Comparison Of Spatial Domain And Transformation Domain Image Fusion Technique For Restoration Of Blur Images

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Abstract:

Pixel level image fusion can be performed in spatial   and transformation domain. In this paper we describe two image fusion techniques, transformation domain technique i.e. Wavelet based image fusion technique and spatial domain technique i.e. Principle component analysis

Both these techniques are compaired by calculating Spatial Frequency Root mean square error and Peak signal to noise ratio. Results shows that transformation domain technique gives better results than spatial domain technique.

Keywords: Image fusion, RMSE, PSNR, blur, PSF, SF. etc.

1.Introduction

Image fusion is fundamental to various modern day image processing applications [1]**.** 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 [3].The process of image fusion must ensure that all the salient information present in the source images are transferred to the composite image. Image fusion can be performed at three levels: pixel, object, and decision level. A number of pixel-level fusion techniques, in which the source images are processed and fused on a pixel basis or according to a small window in the neighborhood of that pixel can be found in literature. These range from simple averaging to more complex multi resolution techniques such as pyramids and wavelets [2].The multi-resolution decomposition based methods decompose input images at different resolutions and scales. Applying appropriate fusion rules a decision map for fused image is devised at every resolution and scale. Finally using these decision maps the fused image is synthesized [3].

Image fusion is well known as a valuable tool for increasing overall system performance in image based application areas such as defense surveillance, remote sensing, medical imaging and computer vision. Below listed are some application areas of image fusion.

Defense systems.   It covers subareas such as detection, identification and tracking of targets, mine detection, tactical situation assessment, and person authentication.

Geosciences. This field concerns the earth study with satellite and aerial images (remote sensing) . The main problem is the interpretation and classification of images. The fused image allows the detection of roads, airports, mountainous areas, etc.

Medical imaging.   The fusion of multimodal images is very useful for clinical applications such as diagnosis, modeling of the human body or treatment planning.

Robotics and industrial engineering. Here, fusion is commonly used to identify the environment in which the robot or intelligent system evolves and for navigation. Image fusion is also employed in industry. [4]

Ideally, any fusion algorithm should satisfy following minimum requirements:

• Preserve all relevant information in the fused image.

• Suppress irrelevant parts of the image and noise.

• Minimize any artifacts or inconsistencies in the fused

Image. [5]

The image blurring process is commonly modeled as the convolution of a clear image with a shift-invariant kernel plus noise, i.e.

$$f = k * g + n \quad \text{---------------------------} \quad (1)$$

Where denotes * the discrete convolution operator, g denotes the clear image, f denotes the available blurry observation, k denotes the blur kernel, and n denotes the image noise. In our method we used blurred image and to remove blurring here two restoration filters namely wiener filter and iterative blind de convolution filter are used. Output image of both these filters are then fused using both spatial domain & transformation domain techniques. wavelet based image fusion is done, by applying different wavelets, best fusion performance is calculated ,this performance is compared with PCA based fusion technique in order to find out best suitable technique.

2. Performance Parameters

Following parameter is used to evaluate the performance of above said methods.

2.1. RMSE (Root mean square error)

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

$$\text{RMSE} = \sqrt{\frac{1}{(m*N)}\left(\sum_{i=1}^{m}\sum_{j=1}^{n}\{I_R(i,j) - I_f(i,j)\}^2\right.} \quad ..\text{-}(3)$$

2.2. PSNR (Peak Signal to Noise Ratio)

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

$$\text{PSNR} = 20\log_{10}\left(\frac{255}{\text{RMSE}}\right) \quad \text{----------------------}(4)$$

2.3. Spatial Frequency (SF)

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

$$\text{SF} = \sqrt{\text{CF}^2 + \text{RF}^2} \quad \text{----------------------------------}(5)$$

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

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

------------(6)

and

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

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

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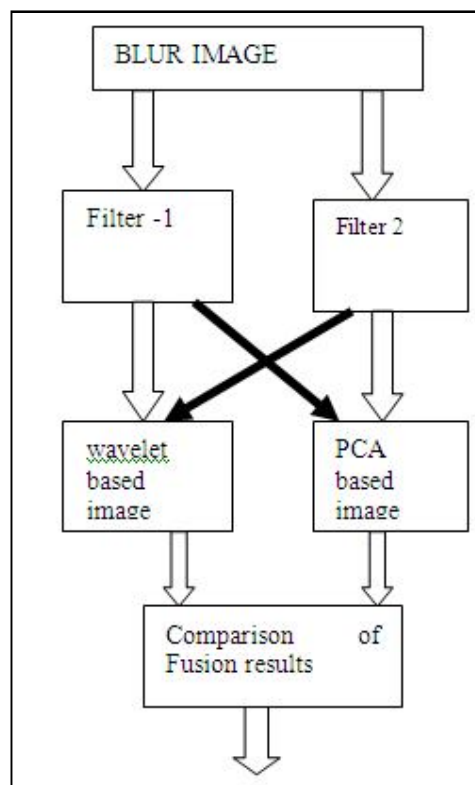
3.Proposed Scheme

Figure 1:Best fused output

3.1.Image Fusion By Wavelets

wavelet based image fusion method uses   pixel level image fusion technique in which first Discrete wavelet transform is performed on the input image 1(image restored

through wiener filter and image 2(image restored through blind de convolution) . After that all 4 sub bands of the fused image 3 are formed by finding the wavelet coefficients from Image 1 and Image 2 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 method pixel which is having maximum intensity is selected in fused image 3. After to improve the results of fusion different wavelets can be applied. 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.

