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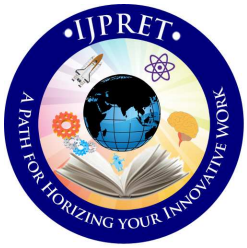

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A PATH FOR HORIZING YOUR INNOVATIVE WORK

IMAGE FUSION USING WAVELET TRANSFORM OF MULTI-FOCUSED IMAGES

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Abstract

An image fusion using wavelet transform of multi-focused images presented. Wavelet transform provide multi-resolution solution based on time scale analysis. Threshold of source image to decide whether maximum selection or weighted average method to be used for sub-images different new wavelet coefficients. Experiments give to improve visibility & resolution using inverse transform than maximum selection method, weighted average method and average method.

1. Introduction

Multi-focused images are important part in multi-sensor images for fusion. Sensors like camera can't capture all things only one picture of camera's scene. We always take numbers of picture. If fused them through some fusion methods then we get more clear and visible. It is applicable in various field as multi-focused CCD visual images, multi-spectrum and panchromatic remote sensing images and functional anatomical medical images. The approach of fusion method concentrated towards some important properties of picture such as detection, recognition and visual properties. Maximum selection, weighted average and average method such are some fusion methods which are called as common method. If we use individual method among these fusion methods then there will cause information lost and reduction in contrast. Burt's method is advantageous in some manners. Burt's method is combination of weighted average and maximum selection. In fusion researcher give attention on rules of fusion such as energy, variance, gradient, fuzzy set and wavelet transform used in common methods. Image fusion is a term which having a function combining multiple images to get more information than that of individual images can be revealed. For the remotely sensed images, some have good spectral information and the high geometric resolution. These are integrated all information from two kinds of information to one kinds of information which called as image fusion.

In this paper Burt's method based on wavelet transform multi-resolution fused by match degree and get better result than any common methods.

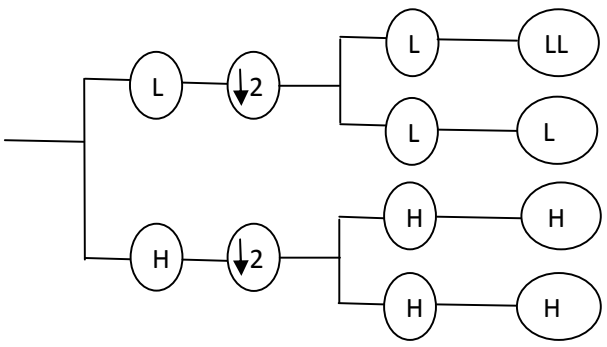
2. Wavelet Transform And Common Fusion Method

a. Wavelet transform and decomposition

Wavelet transform provides multi-resolution solution based on time scale analysis used in image fusion. Each sub-band processed at different resolution, capturing, localized time-frequency data of image to provide unique directional information useful for image representation & feature extraction across different scale. Wavelet transform involves constant

filtering & subsequent nyquist sampling. In each level we get three components of high-frequency and one of low-frequency. The source image decomposition in row and column by low pass and high pass filtering and down sampling at level LL, HH, HL, HH are coefficient components. These components are included LH (horizontal information), HH (diagonal information), HL (vertical information). LL component describes picture. These next level LL decomposition having frequency components are LH1, HH1, LH1 and HL1 respectively. The next level LL1 decomposition having frequency components are LH2, HH2, LH2 and HL2 respectively. And remaining next levels are same as above.

Source image



b. Maximum Selection, Weighted average And Average method

Maximum selection is used for approximation while square & averaging filter mask are applied to detail coefficient and combine coefficients. LL (Low pass filter to row, followed by low pass filter to column), HL (Low pass filter to row, followed by high pass filter to column), LH (high pass filter to row, followed by low pass filter to column), HH (high pass filter to row, followed by high pass filter to column).

3. Multi-resolution images to manage different image resolution. Multi-scale information can be useful in number of images processing applications including image fusion.

4. Discrete wavelet transform (DWT) allow images decomposition in different kind of coefficients preserving the image information.

