second order derivatives of the image neighbourhood windows provide the base to distinguish between blurred and non-blurred regions of the image.

Statistical-based operators [STA]

The blur measure operators of this category utilize several statistical measures which are computed on image neighbourhood windows to differentiate between blurred and non-blurred neighbourhood windows in the image.

Transform-based operators [TRA]

The blur measure operators within this category are predicated on the transform domain representations of the image content. These frequency domain representations offer to be the veridical replica of the same information as in the spatial domain and thus this frequency content of the image can be used to distinguish between blurred and non-blurred regions of the image.

Miscellaneous operators [MIS]

These operators do not belong to any of the aforetime mentioned categories. The De-blurring techniques are fundamentally used to sharp an image utilizing different methods and parameters. Sanctioned owners only de-blur or reconstruct the blurred document images. In this work, we have analyzed two subsisting de-blurring techniques; they are, Blind Deconvolution and Lucy Richardson and one proposed technique is Dabber blur.

Blind De-convolution

Blind De-convolution algorithm is utilized to retrieve information from blurred images. It can be used efficaciously when no information about the distortion (blurring and noise) is kenned. The algorithm renovates the image and the point-spread function simultaneously. Supplemental optical system characteristics can be utilized as input parameters. It avails to amend the quality of the image instauration. The blurred pattern from the digital images is called as Point Spread Function (PSF). The standard non-linear and linear deconvolution technique utilized a kenned PSF. For blind deconvolution, the PSF is estimated from the accumulation of images to perform the deconvolution. PSF constraints can be passed through a utilizer-designated function. The definition of the method of blind de-blurring method can be written as follows:

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

Where $g(x, y)$ is the visually examined image, PSF is Point Spread Function, $f(x, y)$ is the constructed image and $\eta(x, y)$ is the additive noise term.

Lucy Richardson

The Richardson–Lucy algorithm additionally designated as Lucy–Richardson de-convolution. It is very popular deblurring algorithm in the area of image processing. This algorithm not required any information from the pristine clear image and it is an iterative algorithm. The Lucy- Richardson algorithm expressed through the equation as follow:

$$f2\,(n + 1) = f2nH2 * (g * Hf2\,n)$$

Where

(g) is a blurred image, (H) is the blur filter and (H2) is the adjoin of (H),

(n) is the number of the iteration.

Where f^$(n + 1)$ is derived estimation from the blurred image f^n.

This algorithm will be utilized but the only distinction is that in lieu of utilizing $(H*)$ in the pristine equation. This equation is optimized by Lucy- Richardson technique and it is described in the subsequent equation:

$$f2\,(n + 1) = f2nH2 * (9/(Hf2n))$$

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Where, in the first iteration, the value of $(n) = g$. This algorithm is the implementation of maximum likelihood method and it is the facility to provide a good quality reconstructed images.

Dabber Deblur

It is utilized for recuperating the information and it can be visually perceived by the sanctioned persons. It is utilized to get the information very pellucidly from the blurred images. It is considered as decryption method which is utilized to renovate the pristine image from the blur image. The following equation is utilized to reconstruct the blurred image, de-blur is approximately described by this equation:

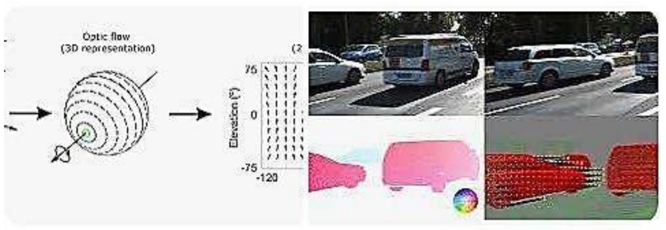
$$(x, y) = \mathrm{h}(x, y) * f + m(x, y)$$

Where (x, y) is the blurred image, h de-blur operator,

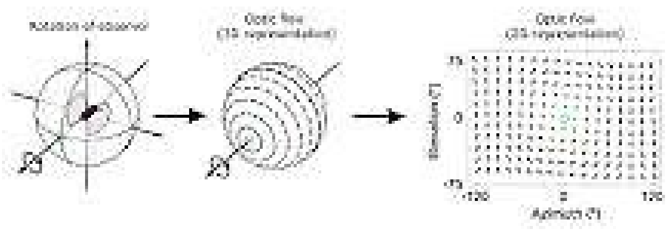
f is de-blur function and m is noise abstraction operator for image reconstruction from the blurred image.

