Restoration of Blur Image Using wavelet Based Image Fusion

Amit.S. Ufade, B.K.Khadse, S.R.Suralkar

Abstract— In this paper we describe Transformation domain fusion technique to restore images taken from any camera. Here first comparison of image restoration method is carried out, for this wiener filter and blind de convolution methods are selected ,then to improve the result of restoration image fusion using transformation domain technique i.e. wavelet based image fusion are suggested. The effectiveness of every stage is tabulated and compared using Spatial Frequency Root mean square error and Peak signal to noise ratio.

Keywords— Image restoration; Image fusion; point spread fusion; wavelet ;RMSE;PSNR;SF

I. INTRODUCTION

Image Restoration is very important issue in image processing. Image blurring is one of the prime causes of poor image quality in digital imaging. Two main causes of blurry images are out-of-focus and camera shake. The image blurring process is commonly modeled as the convolution of a clear image with a shift- invariant kernel plus noise, i.e. PSF [1].During image acquisition process images are often degraded by blur and noise. The relative motion between the scenery and the camera always causes the image blur during the short expose time [4]. The goal of image restoration is to recover the original image from a degraded one [1]. Image restoration methods can be considered as direct techniques when their results are produced in a simple one-step fashion [2], equivalently indirect techniques can be considered as those in which restoration results are obtained after a number of iterations. Known restoration techniques such as inverse filtering and Wiener filtering [2, 3] can be considered as simple direct restoration techniques. The problem with such methods is that they require a knowledge of the blur function [i.e., the point-spread function (PSF)], which is, unfortunately, usually not available when dealing with images blurred by motion [3].

The quality and the reliability of the image restoration process is usually based on the accuracy of information concerning the degradation process.[3]. The degradation of the true Image can be modeled as,

$$g(x, y)=f(x, y)*h(x ,y)+n(x, y) \text{ ---------- } (1)$$

Where(x, y) discrete pixel coordinates of the image frame;
g(x, y) blurred image;
for equations in your paper (Insert | Object | Create New |
f(x ,y) true image;
h(x ,y) point spread function (PSF);
n(x, y) additive noise;
* Discrete two-dimensional (2-D) linear convolution operator

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In this paper we used two image restoration method i.e. blind de convolution and wiener, and then to improve the result of restoration further wavelet based image fusion is suggested. To compare the result of above stages parameters like Spatial Frequency (SF), Peak signal to noise ratio (PSNR) and root mean square error are used (RMSE).

II. IMAGE FUSION

Image fusion has applications in many fields of computer Vision and image processing. Image fusion is the process of obtaining a new image from a set of input images (of the same Scene) that describes the scene better than any single input image [8].Image fusion can be performed at different levels- signal level, pixel level, feature level and decision level.

A. Types of image fusion:

(i) Signal level fusion- This is low level image fusion. At this level of fusion raw images obtained from multimodal imaging systems are fused. The greatest accuracy and information is achieved at this level of fusion. The disadvantage is that it requires transfer of all signals to a central processor, which is difficult.

(ii) Pixel level fusion- In this level of fusion, information content associated with each pixel in an image is enhanced through multiple image combination. Fusion at this level can be performed either in spatial domain or in frequency domain.

(iii) Feature level fusion- This is an intermediate level image fusion. This level can be used as a means of creating additional composite features. Features can be pixel intensities or edge and texture features. At first, relevant features are abstracted from input images and then fused. For this raw data is transformed and represented as feature vector sets. Various kinds of features, such as signal amplitude or shape, length or image segments, are considered depending on the nature of images and the application of the fused image. The fused data can also be used for classification or a detection/decision based on the fused feature set. Fusion at this level has an added advantage that standardized reconstruction procedure is not required. Decisions coming from various fusion experts are fused. This level of fusion is categorized into two types- hard fusion and soft fusion. Different methods of decision fusion are voting methods, fuzzy logic based methods, statistical methods etc. Soft methods are numeric fusion (fuzzy integral), linguistic fusion (position fusion, confidence fusion), predictive fusion (position, separation index) etc. In soft fusion the classifier outputs a number reflecting its confidence in the decision, whereas in hard fusion, the logical information (e.g. class membership) values are combined. [9].