5. Coefficient coming from different images can be combined to obtain new coefficient which gives information in original image is collected.

6. Once coefficients are merged then final fused image is achieved through inverse discrete wavelet transform (IDWT).

Common methods for image fusion using wavelet transform by following equations. Equation (1) & (2), (3) and (4) are used for maximum selection method, weighted average method and average method respectively.

$$D_{LH,HL,HH} = \max\left[D_{LL}^{m}(M,N), D_{LL}^{n}(M,N)\right] \quad (1)$$

$$D_{LL\_maximum} = \max\left[D_{LL}^{m}(M,N), D_{LL}^{n}(M,N)\right] \quad (2)$$

$$D_{LL\_weight} = \frac{\left[\left|D_{LL}^{m}(M,N) \times D_{LL}^{m}(M,N)\right|\right]}{\left[\left|D_{LL}^{m}(M,N) \times D_{LL}^{n}(M,N)\right|\right]} + \frac{\left[\left|D_{LL}^{m}(M,N) \times D_{LL}^{m}(M,N)\right|\right]}{\left[\left|D_{LL}^{m}(M,N) \times D_{LL}^{n}(M,N)\right|\right]} \quad (3)$$

$$D_{LL\_average} = \frac{\left[D_{LL}^{m}(M,N) \times D_{LL}^{n}(M,N)\right]}{2} \quad (4)$$

7. Burt's Fusion Method

Burt's method is combination of maximum selection with weighted average method to fuse then as per match degree. Match degree is calculated by following equation.

$$M_{d}^{k}(i,j) = \frac{2 \times E_{d,A}^{k}(i,j) \times E_{d,B}^{k}(i,j)}{\left(E_{d,A}^{k}\right)^{2}(i,j) \times \left(E_{d,B}^{k}\right)^{2}(i,j)} \quad (5)$$

Where $E_{d,A}^{k}(i,j)$ and $E_{d,B}^{k}(i,j)$ are sub-images having row i and column j with k level. And d is frequency component.

$$C_{d,F}^{k}(i,j) = \begin{cases} C_{d,A}^{k}(i,j), E_{d,A}^{k}(i,j) \geq E_{d,B}^{k}(i,j) \\ C_{d,B}^{k}(i,j), E_{d,A}^{k}(i,j) < E_{d,B}^{k}(i,j) \end{cases}$$

Where $M_{d}^{k}(i,j)$ is match degree which lower than fixed threshold in this Burt's fusion method and always select bigger region.

$$C^{k}_{d,F}(i,j)=\begin{cases} w_{\max}\times C^{k}_{d,A}(i,j)+w_{\min}\times C^{k}_{d,B}(i,j) \\ if\ E^{k}_{d,A}(i,j)\geq E^{k}_{d,B}(i,j) \\ w_{\max}\times C^{k}_{d,B}(i,j)+w_{\min}\times C^{k}_{d,A}(i,j) \\ if\ E^{k}_{d,A}(i,j)< E^{k}_{d,B}(i,j) \end{cases}$$

Where $C^{k}_{d,A}(i,j)$ and $C^{k}_{d,B}(i,j)$ are wavelet coefficient of source image A and B with fusion coefficient $C^{k}_{d,F}(i,j)$.

$$w_{\min}=\frac{1}{2}-\frac{1}{2}\times\frac{1-M^{k}_{d}(i,j)}{1-T},\ w_{\max}=1-w_{\min}$$

Where $w_{\max}$ and $w_{\min}$ are weight.