Optical Flow

Optical flow is defined as the ostensible kineticism of individual pixels on the image plane. It often accommodates as a good approximation of the veritable physical kineticism projected onto the image plane.



Importance of optical flow



Optical flow information has been apperceived as being serviceable for controlling micro air conveyances. The application of optical flow includes the quandary of inferring not only the kineticism of the observer and objects in the scene, but withal the structure of objects and the environment.

Optical flow equation

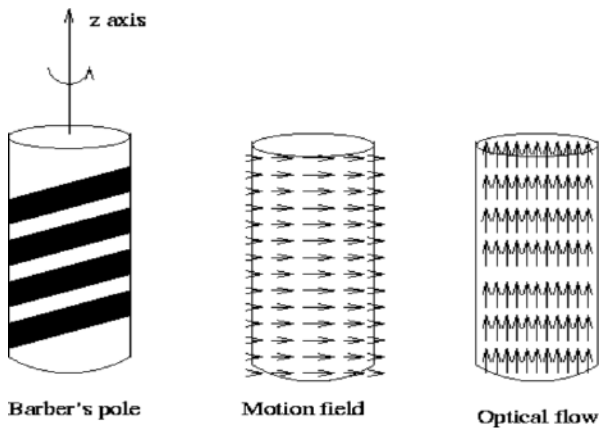


Fig: The motion field and optical flow of barber's pole

The optical flow equation is,

$$I_x u + I_y v + I_t = 0$$

Where subscripts denoted the partial derivatives of I and u and v are the x and y components of the optical flow vector. This last equation is called the constraint equation for the optical flow because it expresses a constraint on the u and v components of the optical flow.

Optical Flow Estimation

Optical-flow methods are predicated on computing estimates of the kineticism of the image intensities over time in a video. The flow fields can then be analyzed to engender segmentations into regions, which might be associated with moving objects.

Recent techniques

Following are sundry techniques for Optical flow estimation.

Multi-grid with rearward warping for more expeditious convergence

In the Computer Vision community numerical multi- grid solvers are kenned as pyramidal approaches. For the estimation of flow, typically a rearward warping strategy is utilized. The later frame is warped towards the earlier frame utilizing the current estimate of optic flow. This warping transpires in at each level going from a coarser to a finer grid. For each level, the final optic flow is the sum of all estimated flows, which is scaled by the ratio between levels.

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Robust through m-functions

Bruhn et al. (2005) suggest a coalescence of a local data constraint and ecumenical regularization constraint both encapsulated into m-functions and a multi-grid numerical optimization method to estimate optic flow robustly.

Constancy of gray-value derivatives or matching of descriptors estimates astronomically immense displacements

Brox et al. (2004) utilized an image gradient constancy posit in additament to the OFCE. Other already aforetime discussed techniques that they used are m-functions for data terms, and regularization term, rearwards warping of image frames and multigrids. A refinement of this conception uses descriptors in lieu of a constancy of gray-value derivatives. These descriptors extracted from the image avail matching sizably voluminous image displacements.

Robustness through L1 norm

In lieu of m-functions, the L1 norm is utilized for data term and regularization term to achieve a robust estimate for optic flow. In an L1 formulation, both data term and regularization term, are not perpetually differentiable. To sidestep this quandary, Zach et al. (2007) use auxiliary variables that are linked to the optic permeate a squared Euclidean distance, which is differentiable. Two optimization quandaries, one for the optic flow variables and one for the auxiliaries, are solved. Each of these quandaries contains only one term that is not perpetually differentiable. This enhanced the robustness and decremented computation time.

Learn from the failure of the gray-value postulation

More general approaches learn contravention of the effulgence constancy postulation for given intensity functions and their associated optic flow in coalescence with the spatial characteristics of optic flow.

Voting and median filtering handles flow discontinuities

Tensor voting avails the handling of flow discontinuities compared to variational optic flow estimation. Anisotropic stick tensor voting is applied to the data term and is coalesced with an anisotropic regularization term, which by definition contains directional information. Another approach to handles flow discontinuities utilizing a median filtering interspersed into the rearwards warping step of the flow solution between levels in an image pyramid.

Filling-in through an anisotropic regularization term

Only if the data term does not provide information about the solution of the flow vector at that location, at spatio-temporal locations Filling-in transpires. This is achieved by automatically determining the weight for the regularization term.