Since proposed method is wavelet based image fusion method hence we proposed pixel level image fusion technique in which first Discrete wavelet transform is

performed on image x and image Y. After that all 4 sub bands of the fused image are formed by finding the wavelet coefficients from Image X and Image Y which is having maximum intensity.

F i, j=max(X i, j Y i, j) and

F j=max (1Aj, 1Bj) ---------- (2)

Where

1Aj (x, y) low frequency sub images of X(x, y)

1Bj(x, y) low frequency Sub images of Y(x, y)

In this technique pixel having maximum intensity is selected in fused image.

B. Wavelet transforms:

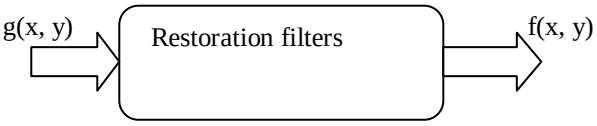
Wavelet transform comes to solve limitations of fixed resolution short-time Fourier transform. Wavelet transform gains much popularity and has been extensively used in the field of image processing due to its multi resolution nature. Wavelet coefficients exhibit well-localized property in both space and frequency domains. Moreover, multi-resolution spirit of the wavelet decomposition leads to superior energy compaction and perceptual quality of the decompressed image [8]. Due to the compactness nature of wavelet transform, it successfully produces natural images during fusion and is helpful in extracting significant features at different resolutions and scales [8]. Normally wavelet based image fusion is most popular technique because it contains both multi resolution property also contain both structural and detail information of image therefore the fused image that is the output of this technique mostly be higher quality than any other techniques in most situations.

III. PROPOSED SCHEME

The goal of image restoration is to recover the original image from a degraded one [1].Hence restoration techniques are pointed towards modeling the degradation first and then different inverse technique can be applied to restore the original image.

A. Phase –I

In phase one image degradation model is formulated. image degradation model is mathematical representation of the way in which gets blurred i.e. as given in eq.1.then image restoration techniques are employed .i. e .wiener filter and blind de convolution.



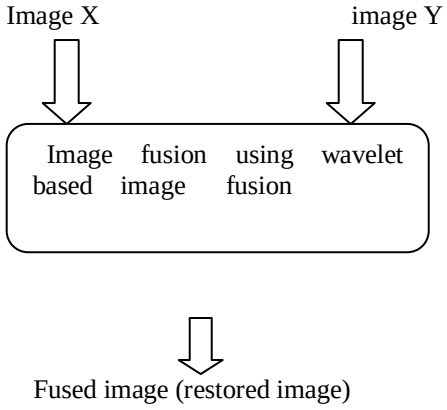
Where g(x, y) is blurred image and f(x ,y) is restored image. Further in this phase to improve result of blind de convolution wavelet based image fusion is proposed. Different iteration levels are also considered for comparison purpose. The general form of Point Spread function (PSF) is given as follows i.e. the general form of motion blur is given as follows

$$h(x,y) = \begin{cases} \frac{1}{L}, if\ \sqrt{x^2 + y^2} \leq \frac{L}{2}, \frac{x}{y} = -\tan(\text{ø}), \\ 0, otherwise \end{cases} \quad \text{---- (3)}$$

From the above equation motion blur is depend upon the two important parameters i.e. motion Length (L) and Motion direction or angle (ø).

B. Phase-II

In this phase filter images obtain from two different restoration technique i.e. wiener filter and blind de convolution are fused using wavelet based image fusion



Where image x is image obtained from wiener filter restoration technique where as image Y is image obtained from blind de convolution image restoration technique with particular value of iteration (say=10).The obtained image again compared, with following same procedure by increasing the number of iterations in order to obtain better results.

