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Wavelet basis Selection for Image Enhancement

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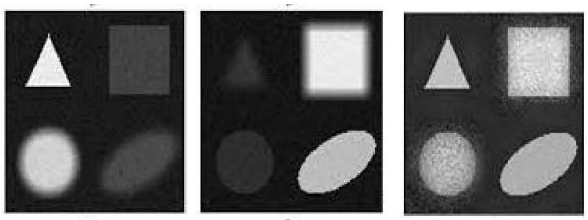
Abstract--*Image fusion is used mainly focused on image enhancement for better visualization of a scene. Multifocus noisy images are fused to achieve the enhanced image having better visual quality. The Main objective of this paper is to perform image fusion using Wavelet Transform. Haar and Biorthogonal wavelet basis is used. The performance evaluation of the fusion is done using objective assessment metrics. In blurred multifocus images edge information and contrast of an image is disturbed. Hence the quality metrics that evaluate the edge and contrast based information is of immense importance. The suitable wavelet can be selected to achieve better enhancement in terms of edge and contrast.*

Gaussian noise of different intensity can be added and fusion performance for different wavelet basis will be compared.

Index Term *- Biorthogonal wavelet, Gaussian noise,Haar wavelet, Multifocus images, Quality metrices,Image Fusion*

1. Introduction

When obtaining images of a 3-dimensional scene it is desirable to have all objects in the scene to be in focus. Cameras suffer from the problem of limited focus range or effective focus range is also known as depth of field (DOF) or shallow focus(It is the distance between the nearest and farthest objects in a picture that appear acceptably sharp in an image) and this disallows a typical imaging system to obtain such an all-in-focus image.



(a) *(b)* *(c)*

Figure 1. An example of multifocus fusion (a) left focused (b) right focused (c) Both clock faces fused by multifocus fusion.

This is major problem in inspection of microscopic scenes. In multifocus fusion, one main aim is to acquire information from different focal planes and fuse them into one image in which all objects in the scene appear to be in focus with clear visualization [1], as shown in figure 1.

2. Wavelet based Fusion for Image Enhancement

Image is corrupted by noise at the time of capturing or at the time of transmission. Image de-noising used to remove added noise and retain as much as possible most prominent features, which gives proper information related to image [2].

Wavelet transform is most important and powerful tool of signal representation. It has been used in image enhancement, data compression, and signal processing. Wavelet is basic function that is isolated with time or special frequency or wave number. Each wavelet has characteristic location and scale. A wavelet is a mathematical function used to divide a given function or continuous-time signal into different scale components. The word wavelet is due to Morlet and Grossmann in the early 1980s. They used the French word ondelette, meaning "small wave". Soon it was transferred to English by translating "onde" into "wave", giving "wavelet" [4].

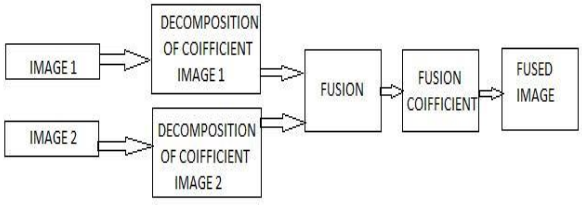


Figure 2. Fusion of image using wavelet

Wavelet provides an appropriate basis for removing noise from noisy signal. Main motivation of wavelet

transform is good at energy compaction. The small pixels or coefficient in image are due to affecting noise and significant features of image are in the large pixels or coefficients. So main aim is to remove small pixels from noisy image without affecting significant features by setting appropriate threshold value [3].

The motivation is that as the wavelet transform is good at energy compaction, the small coefficient in image are more likely due to affecting noise and large coefficient due to important signal features [5]. These small coefficients can be threshold without affecting the significant features of the image.

3. Basics of Wavelet

Wavelet-- Wavelet is complimentary method for Fourier method which is far better or easier and effective than Fourier method. [5]

$$F(x) = \sum_{n=0}^{\infty} a^n f^n(x)$$

Wavelet is mathematical tool for representing wide class of function F. Wavelet is small wave like oscillations.

Wavelet Transform – Analysis of wavelet is nothing but observing signal for small duration of time.
It transforms original signal into another form in which signal is more effective or useful or all features are clearly distinguish [5].

$$\varphi a, b(t) = \frac{1}{\sqrt{|a|}} \varphi \left(\frac{t-b}{a}\right)$$

Wavelet function is time limited or should be time limited. For given scaling parameter wavelet translation done by varying parameters.

$$W(a.b) = \int_t \frac{1}{\sqrt{|a|}} \varphi \left(\frac{t-b}{a}\right) dt$$

For every (a, b) have wavelet transform coefficient
If |a|<1 then wavelet in above equation is compressed version of original wavelet and having higher frequency.
If |a|>1 then wavelet has larger time width and corresponds to lower frequency [5].

4. Different noise types

Noise is the undesirable effects produced in the image. During image acquisition or transmission, several factors are responsible for introducing noise in the image. Depending on the type of disturbance, the noise can affect the image to different extent. Generally our focus is to remove certain kind of noise. So we identify certain kind of noise and apply different algorithms to remove the noise. Image noise can be classified as Impulse noise (Salt-and-pepper noise), Amplifier noise (Gaussian noise), Shot noise, Quantization noise (uniform noise), Film grain, on-isotropic noise, Multiplicative noise (Speckle noise) and Periodic noise.

