# New Image Fusion method based on integration of Wavelet and Curvelet tranform in Image Processing

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***Abstract-*** **Image fusion is the perfect combination of relevant information from two or more images into a single fused image. As a result the final resultant image will carry more information as compare to the input images. There are so many Techniques for Image Fusion such as Principal component analysis (PCA) based fusion, Discrete wavelet transforms (DWT) and Curvelet transforms. Principal Component Analysis (PCA) has been most widely used method for dimensionality reduction and feature extraction. The discrete wavelet transform has become a very useful tool for fusion. And the Curvelet transform has evolved as a tool for the representation of curved shapes in graphical applications. The application of the curvelet transform in image fusion would result in better fusion results than that obtained using Principal Component Analysis (PCA) and Discrete wavelet transforms (DWT). The research work shows the implementation of Weighted fusion of Curvelet co-efficient and Simple Average fusion of Curvelet co-efficient and to compare the same with existing approaches of image fusion to show improvement in performance metrics.**

***Index Terms-*** **Image fusion, Principal Component Analysis (PCA), Discrete wavelet transform (DWT), Curvelet transform, Weighted average, Peak Signal to Noise Ratio (PSNR).**

## I. INTRODUCTION

Image fusion produces a single image by combining information from a set of source images together, using pixel, and feature or decision level techniques. The main aim of an image fusion algorithm is to take redundant and complementary information from the source images and to generate an output image with better visual quality.

The fused image contains greater information content for the scene than any one of the individual image sources alone. The reliability and overall detail of the image is increased, because of the addition of analogous and complementary information. Image fusion requires that images be registered first before they are fused. Data fusion techniques combine data from different sources together.

The main objective of employing fusion is to produce a fused result that provides the most detailed and reliable information possible.

## II. METHODOLOGY

The details of Principal Component Analysis, Wavelet transform and Curvelet transform are mentioned and their use in image fusion is described in this section

### 2.1 Principal Component Analysis

Principal component analysis (PCA) is a novel scheme for dimension reduction and is used for image fusion [8]. It is also a vector space transform used for reducing the Multidimensional data sets to lower dimensions. The PCA algorithm for the fusion of images is discussed as follows.

1. Generate the column vectors from the input image matrices.
2. Calculate the covariance matrix of the two column vectors produce.
3. The diagonal elements of the 2x2 covariance matrix contain the variance of each column vector with itself, respectively.
4. Calculate the Eigen values and the Eigen vectors of the covariance matrix.
5. Normalize the column vector corresponding to the larger Eigen value by dividing each element with mean of Eigen vector.
6. The output values of the normalized Eigen vector act as the weight values which are respectively multiplied with each pixel of the input images. Sum of the two scaled matrices

calculated in the previous step will be the fused image matrix [8].

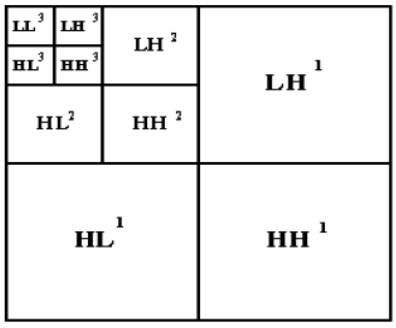
**2.2 Wavelet transform**

The Discrete Wavelet Transform (DWT), which is based on sub-band coding is found to yield a fast computation of Wavelet Transform. It is easy to implement and reduces the computation time and resources required.

In DWT, the most prominent information in the signal appears in high amplitudes and the less prominent information appears in very low amplitudes. Data compression can be achieved by discarding these low amplitudes. The wavelet transforms enables high compression ratios with good quality of reconstruction. Recently, the Wavelet Transforms have been chosen for the JPEG 2000 compression standard.

The discrete wavelet transform uses low-pass and high-pass filters, h (n) and g (n), to expand a digital signal. They are referred to as analysis filters. The dilation performed for each scale is now achieved by a decimator [4].

