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A Survey on Various Image Deblurring Techniques

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Abstract— Image blur is difficult to avoid in many situations and can often ruin a photograph. Image deblurring and restoration is necessary in digital image processing. Image deblurring is a process, which is used to make pictures sharp and useful by using mathematical model. Image deblurring have wide applications from consumer photography, e.g., remove motion blur due to camera shake, to radar imaging and tomography, e.g., remove the effect of imaging system response. There have been many methods that were proposed in this regard and in this paper we will examine different methods and techniques of deblurring. The analysis is done on the basis of performance, types of blur and PSNR (Peak Signal to Noise Ratio).

Keywords—Blur type, degradation model, image deblurring, motion blur, point spread function (PSF), peak signal to noise (PSNR).

I. INTRODUCTION

Digital images are electronic snapshots taken of a scene, which typically composed of picture elements in a grid formation known as pixels. Each pixel holds a quantized value that represents the tone at a specific point. Images are obtained in areas ranging from everyday photography to astronomy, remote sensing, medical imaging, and microscopy.

Unfortunately all images end up more or less blurry. This is due to the fact that there is a lot of interference in the environment as well as in the camera. The blurring or degradation of an image can be caused by many factors such as movement during the capture process, using long exposure times, using wide angle lens etc. Image deblurring is used to make pictures sharp and useful by using mathematical model.

A. Degradation Model

The degradation process can be visualised with the following system.

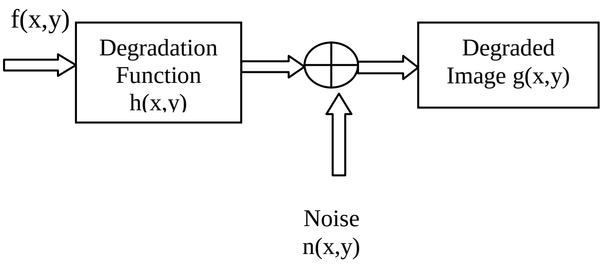

Fig 1: Degradation Model

The original input is a two-dimensional (2D) image f(x, y). This image is operated on by the system h(x.y) and after the addition of noise n(x, y). One can obtain the degraded image g(x,y). Digital image restoration may be viewed as a process in which we try to obtain an approximation to f(x, y). The blurred image can be described with the following equation.

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

B. Blur Type

In digital camera there are four common types of blur effects:

1). Average Blur:

The Average blur is one of several tools you can use to remove noise and specks in an image. Use it when noise is present over the entire image. This type of blurring can be distribution in horizontal and vertical direction and can be circular averaging by radius R which is evaluated by the formula:

$$R = \sqrt{g^2 + f^2} \quad (2)$$

Where: g is the horizontal size blurring direction and f is vertical blurring size direction and R is the radius size of the circular average blurring.

2). Motion Blur:

The Many types of motion blur can be distinguished all of which are due to relative motion between the recording device and the scene. This can be in the form of a translation, a rotation, a sudden change of scale, or some combinations of these. The Motion Blur effect is a filter that makes the image appear to be moving by adding blur in a specific direction. The motion can be controlled by angle or direction (0 to 360 degrees or –90 to +90) and/or

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by distance or intensity in pixels (0 to 999), based on the software used.[1]

3).Gaussian Blur:

A Gaussian blur is the result of blurring of an image by Gaussian function. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail. Gaussian blur is also used as a pre-processing stage in computer vision algorithms in order to enhance image structures at different scales. The Gaussian Blur effect is a filter that blends a specific number of pixels incrementally, following a bell-shaped curve. The blurring is dense in the centre and feathers at the edge. Apply Gaussian Blur to an image when you want more control over the Blur effect.[5]

4). Out-of-focus Blur:

When a camera images a 3-D scene onto a 2-D imaging plane, some parts of the scene are in focus while other parts are not. If the aperture of the camera is circular, the image of any point source is a small disk, known as the circle of confusion (COC). The degree of defocus (diameter of the COC) depends on the focal length and the aperture number of the lens, and the distance between camera and object. An accurate model not only describes the diameter of the COC, but also the intensity distribution within the COC.

II. DEBLURRING TECHNIQUES

A. Lucy- Richardson Algorithm Technique:

The Richardson–Lucy algorithm, also known as Richardson–Lucy deconvolution, is an iterative procedure for recovering a latent image that has been the blurred by a known PSF.[4]

$$C_i = \Sigma_j \, p_{ij} u_j \qquad (3)$$

Where: p_{ij} is the point spread function (the fraction of light coming from true location j that is observed at position i), u_j is the pixel value at location j in the latent image, and c_i is the observed value at pixel location i. The statistics are performed under the assumption that u_j are Poisson distributed, which is appropriate for photon noise in the data. The basic idea is to calculate the most likely u_j given the observed c_i and known p_{ij}. This leads to an equation for u_j which can be solved iteratively according to:

$$u_j = u_j^t \Sigma j \frac{c_i}{c_i} p_{ij} \qquad (4)$$

Where

$$C_i = \Sigma_j \, u_j^t \cdot p_{ij} \qquad (5)$$

It has been shown empirically that if this iteration converges, it converges to the maximum likelihood solution for u_j.

- Point Spread Function(PSF)

Point Spread Function (PSF) is the degree to which an optical system blurs (spreads) a point of light. The PSF is the inverse Fourier transform of Optical Transfer Function (OTF).in the frequency domain, the OTF describes the response of a linear, position-invariant system to an impulse.OTF is the Fourier transfer of the point (PSF).

B. Neural Network Approach:

Neural networks is a form of multiprocessor computer system, with simple processing elements, a high degree of interconnection, adaptive interaction between elements, When an element of the neural network fails, it can continue without any problem by their parallel nature[5].