The goal of this paper is to find out the best method of fusion out of two above mentioned methods one technique form spatial domain and other technique form transformation domain namely wavelet based & PCA based image fusion. For this in proposed scheme both this images are filter through wiener filter & blind de convolution which is iterative method .Following steps explain the process of image fusion using wavelets.

- Step -1: Input image if restored using restoration technique.
- Step-2: First restoration technique is wiener filter.
- Step-3: Second restoration technique is Blind de convolution.
- Step-4: First level of image decomposition is done using DWT.

- Step-5: Second level of decomposition is performed on the low frequency coefficient image of first decomposition.
- Stpe-6: Fusion rule is designed which select maximum pixel intensity of second level decompose image.
- Step-7: IDWT is performed to reconstruct the fused image

3.2.Image Fusion By PCA

PCA is a mathematical tool which transforms a number of correlated variables into a number of uncorrelated variables. The PCA is widely used for applications like image compression, image classification. The PCA is a mathematical procedure which transforms a number of correlated variables

into a number of uncorrelated variables called principal components. PCA computes a compact and optimal description of the data set. The first principal component accounts for as much of the variance in the data as possible and each succeeding component accounts for as much of the remaining variance as possible. First principal component is taken to be along the direction with the maximum variance. The second principal component is constrained to lie in the subspace perpendicular of the first. Within this Subspace, this component points the direction of maximum variance. The third principal component is taken in the maximum variance direction in the subspace perpendicular to the first two and so on [7].Following steps explain the process of PCA based image fusion.

- Step 1: Input image if restored using restoration technique.
- Step-2: First restoration technique is wiener filter.
- Step-3: Second restoration technique is Blind de convolution.
- Step-4: find the covariance matrix form the restored images
- Step-5: Find out Eigen vector & Eigen value form Covariance matrix.
- Step-6: Eigen vector with highest Eigen value is the principle component.
- Step-7: From the obtain principle component find out normalized component & use these component to form fused image.

(256   x256 size) are selected and best performing wavelet readings are tabulated

4.Experimental Results

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	33.7807	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

*image chosen **Table 1**: The readings tabulated in table-1 are of wavelet based image fusion technique. For this 10 different images(256 x256 size) are selected and best performing wavelet readings are tabulated previously.*

Sr .no	Images	Wavelet Based Image Fusion			PCA Based image fusion		
		RMSE	PSNR	SF	RMSE	PSNR	SF
1	Cameraman. .tif	5.2281	34.8412	28.6125	6.0854	32.3767	17.8370
2	Eight.tif	3.5313	37.8833	16.0315	4.4439	35.1755	10.6787
3	Lena.tif	4.9816	34.574	24.0415	6.4583	31.4749	14.3655
4	Rice.png	5.1279	33.7807	24.2290	7.1291	29.1319	15.7261
5	woman.tif	4.1039	36.6427	21.6628	4.3143	35.4325	13.8606
6	Pout.tif	4.3684	34.5546	15.6875	3.6459	35.7688	8.9079
7	Moon.tif	3.8051	37.618	19.6244	4.3143	35.4325	12.9973
8	Lifting body.png	4.1655	36.9016	17.4793	4.2215	35.6214	11.0586
9	World map.tif	2.6149	40.75	12.2397	3.6459	36.1886	8.2566
10	Pulsar.tif	4.8927	34.8088	22.2644	5.41	33.4669	13.9517

***Table 2**: In this .Table comparison is carried out for wavelet based image fusion technique and PCA based fusion technique .This activity is carried out on the same set of image chosen previously*
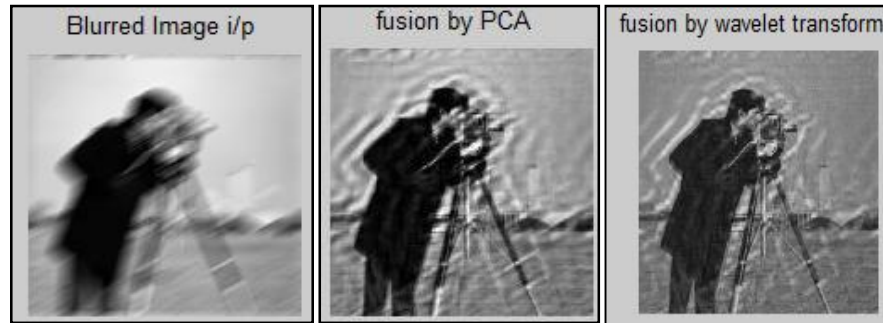
Figure 1: blurred image Figure 2: fusion by B   Figure 3: fusion by wavelets

5.Conclusion

From above carried out , work it is found that transformation domain technique i.e. wavelet based image fusion provides better results than spatial domain technique i.e. PCA based image fusion. Out of   15 different wavelets used BIOR1.5 provide good result i.e. reduced RMSE , improved PSNR as well good Spatial frequency.

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