In two-dimensional separable dyadic DWT, each level of decomposition produces four bands of data, one corresponding to the low pass band (LL), and three other corresponding to horizontal (HL), vertical (LH), and diagonal (HH) high pass bands.




1, 2, 3 - Decomposition levels
H - High frequency bands
L - Low frequency bands

**Fig 1 Wavelet decomposition [4]**

**2.3 Curvelet transform**

The curvelet transform has evolved as a tool for the representation of curved shapes in graphical applications. Then, it was extended to the fields of edge detection and image denoising. Recently, some authors have proposed the application of the curvelet transform in image fusion [6].

The Algorithm of the Curvelet transform of an image P can be summarized in the following steps [14]:

A) The image P is split up into three sub bands Δ1, Δ2 and P3 using the additive wavelet transforms.

B) Tilting is performed on the sub bands Δ1 and Δ2.

C) The discrete Ridgelet transform is performed on each tile of the sub bands Δ1 and Δ2.

## III. PROPOSED IMAGE FUSION **ALGORITHM**

The steps involved in proposed algorithm can be summarized as follows:

1. Read input blur images
2. Apply Gaussian filter on both the input images

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

3. Perform Wavelet decomposition
4. Deriving wavelet co-efficients using Wavelet basis function

$$W_{a,b}(f(x)) = \int_{x=-\infty}^{\infty} f(x)\psi_{a,b}(x)dx$$

$$\psi_{a,b}(x) = \frac{1}{\sqrt{a}}\psi\left(\frac{x-b}{a}\right)$$

5. Perform IDWT on images
6. Perform Curvelet transform –
   Tilting and find Ridgelet transform
   The ridgelet basis function is given by:
   Ψa, b, θ(x1, x2) =a-1/2ψ (x1cosθ+ x2sinθ-b)/a)
   Ridgelet coefficients of an image f(x1, x2) are given by:
   Rf (a, b, θ) = ∫ Ψa, b, θ (x1, x2) f(x1, x2) dx1 dx
7. Perform Simple average by given formula
   f (i , j) = x (i , j) + y(i , j) / 2
8. Perform Weighted average by given formula
   f (i , j) = w1*x (i , j) + w2* y(i , j) / 2
9. Compare the results of Spatial and Frequency Domain with proposed method - Fusion of Wavelet and Curvelet by Simple Average and Weighted method, in terms of PSNR and MSE.

## IV. EXPERIMENTAL RESULTS

The experimental results PCA, Wavelet transform, Curvelet transform and Proposed image fusion methods for fusion of multifocus images are shown in figures

