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COMPARISON OF EFFECT OF VARIOUS MEANS ON WAVELET COEFFICIENTS FOR IMAGE FUSION.

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Abstract—Different Wavelets are one of the efficient techniques used for fusing of two digital images. Coefficients obtained from various wavelet techniques are mathematically operated in many methods to obtain the corresponding coefficients for the fused image. In this paper, various such methods are compared using the entropy values. Higher the entropy, more information the output image holds and better the fusion method will be. Here, various mean combinations have been analyzed and best combination is predicated on the basis of entropy value.
Keywords—Image Fusion, wavelet coefficients, arithmetic mean, geometric mean, harmonic mean.

INTRODUCTION

The vision of an eye is generally classified into two of its major types. One is computer vision and the other is the human vision. The computer-based vision system usually requires a camera, its interface and a computer whereas the human visual system requires sense to act on visual-based stimuli [4]. The Image fusion refers to a process that extracts information from a set of input images and fuses it into a single and more complete image [1]. Averaging method, principal component analysis (PCA) and singular value decomposition (SVD) based techniques are some of the commonly used spatial domain techniques for image fusion [5]-[6]. In recent years, wavelet transform [2] is widely used in image fusion area because it's properties such as multi-resolution analysis, accurate reconstruction and similar to people's visual understanding. A multiresolution decomposition enables us to have a scale-invariant interpretation of the image. The scale of an image varies with the distance between the scene and the optical center of the camera. When the image scale is modified, our interpretation of the scene should not change [2]. A multiresolution representation provides a simple hierarchical framework for interpretating the image information [3]. The rest of the paper is organised as follows: Section II discusses various features and methods involved in the process of fusion of grey scale and colour images. Section III explains the work done by the author. Section IV shows the experimental data verifying the comparative analysis done on various mean methods. Section V concludes the findings of the paper.

WAVELET TRANSFORM

Wavelets can be described by two functions viz. the scaling function f (t), also known as 'father wavelet'(low pass filter) and the wavelet function or 'mother wavelet'(high pass filter) [7].

'Mother' wavelet ψ (t) undergoes translation and scaling operations to give self-similar wavelet families as

$$\Psi_{a,b}(t) = \left(\frac{1}{\sqrt{a}}\right)\Psi\left(\frac{t-b}{a}\right), (a, b \in R), a > 0 \quad [7] \qquad (1)$$

where a is the scaling parameter and b is the translation parameter.

One-dimensional Wavelet Transform

Wavelets can be realized by iteration of filters with rescaling. The resolution of the signal, which is a measure of the amount of detail information in the signal, is determined by the filtering operations, and the scale is determined by up-sampling and down-sampling. For a one-dimensional discrete signal, down-sampling means keep one sample out of two; up-sampling means put one zero between each sample [1].

The integral wavelet transform is given by

$$F(a,b)=\frac{1}{\sqrt{|a|}}\int_{-\infty}^{\infty}\Psi\left(\frac{x-b}{a}\right)f(x)dx \qquad (2)$$

Two-dimensional Wavelet Transform

The 2D algorithm is based on separate variables leading to prioritizing of x and y directions. This is done for 2D signals, considering wavelet transform of single dimensions separately.

IMAGE FUSION BASED ON MEANS OF WAVELET COEFFICIENTS

Wavelet is Interdisciplinary and implementing image denoising using wavelet transform is similar to the working of human eye. It was developed to allow some temporal or spatial information of the image. Wavelet are basically produced from one single function (basis function) called mother wavelet. The wavelet function work on an idea of using a family of functions localized in both time and frequency. It represents an image as a sum of wavelet functions with different locations and scales. Decomposition of an image into wavelets involves a high frequency waveforms containing detailed part of an image called wavelet function and low frequency waveform representing smooth part of the image called scaling function.

Using wavelet transform, image can be decomposed at various levels of resolution as wavelet decomposition has varying window size and can also be processed from low resolution to high resolution as wavelet transformation is localized both in time and frequency domains. When an image is decomposed using wavelet transform, it produces four sub images i.e. approximation details, horizontal details,verticaldetails and diagonal details in which there are two coefficients namely small coefficients andlarge coefficients. Small coefficients arises due to noise and can be thresholded without affecting the significant features of the image.