8. Experimental Results

In the following experiment shows which method is best on basis of PSNR (peak signal to noise ratio), SNR (signal noise ratio) and MSE (mean squared error). These are calculated by following equations.

$$MSE=\frac{\sum_{i-1}^{M}\sum_{j-1}^{N}\left[S(i,j)-F(i,j)\right]^{2}}{M\times N} \quad (6)$$

$$PSNR=10\log_{10}\left(\frac{255^{2}}{MSE}\right)$$

$$SNR=\frac{10\log_{10}\sum_{i-1}^{M}\left(S(i,j)^{2}\right)}{\sum_{i-1}^{M}\sum_{j-1}^{N}\left[S(i,j)-F(i,j)\right]^{2}}$$

The first experiment is multi-focused images “Statue” shown in fig.1:

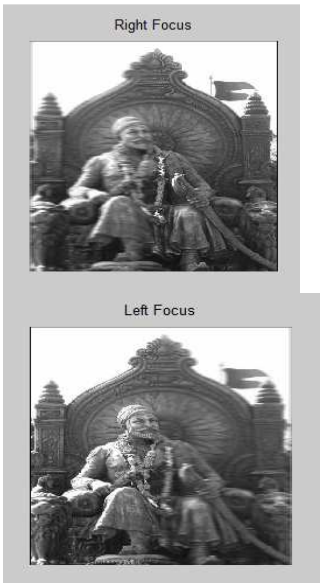
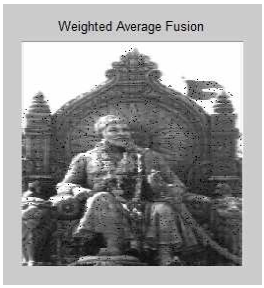


Fig.(1a) Fig.(1b)

In above fig.(1a) and fig.(1b) are right focused and left focused image which

having input respectively. Size of image filter window is 3* 3 and 1 decomposition level.



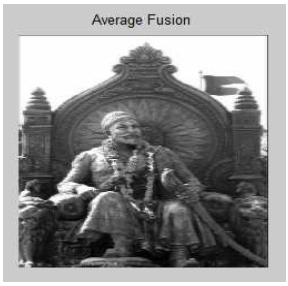


Fig.(1c) Fig.(1d)

Fig.(1e) Fig.(1f)

When fig.(1a) and fig.(1b) fused on basis common methods then we get fig.(1e) maximum selection method. The fig.(1d) average method and fig.(1c) weighted average method. Given example showing better visibility & clarity in fig.(1f) and contain much information as compare to common methods. Table (1) shows result of fused image on the basis of values of MSE, PSNR & SNR.

measurement → / figure ↓	*MSE*	*SNR*	*PSNR*
Fig.(1c)	*36.4598*	*16.8701*	*65.0253*
Fig.(1d)	*16.3631*	*23.8291*	*71.9843*
Fig.(1e)	*6.4398*	*31.9290*	*80.0842*
Fig.(1f)	*3.2250*	*37.9359*	*86.0911*

Table (1)

The second experiment is multi-focused images “Man” shown in fig.2:

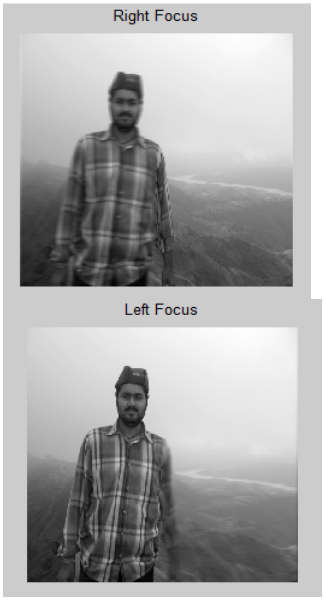


Fig.(2a)

Fig.(2b)

In above fig.(2a) and fig.(2b) are right focused and left focused image which having input respectively. Size of image filter window is 3*3 and 1 decomposition level.

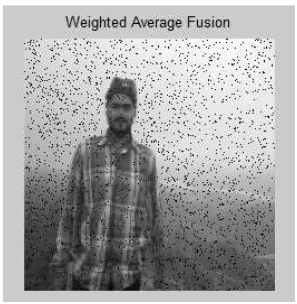


Fig.(2c)

Fig.(2d)

Fig.(2e)

Fig.(2f)

When fig.(2a) and fig.(2b) fused on basis of common methods then we get fig.(2e) maximum selection method. The fig.(2d) average method and fig.(2c) weighted average method. Given example showing better visibility & clarity in fig.(2f) and contain much information as compare to common methods. Table (2) shows result of fused image on the basis of values of MSE, PSNR & SNR.