5. Gaussian noise

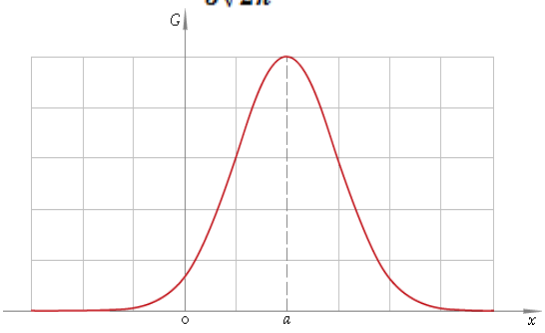
The main sources of Gaussian noise in digital images arise during capturing of image e.g. sensor noise caused by poor illumination and/or high temperature, and/or transmission e.g. electronic circuit noise. In digital image processing Gaussian noise can be reduced using a spatial filter, though when smoothing an image, an undesirable outcome may result in the blurring of fine-scaled image edges and details because they also correspond to blocked high frequencies [7].

5.1 Gaussian Blurr

Gaussian filter is windowed filter of linear class, by its nature is weighted mean. Named after famous scientist Carl Gauss because weights in the filter calculated according to Gaussian distribution the function Carl used in his works. Another name for this filter is Gaussian blur.

In image processing, a Gaussian blur (also known as Gaussian smoothing) is the result of blurring an image by a Gaussian function. Gaussian blur to an image is the same as convolving the image with a Gaussian function. Gaussian smoothing is commonly used with edge detection [8].

$$G(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-a)^2}{2\sigma^2}}$$



6. Different Wavelet Basis Selection

The wavelet transform has been increasingly applied for analyzing dynamic signal for system health monitoring in manufacturing, civil and

mechanical structure, surveillance, and medical diagnosis, selection of the base wavelet has remained largely as an *ad hoc* process (specific solution for specific problem or solution already defined for particular problem).

6.1 Levels of Fusion

Fusion process is classified into three classes as follows[10].

- Pixel fusion

Image fusion at pixel-level is the lowest processing level which generates a fused image in which each pixel is determined from a set of pixels in each original image and comprise the details on the information which other levels do not have.

- Feature fusion

Feature-level fusion the medium level fusion. In this method firstly extraction of features done from the input and fusion is done based on features that matches certain selection criteria [11]. The distinctive features are edge, shape, profile, angle, texture, similar lighting area and similar depth of focus area.

- Decision fusion

Decision-level fusion is the highest-level fusion. In this level, all decision and control are decided according to the results of decision level fusion.

6.2 Haar wavelet basis selection

The graphic distribution of the Haar wavelet spectral coefficients also was presented. Additionally, graphic presentation of spectra distribution allows us to point appropriate selection or modification (reduction) of the Haar–wavelet coefficients. It may be removed vertical, horizontal or diagonal details of a given image [11].
The Haar transform is one of the simplest Wavelet Transforms. The attracting features of the Haar transform, including fast for implementation and used in computer engineering applications, such as signal and image compression. Haar wavelet is a sequence of rescaled "square-shaped" functions which together form a wavelet family or basis [12].

Haar wavelet mother function is as follows

$$\varphi(t) = \begin{cases} 1 & 0 \le t < \frac{1}{2} \\ -1 & \frac{1}{2} \le t < 1 \\ 0 & otherwise \end{cases}$$

6.3 Bior Wavelet basis selection

DWT is implemented using two wavelets HARR & BIOR. BIOR proves to be better than HARR wavelet transform. Lifting scheme speed up the decomposition process with a comparable performance in peak signal to noise ratio (PSNR) and reconstructed image quality. BIOR gives best result with lifting scheme. This approach is suitable for the applications in which the speed is critical factor i.e. software based video conferencing and real time image compression systems [13].

7. Performance matrices for image fusion

Entropy (H)

The Entropy (H) is the measure of information content in an image. The maximum value of entropy can be produced when each gray level of the whole range has the same frequency. If entropy of fused image is higher than parent image then it indicates that the fused image contains more information.

$$H = -\sum_{g=0}^{l=1} P(g) \log_2 P(g)$$

where p(g) parent image [12].

Root Mean Square Error (RMSE)

A commonly used reference based assessment metric is the Root Mean Square Error (RMSE). The RMSE between a reference image, R, and a fused image, F, is given by the following equation

$$RMSE = \sqrt{\frac{1}{MN}\sum\sum(R(m,n) - P(m,n))2}$$

where R(m,n) and F(m,n) are the reference (CT or MR) and fused images, respectively, and M and N are image dimensions. Smaller the value of the RMSE, better the performance of the fusion algorithm [12].

Peak Signal to Noise Ratio (PSNR)

PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. The PSNR of the fusion result is defined as follows [12].

$$PSNR = 10\log(\frac{fmax^2}{RMSE^2})$$

8. Conclusion

Wavelet is used for improving the image quality using different wavelet forms. In that Haar and Biorthogonal wavelet is the basic wavelet forms. It is clear that haar is the simple wavelet form. All features we get using this wavelet but Biorthogonal wavelet is more efficient than Haar wavelet .

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