Whereas large coefficients are generated due to essential signal features. In thresholding technique or non-linear technique only one wavelet coefficient is operated at a time. In thresholding technique, each coefficient iscompared against generated threshold value. If the coefficient is smaller than threshold, then it is set to zero; otherwise it is kept or modified. After performingthresholding, inverse wavelet transform is performed to reconstruct essential image characteristics with lesser noise. When multilevel wavelet decomposition of image is performed we obtain sub bands LL2 (low frequency or approximation coefficients), HL2(horizontal details), LH2 (vertical details), HH2 (diagonal details) and the first level details HL1, LH1, HH1.

Similarly higher level decomposition is also feasible using same procedure. For fusion purpose, image selection of mother wavelet plays a dominant role. In wavelet transform family numerous types of wavelets such as Haar, Morlet, Symlet, Daubechies, etc. are available. Haar transform is the oldest and the simplesttransform. It is discontinuous in nature just like step function. Haar is used to analyse images efficiently at various resolutions. Daubechies transform is the most popular transform it has lead the foundation of wavelet based multidimensional signal processing. Whereas Morlet and Symlet transform are both symmetric in shape and has no scaling function.

Means are used to find the coefficients of output images. Various means available are arithmetic, geometric and harmonic means. All the means are known for their specific characteristics. Arithmetic mean is known for the weighted average and is used in various field such as scores, average temperatures etc. Geometric mean is known for the average without considering weights associated with the data.

The harmonic mean is also a weighted means and helps to find multiplicative or divisor relationships between fractions without worrying about common denominators [7] . Harmonic mean finds application in finance field such as estimating mean price to earning ratio in share market.

EXPERIMENT AND ANALYSIS

Input images considered are the images 'football.jpg' and 'wpeppers.jpg', both are available in MATLAB database.

Fig. 1 Input Image 1

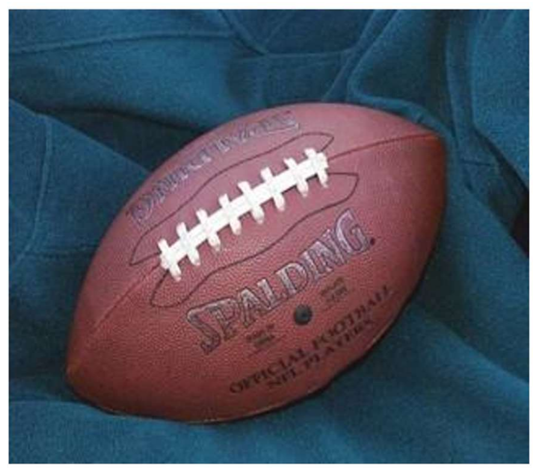

Fig. 2 Input Image 2

Considering the arithmetic (AM), geometric (GM) and harmonic mean.(HM), following combinations are possible to be applied on average coefficient matrix (ACM) horizontal coefficient matrix (HCM), vertical coefficient matrix (VCM) and diagonal coefficient matrix (DCM):

Combinations of Various Means

Wavelet Matrices	Combinations								
	1	2	3	4	5	6	7	8	9
ACM	AM	GM	HM	AM	AM	GM	GM	HM	HM

HCM	AM	GM	HM	GM	HM	HM	AM	AM	GM
VCM	AM	GM	HM	GM	HM	HM	AM	AM	GM
DCM	AM	GM	HM	GM	HM	HM	AM	AM	GM

The output images obtained are:

