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A Brief Review of Different Image Fusion Algorithm

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Abstract: ***Image fusion is a strategy that combine complimentary details from two or more input image such that the new image gives more information and more suitable for the motivation behind human visual system. This paper presents a survey on a percentage of the image fusion technique (simple average, simple minimum, simple maxima, PCA, DWT). Comparative examination of the considerable number of systems closes the better approach for its future exploration.***

Keywords: Image Fusion, Discrete Wavelet Transform (DWT), DTCWT, Averaging, Minima, Maxima, Principal Component Analysis (PCA).

1. Introduction

Image Fusion is a procedure of merging the required image information from two or more images of the same scene or background into a single picture and the resultant fused picture will be more informational and complete than any of the input images, which was taken for fusion. Processing image could be multi sensor, multimodal, multifocal or multi passing. There are some basic necessities for the image fusion process [1]:

1) All the relevant information must be present in the final fused image.
2) Image fusion process should not take any wrong artifacts for their fusion algorithm. If it is so, it may lead wrong fusion.

Image registration is one of the critical preprocessing steps for the image fusion. Image registration is the process of changing different set of information into one coordinate system. Image fusion discover application in the field of navigation, object & character detection and recognition, medical diagnosis, satellite imaging for remote sensing and military, etc. Image fusion algorithm can be arranged into diverse levels: pixel, feature, and decision levels. Pixel level fusion meets expectations specifically on the pixels of source pictures while feature level fusion methodology work on feature extracted from the source pictures.

2. Image Fusion Algorithm

There are basically two methods of image fusion:
1. Spatial domain fusion method
2. Transform domain fusion method

In spatial domain fusion method we directly deal with pixel value of input image. Methods used for image fusion in spatial domains are:
a) Simple Maximum
b) Simple Minimum
c) Averaging
d) Principle component analysis (PCA)

In transform domain, a fixed step is followed before applying any type of algorithm for fusion i.e. conversion of input image into frequency domain. Basically two type of method are come unde transform domain is:
a) DWT
b) DTCWT

1. **Simple Maximum Method:** Two or more input image is compared pixel by pixel in this method. Maximum pixel is selected for the construction of new fused image. Mathematical representation of this method is explained below:
   $\mathbf{Y(i,j)}=\sum_{\substack{0\le i\le m\\ 0<j<n}} \boldsymbol{max}(\boldsymbol{P(i,j)}\,\boldsymbol{Q(i,j)})$
   Where P(i,j) and Q(i,j) are the input image and Y(i,j) is the output fused image.
2. **Simple Minimum Method:** In this system, the resultant fused image is reconstructed by selecting the minimum pixel intensity of comparing pixels from both the input image.
   $\mathbf{Y(i,j)}=\sum_{\substack{0\le i\le m\\ 0<j<n}} \boldsymbol{min}(\boldsymbol{P(i,j)}\,\boldsymbol{Q(i,j)})$
   Where P (i,j) and Q (i,j) are the input image and Y(i,j) is the output fused image.
3. **Simple Average Method:** In this technique we take the mean value of two inputs taken for fusion and replace that pixel intensity in the final fused image.
   $\mathbf{Y(i,j)}=\frac{\boldsymbol{P(i,j)+Q(i,j)}}{\mathbf{2}}$
   Where P (i,j) and Q (i,j) are the input image and Y(i,j) is the output fused image.
4. **Weighted Average Method:** In this technique we take the weighted average value of two inputs taken for fusion and replace that pixel intensity in the final fused image.
   $\mathbf{Y(i,j)}=\sum_{i=0}^{m}\ \sum_{j=0}^{n} \boldsymbol{wP(i,j)}+\ \boldsymbol{(1-w)Q(i,j)}$
   Where P (i,j) and Q (i,j) are the input image, Y(i,j) is the output fused image and w is weight factor.
5. **Principal Component Analysis (PCA) method:** Principal component analysis (PCA) is a vector space transform regularly used to reduce multidimensional information sets to lower dimension for investigation. It uncovers the internal structure of information in an

unbiased way. We give step wise depiction of how we utilized the PCA calculation for fusion.

a) Produce the column vectors, separately, from the input image matrices.
b) Figure out the co-variance matrix of the two column vectors generated in step-1
c) The slanting components of the 2x2 co-variance vector would contain the difference of every section vector with itself, individually.
d) Figure the Eigen values and the Eigen vectors of the co-variance lattice
e) Standardize the segment vector comparing to the bigger Eigen esteem by isolating every component with mean of the Eigen vector.
f) The estimations of the standardized Eigen vector go about as the weight values which are separately increased with every pixel of the information pictures.
g) Whole of the two scaled networks computed in 6 will be the combined picture network. Flow diagram of PCA method is explained in figure 1.

6. **DWT:** Multi-resolution images are decomposed by Wavelet transforms tool that give various channels representing of image features by diverse frequency sub-bands at multi-scale. It is an acclaimed method in breaking down signals. Signal analysis is frequently done by wavelet transform method. At the point when decomposition is performed, the estimate and subtle element part can be isolated 2-D Discrete Wavelet Transform (DWT) changes over the image from the spatial domain to frequency domain. The image is isolated by vertical and horizontal lines and represent to the initially request of DWT, and the image can be divided in four sections those are LL1, LH1, HL1 and HH1.