4. Deblurring Model

An unclear image or decaying image is able to describe by:

$$g = Hf + n$$

Here, g stands for the blurred image and H for the distortion factor, which is called the point spread function (PSF). In the spatial domain, PSF denotes the rate at which the optical system blurs the spot. PSF refers to an inverse Fourier transform of the optical transfer function (OTF). In the frequency domain, the (OTF) describes the response of a linear system and a fixed position of the pulse. The OTF is obtained as the Fourier transform of the point spread function (PSF). Deformation occurs when the image with the degradation factor degradation result from the point spread function is only a single type of distortion, which f as an input image, and n was what the additional noise introduced by the image acquisition, which was the image Comipts. Image deblurring and restoration are so important in digital imaging because images are captured in fields such as ordinary photography, astronomy, remote sensing, medical imaging, and microscopy. Image blur is difficult to avoid in many situations and can often damage a photograph. Everyone is familiar with camera shake, and it can cause blurring in photos taken in low-light conditions. While significant progress has been made recently in eliminating this blur from images, in general almost all current advances in this problem model the blurred image as a convolution of a sharp image with a linear filter. In reality, however, camera shake, represented as camera rotation during shooting, does not result in uniform blur. Recently, there are many approaches to remove motion blur from photos. Various deblurring techniques are discussed based on a single image or a pair of images. We can describe the desharpening process as the following system.

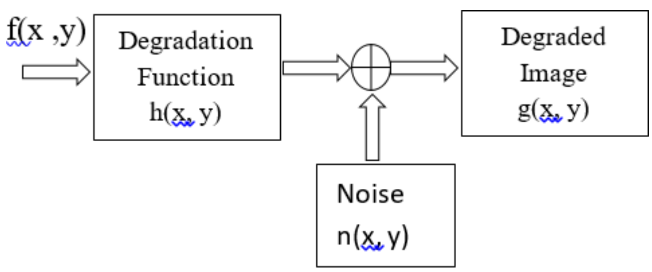

Fig 4.1 Deblurring model

A two-dimensional image f(x,y) considered as an original input. These image was performed on system h(x, y) and after adding noise n(x, y). The degraded image g(x, y) might be obtained. Digital image restoration may be seen as an operation in that we attempt to approximate f (x, y). That blurred image might be explained with the following:

$$g(x.y) = h(x,y) * f(x,y) + n(x.y)$$

5. Performance Measures

Different performance measures considered for this approach are

MSE (Mean Square Error)

Mean Squared Error (MSE) indicates how close a fitted line is to the data points. For each data point, the vertical distance between the point and the corresponding y-value on the fitted curve (the error) is determined and the value squared.

PSNR (Peak Signal to Noise Ratio)

The peak signal-to-noise ratio (PSNR) is the relationship between the maximum possible value (power) of a signal and the amount of distorting noise which affects the quality of presentation.

SSIM (structural kindred attribute index measure)

Structural Homogeneous Attribute Index (SSIM) is a method for predicting the perceived quality of digital television and cinema images, as well as other types of digital images and videos. SSIM is used to quantify the relatedness between two images.

6. Comparison between Various DeBlurring Techniques

In this section, the differentiation between various de-blurring techniques is presented as below:

Table 1: Comparison Table

Method	Type Of Blur	Performance	PSNR Ratio
Weiner filter	Gaussian Blur	Worst Result	17.05
Regularized Filter	Gaussian Blur	Efficient	20.10
Lucy Richardson	Gaussian Blur	Efficient	21.06
Handling Outliers	Gaussian Blur	Efficient	21.91
HyperSpectral (PCA)	HyperSpectral image Blur	Efficient	22.34
MDF	Motion Blur	Efficient	24.30
Motion Density	Motion Blur	Efficient	24.31
Dabber De-blur	Gaussian Blur	Efficient	26.45
Blind Deconvolution	Gaussian & Motion Blur	Efficient	26.78
Neural Network	Gaussian & out-of-focus Blur	Very Efficient	30.11
ASDS-AR	Gaussian Blur	Very Efficient	31.20

7. Conclusion

Image denoising plays an important role in a variety of applications, such as image instauration, visual tracking, image registration, image segmentation, and image displacement, where preserving pristine image content is critical for strong performance. This research work is to improve the various performance features such as image denoising method by implementing blur abstraction techniques. The review of the different research work has revealed the different parameters for different image de-noising techniques. The overall consideration is about the image quality. Many parameters are used to improve the quality of an image. So the proposed algorithm is about image quality. Deblurring uses different parameters are used such as degraded model, recovery techniques, different algorithms and other techniques.

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