Fig. 3 Output Image for combination 1

Fig. 4 Output Image for combination 2

Fig. 5Output Image for combination 3

Fig. 6 Output Image for combination 4

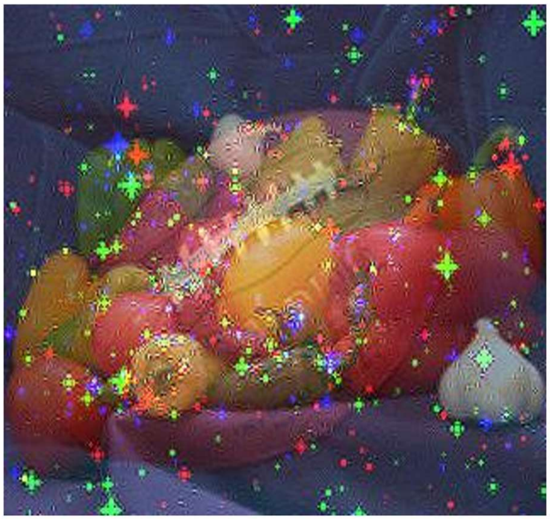

Fig. 7 Output Image for combination 5

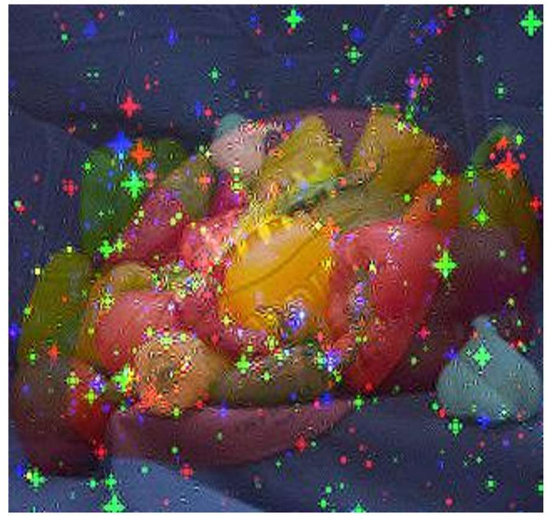

Fig.8. Output Image for combination 6

Fig. 9 Output Image for combination 7

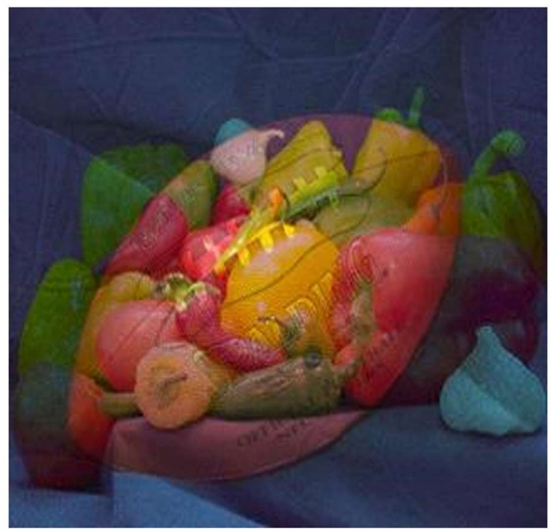

Fig. 10 Output Image for combination 8

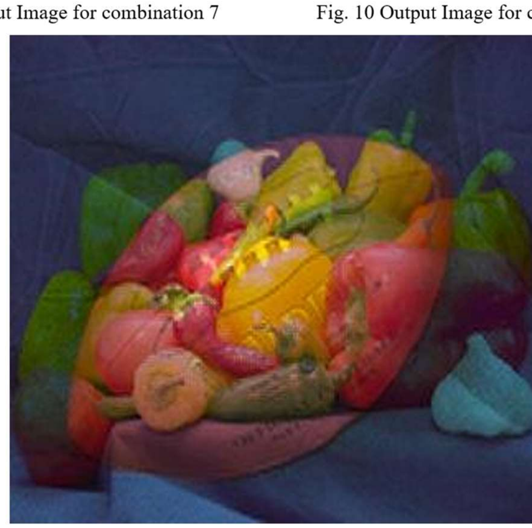

Fig. 11 Output Image for combination 9

Using these combinations, entropy value of input and output images are as shown below:

Entropy data of Input and Output Images

Combinations	Entropy (Input image 1)	Entropy (Input image 2)	Entropy (Output image 3)
1	7.1796	7.4035	7.0100
2	7.1796	7.4035	6.9935
3	7.1796	7.4035	7.1585
4	7.1796	7.4035	6.9899
5	7.1796	7.4035	7.2175
6	7.1796	7.4035	7.1913
7	7.1796	7.4035	7.0134
8	7.1796	7.4035	6.9806
9	7.1796	7.4035	6.9592

Conclusion

This paper shows the comparative analysis done in the process of combining the approximate coefficients, horizontal coefficients, vertical coefficients and diagonal coefficients using arithmetic mean, geometric mean and harmonic mean. Various combinations for the means are shown in Table 1. Using the entropy data shown in Table II, it is concluded that combination 5 (AM, HM, HM, HM) gives the output image with best entropy value.

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