Table (2)

measurement → / figure ↓	*MSE*	*SNR*	*PSNR*
Fig.(2c)	*22.5410*	*21.0682*	*69.2021*
Fig.(2d)	*6.7149*	*31.5869*	*79.7208*
Fig.(2e)	*1.5542*	*44.2975*	*92.4315*
Fig.(2f)	*0.9650*	*48.4366*	*96.5706*

The third experiment is multi-focused images “Wall” shown in fig.3:

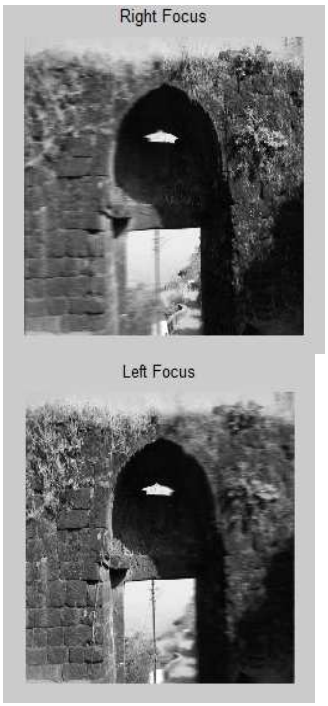
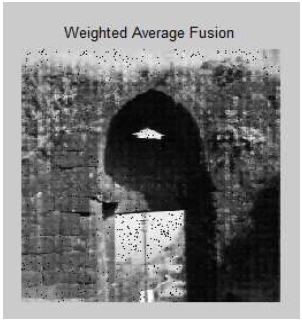


Fig.(3a)

Fig.(3b)

In above fig.(3a) and fig.(3b) are right focused and left focused image which having input respectively. Size of image filter window is 3*3 and 1 decomposition level.



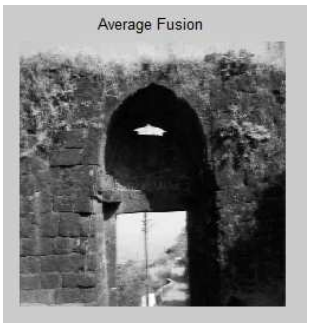
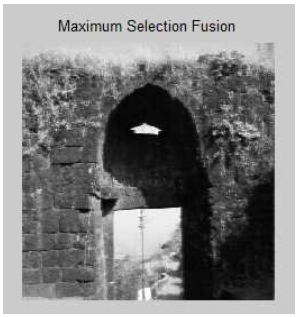


Fig.(3c) Fig.(3d)



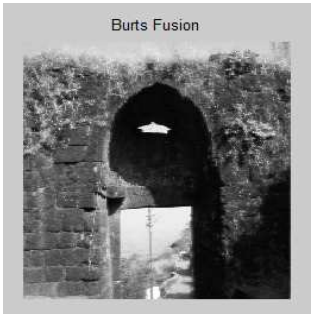


Fig.(3e) Fig.(3f)

When fig.(3a) and fig.(3b) fused on basis of common methods then we get fig.(3e) maximum selection method. The fig.(3d) average method and fig.(3c) weighted average method. Given example showing better visibility & clarity in fig.(3f) and contain much information as compare to common methods. Table (3) shows result of fused image on the basis of values of MSE, PSNR & SNR.

Table (3)

measurement → / figure ↓	*MSE*	*SNR*	*PSNR*
Fig.(3c)	*47.9770*	*13.8975*	*62.6410*
Fig.(3d)	*24.9333*	*19.5826*	*68.3260*
Fig.(3e)	*12.1182*	*25.8494*	*74.5929*
Fig.(3f)	*5.3800*	*32.9025*	*81.6460*

9. Conclusion

As an image fusion using wavelet transform of multi-focused images is presented in this paper. There is recover impurity in common fusion method by Burt's fusion method with better result on the basis of values of various error factors. In this experiment concluded that Burt's fusion method is better than common methods.

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