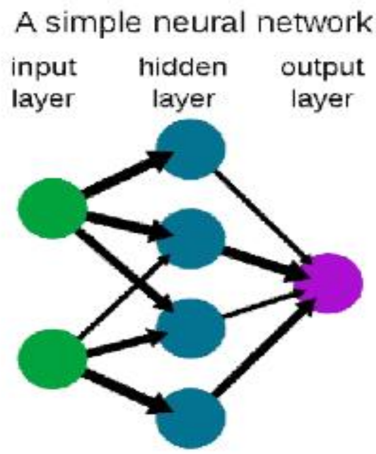

Fig 2: Artificial Neural Network

ANN provides a robust tool for approximating a target function given a set input output example and for the reconstruction function from a class a images. Algorithm such as the Back propagation and the Perceptron use gradient- decent techniques to tune the network parameters to best-fit a training set of input-output examples. Here we are using Back propagation neural network approach for image restoration. This approach is capable of learning complex non-linear functions is expected to produce better structure especially in high frequency regions of the image. We used a two-layer Back propagation network with full connectivity.

C. Blind Deconvolution Technique:

There are basically two types of deconvolution methods. They are projection based blind deconvolution and maximum likelihood restoration. In the first approach it simultaneously restores the true image and point spread function. This begins by making initial estimates of the true image and PSF. The technique is cylindrical in nature. Firstly we will find the PSF estimate and it is followed by image estimate. This cyclic process is repeated until a predefined convergence criterion is met. The merit of this method is that it appears robust to inaccuracies of support size and also this approach is insensitive to noise. The problem here is that it is not

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unique and this method can have errors associated with local minima. [6]
In the second approach the maximum likelihood estimate of parameters like PSF and covariance matrices. As the PSF estimate is not unique other assumptions like size, symmetry etc. of the PSF can be taken into account. The main advantage is that it has got low computational complexity and also helps to obtain blur, noise and power spectra of the true image. The drawback with this approach is of algorithm being converging to local minima of the estimated cost function. [3]

D. Deblurring With Blurred/Noisy Image Pairs:

In this approach the image is deblurred with the help of noisy image. As a first step both the images the blurred and noisy image are used to find an accurate blur kernel. It is often very difficult to get blur kernel from one image. Following that a residual deconvolution is done and this will reduce artifacts that appear as spurious signals which are common in image deconvolution. As the third and final step the remaining artifacts which are present in the non-sharp images are suppressed by gain controlled deconvolution process. The main advantage of this approach is that it takes both the blurred and noisy image and as a result produces high quality reconstructed image. With these two images an iterative algorithm has been formulated which will estimate a good initial kernel and reduce deconvolution artifacts. There is no special hardware is required. There are also disadvantages with this approach like there is a spatial point spread function that is invariant.[7]

E. Deblurring With Motion Density Function:

In this method image deblurring is done with the help of motion density function. A unified model of camera shake blur and a framework has been used to recover the camera motion and latent image from a single blurred image. The camera motion is represented as a Motion Density Function (MDF) which records the fraction of time spent in each discretized portion of the space of all possible camera poses. Spatially varying blur kernels are derived directly from the MDF. One limitation of this method is that it depends on imperfect spatially invariant deblurring estimates for initialization.[2]

F. Deblurring With Handling Outliers:

In this method various types of outliers such as pixels saturation and non-Gaussian noise are analysed and then a deconvolution method has been proposed which contains an explicit component for outlier modelling. Image pixels are classified into two main categories: Inlier pixels and Outlier pixels. After that an Expectation-Maximization method is employed to iteratively refine the outlier classification and the latent image.[19]

G. Deblurring by ADSD-AR:

In this approach ASDS (Adaptive Sparse Domain Selection) scheme is introduced, which learns a series of compact sub-dictionaries and assigns adaptively each local patch a sub-dictionary as the sparse domain. With ASDS, a weighted l_1-norm sparse representation model will be proposed for IR tasks. Further two adaptive regularization terms has been introduced into the sparse representation framework. First, a set of autoregressive (AR) models are learned from the dataset of example image patches. The best fitted AR models to a given patch are adaptively selected to regularize the image local structures. Second, the image nonlocal self-similarity is introduced as another regularization term.[20]

IV. COMPARISON OF DIFFERENT DEBLURRING TECHNIQUES

This work makes a comparison between different deblurring techniques. Following are tabular results obtained after the comparison.

Table1. COMPARISON TABLE

Methods Used	Types of Blur	Performance	PSNR Value
Wiener filter	Gaussian	Worst Result	17.06
Lucy-Richardson	Gaussian	Efficient	21.02
Blind Image Deconvolution	Motion	Efficient	26.76
Using MDF	Motion	Efficient	24.30
Using Handling Outliers	Gaussian	Efficient	21.91
Using ASDS-AR	Gaussian	Very Efficient	31.20
Neural Network	Gaussian, Out-of-focus	Very Efficient	30.10

IV. DISCUSSION AND CONCLUSION

After conducting the literature survey on various new image deblurring techniques proposed by different researchers. It is concluded that Restoration or deblurring average blur from images is a very difficult problem to resolve. From the above analysis we can see that ASDS-AR method for image deblurring is more accurate and less complex than other approaches. The PSNR value of ASDS-AR method is 31.20, which is higher than other methods. A higher value of PSNR is good because it means that the ratio of peak signal-to-noise is higher. The performance of neural network method is also very efficient and PSNR value is 30.10. Wiener filter method has Lowest PSNR value i.e. 17.06.

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