C. Phase –III

Measurement of image quality plays a major role in many image processing tasks such as compression, transmission, restoration and enhancement. Research on image quality assessment has become a crucial issue. Since humans are the end-users of most image processing applications, the evaluation based on subjective experiments is the most correct solution [11]. In this phase first comparison of image restoration technique is done i. e wiener filter and blind de convolution technique. first comparison is done for iterations=10 and next comparison is done for iterations =20.These readings are tabled as given in table 1.After this comparison of image fusion is done For change in image fusion iteration (i.e..10 and 20) for comparison following parameters are selected.

A. Root *Mean Square Error (RMSE)*

When the reference image is available then RMSE is the most valuable performance evaluation criterion [8]. It is defined as

$$\text{RMSE}=\sqrt{\frac{1}{(m*N)}(\sum_{i=1}^{m}\sum_{j=1}^{n}\{I_R(i,j) - I_f(i,j)\}^2} \quad \text{--------.(4)}$$

B..Peak Signal to Noise Ratio (PSNR)

This objective metric is used to measure quality of the fused image [8]. It is defined as,

$$\text{PSNR}= 20\ Log_{10}\left(\frac{255}{RMSE}\right) \quad \text{----------(5)}$$

Smaller value of RMSE and higher values of PSNR indicate better fusion result.

c. Spatial Frequency (SF)

Spatial frequency is used to assess the overall activity level of the fused image. It is defined as in [8],

$$SF = \sqrt{\text{CF}^2 + \text{RF}^2} \quad \text{----------(6)}$$

Where RF and CF are the row frequency and column frequency and is given by,

$$\text{CF} = \sqrt{\left\{\frac{1}{M\ X\ N}\sum_{i=1}^{M}\sum_{J=2}^{N}[I_F\ (i,j) - I_F\ (i,j-1)]^2\right\}}$$

----------(7)

and

$$RF= \sqrt{\left\{\frac{1}{M\ X\ N}\sum_{i=2}^{M}\sum_{J=1}^{N}[I_F\ (i,j) - I_F\ (i-1,j)]^2\right\}} \quad \text{----------(8)}$$

Smaller value of RMSE and higher values of PSNR and SF indicates better fusion results [8].

IV. EXPERIMENTAL RESULTS

In this Phase we have performed different experiments using different wavelets and the proposed method results are displayed. For this cameraman image is selected and results are compared using parameter like spatial frequency, RMSE and PSNR .theses parameters are compared using different image sizes as show in tables below.

Table-1 provides the measurement details of two restoration method namely wiener filter & blind de convolution.

Table-2 provides the details of measurement of

Proposed restoration method based image fusion and comparison of fused images using different wavelets. For this size of image is 256 x256.

Table-3 provides the details of comparison of RMSE, PSNR, and SF of fused images with different iteration

Table-4 provides the details of measurement taken with 10 different images and their comparison. Tabulated reading here displayed only for 256 x 256 images.

For our work we have only considered 3 parameter for image quality measurement there are other numerous parameter that can be used like entropy, mean etc. From these parameter we have selected 3 most valuable parameter i.e. SF, RMSE, PSNR

Table no-1:

Sr.. no	Size of image .	Blurred noisy image	Blind de convolution N=10	Blind de convolution N=20	Wiener filter	Blurred noisy image	Blind de convolution N=10	Blind de convolution N=20	Wiener filter
		RMSE	RMSE	RMSE	RMSE	PSNR	PSNR	PSNR	PSNR
1	64 x64	8.6281	8.8072	9.4558	8.5936	29.0295	28.7436	28.6169	29.1704
2	128 x128	7.4964	7.8859	8.7886	7.5822	30.5654	30.1937	29.2524	30.5349
3	256 x256	6.7493	7.0159	7.8684	6.0955	31.4772	31.2091	30.2131	32.4306
4	512 x512	5.6512	5.8579	6.4695	4.5010	33.0880	32.7759	31.9134	35.0646