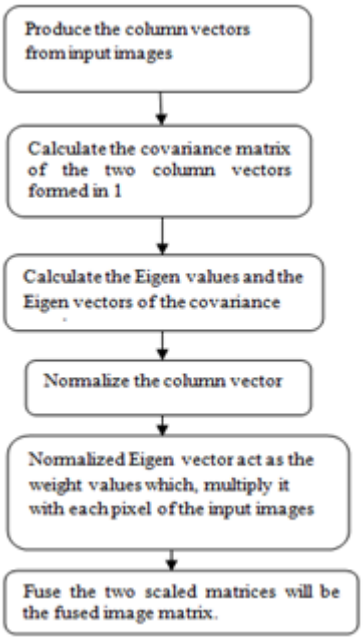

Figure 1: Flow diagram of PCA method

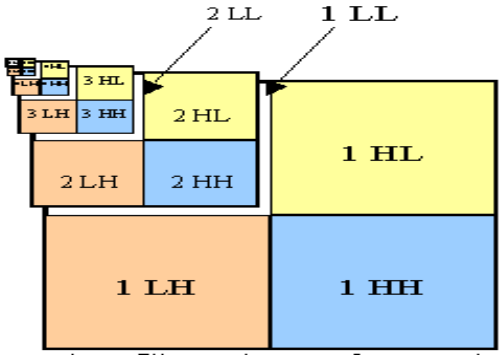

Figure 2: Wavelet Decomposition

Let s(n1,n2) is input image with size N1xN2 then scaling and wavelet function are

$$w_{\emptyset}(j0,k1,k2) = {}^{1}/_{\sqrt{N1N2}} \sum_{n1=0}^{N1-1} \sum_{n2=0}^{N2-1} s(n1,n2)\emptyset_{j0,k1,k2}(n1,n2)$$

$$w_{\epsilon}(j0,k1,k2) = {}^{1}/_{\sqrt{N1N2}} \sum_{n1=0}^{N1-1} \sum_{n2=0}^{N2-1} s(n1,n2)\in_{j0,k1,k2}(n1,n2)$$

General process of image fusion using DWT:

Step1. Implement Discrete Wavelet Transform on both the info picture to make wavelet lower decomposition.
Step2. Combine each decomposed level by utilizing distinctive fusion rules and guideline.
Step3. Apply Inverse Discrete Wavelet Transform on fused decomposed level, which intends to rebuild the image, while the picture recreated is the fused image F.

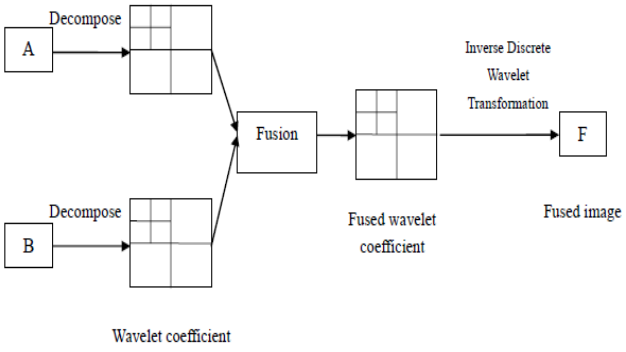

Figure 3: Wavelet Based image fusion

3. Image Quality Analysis

The evaluation measures that are utilized to assess the performance of fusion are PSNR, Mean Square Error (MSE), and Entropy.

a) Peak Signal to Noise Ratio (PSNR)

The peak signal to noise ratio frequently curtailed as PSNR, is defined as the ratio the maximum possible signal power and the tainting noise power that influences the constancy of its representation. Since numerous signals have a wide dynamic range, PSNR is typically communicated in terms of the logarithmic decibel scale (db). The PSNR is mostly utilized as a measure of quality of reconstructed image after fusion and its restoration. It can be characterized by means of the Mean Square Error (MSE). For 2d M×N monochrome imagery, the PSNR computation is given by equation (1).

$$\text{PSNR}=10log10\left(\frac{MAXi\hat{}2}{MSE}\right) \quad \ldots(1)$$

When the pixels are represented using 8 bits per sample, i.e. MAX= 255. Higher the PSNR better is the quality.

b) Mean Square Error

Mean Square Error (MSE) shows average error of the pixels all through the image. A meaning of a MSE does not show that the denoised image endures more errors rather it alludes to a more prominent distinction between the original and denoised image. This implies that there is a noteworthy noise decrease. The equation for the MSE count is given by Mathematical statement-2

$$MSE = \frac{\sum_i \sum_j \left(Y(i,j) - \hat{Y}(i,j)\right)^2}{M \times N} \quad ..(2)$$

Y represents the original image, bar y(i,j) denotes the fused image.

c) **Entropy (EN)**

Entropy is used to calculate the amount of information. Higher value of entropy indicates that the information increases and the fusion performances are improved.

$$\sum_{i=0}^{l-1} pi\log_2(p_i) \quad \ldots(3)$$

4. Conclusion

High spatial resolution can be achieved by spatial domain image fusion techniques but at the same time it also introduce blurring effect in the output image. Through Wavelet transforms technique we can get high quality spectral content. Image fusion quality can be greatly improved by Combination of DWT and PCA. But this system will be complex. To reduce the complexity and improve the image visual quality we will be using DTCWT technique for image fusion.

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