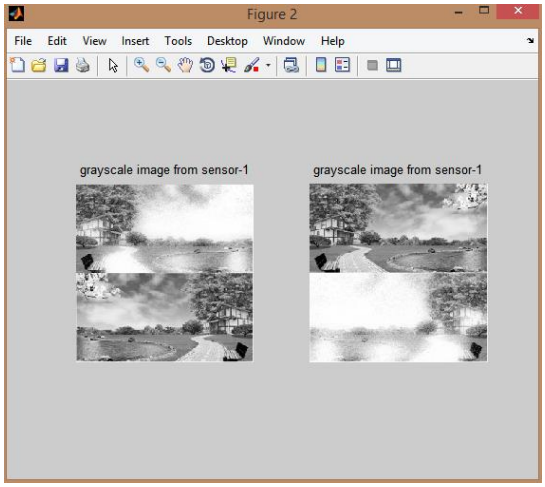



**Figure 2. Gray scale image**

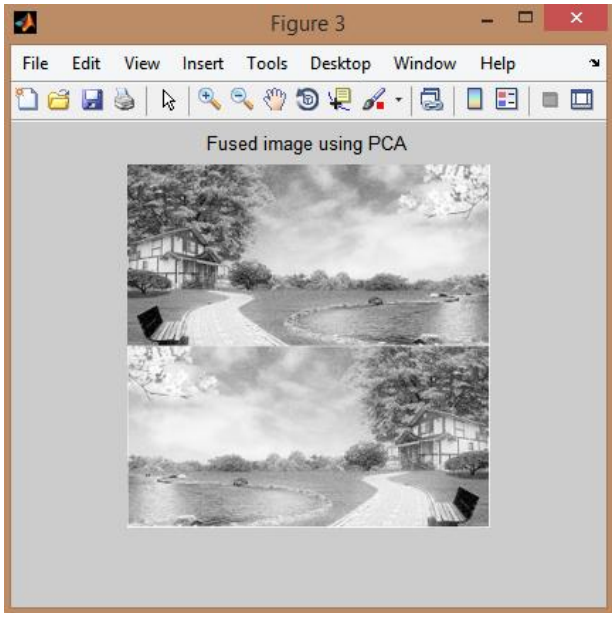



**Figure 3. Fused image by PCA**

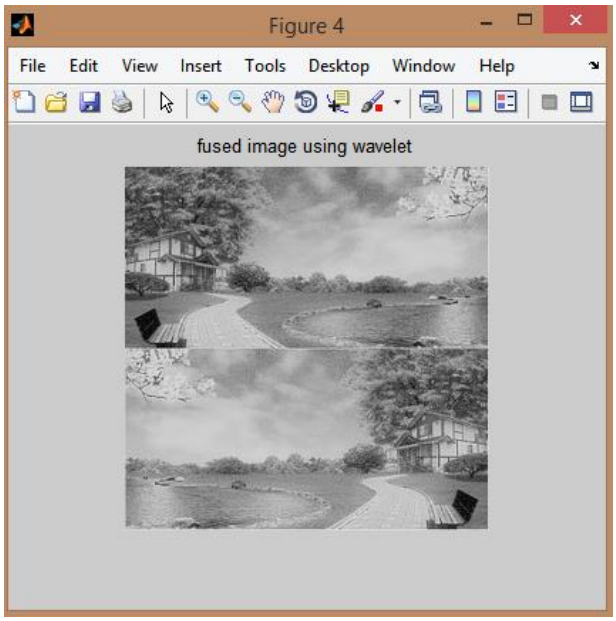



**Figure 4. Fused image by Wavelet transform**

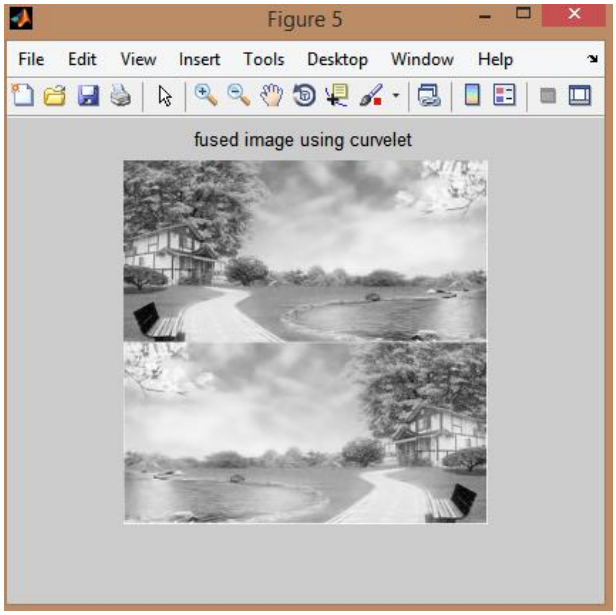



**Figure 5. Fused image by Curvelet transform**

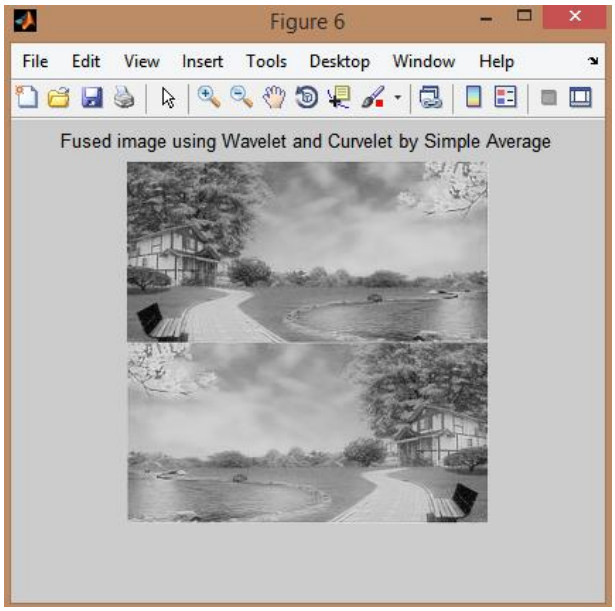



**Figure 6. Fused image by Simple average**

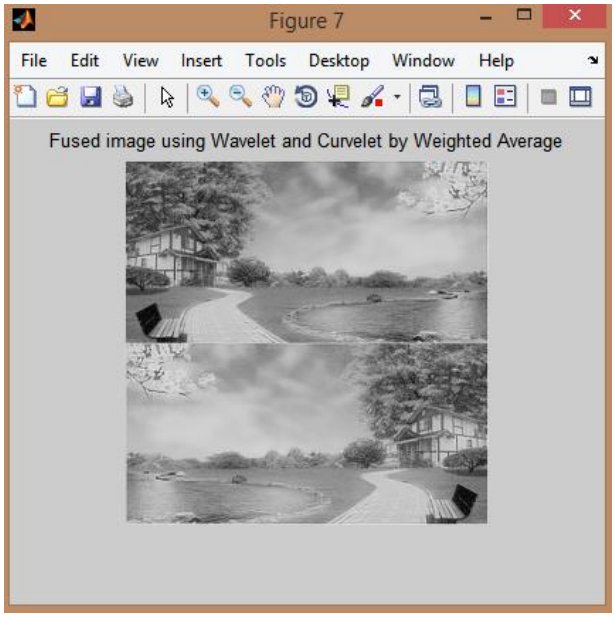



**Figure 7. Fused image by Weighted average**

**Table 1. Quantitative analysis of fusion methods**

| | **PCA** | | **Wavelet** | |
|---|---|---|---|---|
| | PSNR | MSE | PSNR | MSE |
| Image-1 and IDEAL | 64.87 | 0.021 | 64.87 | 0.021 |
| Image-2 and IDEAL | 62.20 | 0.039 | 62.20 | 0.039 |
| **Fused image and IDEAL** | **66.27** | **0.015** | **66.41** | **0.0149** |

**(a) PCA and Wavelet**

| | **Curvelet** | | **Proposed algo. Fusion of Wavelet and Curvelet Using Simple Average** | | **Proposed algo. Fusion of Wavelet and Curvelet Using Weighted Average** | |
|---|---|---|---|---|---|---|
| | PSNR | MSE | PSNR | MSE | PSNR | MSE |
| Image-1 and IDEAL | 64.87 | 0.021 | 64.87 | 0.021 | 64.87 | 0.021 |
| Image-2 and IDEAL | 62.20 | 0.039 | 62.20 | 0.039 | 62.20 | 0.039 |
| **Fused image and IDEAL** | **66.23** | **0.015** | **62.84** | **0.010** | **72.38** | **0.0075** |

**(b) Curvelet and Proposed methods**

## V. CONCLUSION

With the help of experimental results on multi focus images, we have proved that instead of simple Curvelet based image fusion, a weighted average fusion using Curvelet will enhanced the PSNR and reduce the MSE compared to all other methods

## VI. FUTURE SCOPE

In future, the proposed algorithm can be implemented using more robust average fusion method.The robustness of proposed algorithm can be improved by having efficient method for determining the weights using statistical approach.

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