Table-2

Sr. no	Wavelets	RMSE	PSNR	SF	RMSE	PSNR	SF
		Iterations=10			Iterations=20		
1	HAAR	5.3497	34.2265	28.3666	5.3094	34.0248	28.4432
2	DB2	5.3161	34.2099	28.2381	5.2857	33.9881	28.3397
3	DB4	5.3440	34.3340	28.2754	5.3084	34.1713	28.3515
4	DB5	5.3336	34.0169	28.2015	5.3096	34.0342	28.2998
5	COIF1	5.2747	34.2600	28.2547	5.2556	34.2593	28.3562
6	COIF2	5.2782	34.2678	28.2219	5.2635	34.2203	28.3292
7	COIF4	5.3339	34.3576	28.2624	5.2889	34.3833	28.3361
8	COIF5	5.3040	34.4002	28.2443	5.2733	34.2269	28.3228
9	SYM2	5.3161	34.2099	28.2381	5.2857	33.9881	28.3397
10	SYM4	5.2977	34.1353	28.2345	5.2692	34.3694	28.33
11	SYM5	5.3171	34.1105	28.2112	5.3016	33.957	28.3038
12	BIOR1.1	5.3497	34.2265	28.3666	5.3094	34.0248	28.4432
13	BIOR1.3	5.2644	34.6554	28.5327	5.2093	34.4698	28.6209
14	BIOR1.5	5.2281	34.8412	28.6125	5.1666	34.6747	28.7097
15	DMEY	5.3044	34.0875	28.2162	5.2808	34.3493	28.3014

Table-3

Sr. no	Size of image	Blurred noisy image	Fused image with 10 Iterations	Fused image with 20 Iterations	Blurred noisy image	Fused image with 10 Iteratio ns	Fused image with 20 Iterations	Fused image with 10 Iterations	Fused image with 20 Iterations
		RMSE	RMSE	RMSE	PSNR	PSNR	PSNR	SF	SF
1	64 x64	8.6281	4.7698	7.5279	29.0295	34.9488	30.6278	34.9488	56.4431
2	128 x128	7.4964	4.9344	6.4901	30.5654	34.6590	32.2049	31.1195	40.2808
3	256 x256	6.7493	4.9742	5.1666	31.4772	35.2726	34.6747	27.3861	28.7097
4	512 x512	5.6512	3.5511	3.7025	33.0880	38.0296	37.4626	13.9522	14.7973

Table-4

Sr. no	Images	Wavelet	RMSE	PSNR	SF
1	Cameraman. .tif	BIOR1.5	5.2281	34.8412	28.6125
2	Eight.tif	BIOR1.5	3.5313	37.883	16.0315
3	Lena.tif	BIOR1.5	4.9816	34.574	24.0415
4	Rice.png	BIOR1.5	5.1279	33.8464	24.229
5	woman.tif	BIOR1.5	4.1039	36.6427	21.6628
6	Pout.tif	BIOR1.5	4.3684	--------	15.6875
7	Moon.tif	BIOR1.5	3.8051	37.618	19.6244
8	Lifting body.png	BIOR1.5	4.1655	36.9016	17.4793
9	World map.tif	BIOR1.5	2.6149	40.75	12.2397
10	Pulsar.tif	BIOR1.5	4.8927	34.8088	22.2644

V. CONCLUSION

From above experimental result it can be seen that the proposed method provide better restoration results than both other restoration technique namely wiener filter and iterative blind de convolution. Blind de convolution requires more computational complexity and processing time also increases with increase in iterations. The proposed method with wiener filter and blind de convolution fusion gives better and faster results. Spatial frequency results indicate that for lower value of resolution gives better fusion. Wavelet bior1.5 gives better fusion results compared to other wavelets. The proposed approach achieves supremacy on traditional image restoration techniques. With proposed scheme for image fusion Provides higher PSNR and lower RMSE values as well good SF at low image size.

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