Research Paper

IMAGE FUSION BASED ON STATIONARY WAVELET TRANSFORM

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ABSTRACT

Image fusion is defined as the process of combining two or more different images into a new single image retaining important features from each image with extended information content. There are two approaches to image fusion, namely Spatial Fusion and Transform fusion. In this paper, we propose an image fusion approach based on Stationary Wavelet Transform (SWT). Stationary Wavelet Transform (SWT) is firstly applied with the original image to get the edge image information both in level 1 and level 2. Next, both edge images are fused to get a complete edge image using Spatial Frequency Measurement, which is compared with a few simple fusion Methods.

KEYWORDS: Image Fusion, Stationary Wavelets, Multiresolution.

1. INTRODUCTION

Now a day, the image fusion has become an essential sub-topic in digital image processing research area. The main objective of image fusion is to combine information from two or more source images of the same scene to obtain an image with completely information. The multi-sensor data in the field of remote sensing, medical imaging and machine vision may have multiple images of the same scene providing different information. In machine vision, due to the limited depth-of-focus of optical lenses in Charge Coupled Devices, it is not possible to have a single image that contains all the information of objects in the image. To achieve this, image fusion is required. Image fusion is defined as the process of combining two or more different images into a new single image retaining important features from each image with extended information content.

With a fusion process a unique image can be achieved containing both: high spatial resolution and color information. There are two approaches to image fusion, namely Spatial Fusion (SF) and Transform fusion (TF). In Spatial fusion, the pixel values from the source images are summed up and taken average to form the pixel of the composite image at that location. Image fusion methods based on

Multiscale Transforms (MST) are a popular choice in recent research. MST fusion uses Pyramid Transform (PT) or Discrete Wavelet Transform (DWT) for representing the source image at multi scale. PT methods construct a fused pyramid representation from the pyramid representations of the original images. The fused image is then obtained by taking an inverse PT. Due to the disadvantages of PT, which include blocking effects and lack of flexibility; approaches based on DWT have begun. DWT approach is considered and it uses area level maximum selection rule and a consistency verification step. But, DWT suffers from lack of shift invariance and poor directionality. One way to avoid these disadvantages is to use Dual Tree Complex Wavelet Transform (DTCWT), which is most expensive, computationally intensive, and approximately shift invariant. But, the un-decimated DWT, namely Stationary Wavelet Transform (SWT) is shift invariant and Wavelet Packet Transform (WPT) provides more directionality. This benefit comes from the ability of the WPT to better represent high frequency content and high frequency oscillating signals in particular. The Multi Wavelet Transform (MWT) of image signals produces a non-redundant image representation, which provides better spatial and spectral localization of image formation than DWT. This paper presents the performance of Multi-Stationary Wavelet Packet Transform in multi-focused image fusion in terms of Peak Signal to Noise Ratio (PSNR).

2. WAVELET TRANSFORM THEORY:

Wavelet transform is a multiresolution analysis that represents image variations at different scales. A Wavelet is an oscillating and attenuated function and its integrals equal to zero. The computation of wavelet transform of a 2-D image involves recursive filtering and sub-sampling. At each level, there are three detail images. We denote these detail images as LH (containing horizontal information in high frequency), HL (containing vertical information in high frequency), and HH (containing diagonal information in high frequency). The decomposition also produces one approximation image, denoted by LL, which contains the low frequency information. The wavelet transform can decompose the LL band recursively. Wavelets are finite duration oscillatory functions with zero average value. The irregularity and good localization properties make them better basis for analysis of signals with discontinuities. Wavelets can be described by using two functions viz. the scaling function f (t), also known as 'father wavelet' and the wavelet function or 'mother wavelet'. 'Mother' wavelet ψ (t) undergoes translation and scaling operations to give self similar wavelet families as follows,

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

Where a is the scale parameter and b the translation parameter.

Practical implementation of wavelet transforms requires discretisation of its translation and scale parameters by taking,

$$a=a_0^j, b=ma_0^j b_0 \;\; j,m\varepsilon Z \quad (2)$$

Thus the wavelet family can be defined as,

$$\Psi_{j,m}(t)=a_0^{-j/2}\Psi\left(a_0^{-j}t-mb_0\right) \;\; j,m\varepsilon Z \quad (3)$$

If discretisation is on a dyadic grid with a0 = 2 and b0=1 it is called standard DWT. Wavelet transformation involves constant Q filtering and subsequent Nyquist sampling as given by Fig.1. Orthogonal, regular filter bank when iterated infinitely gives orthogonal wavelet bases. The scaling function is treated as a low pass filter and the mother wavelets high pass filter in DWT implementation.

The source image is decomposed in rows and columns by low-pass (L) and high-pass (H) filtering and subsequent down sampling at each level to get approximation (LL) and detail (LH, HL and HH) coefficients.

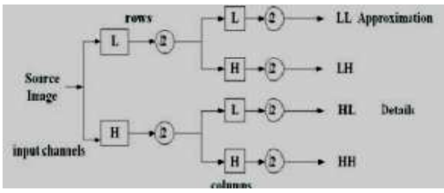


Fig1: Two-dimensional subband coding algorithm for DWT

Scaling function is associated with smooth filters or low pass filters and wavelet function with high-pass filtering

3. STATIONARY WAVELET TRANSFORM:

The Discrete Wavelet Transform is not a time-invariant transform. The way to restore the translation invariance is to average some slightly different DWT, called un-decimated DWT, to define the stationary wavelet transform (SWT). It does so by suppressing the down-sampling step of the decimated algorithm and instead up-sampling the filters by inserting zeros between the filter coefficients. Algorithms in which the filter is upsampled are called “à trous”, meaning “with holes”. As with the decimated algorithm, the filters are applied first to the rows and then to the columns. In this case, however, although the four images produced (one approximation and three detail images) are at half the resolution of the original; they are the same size as the original image. The approximation images from the undecimated algorithm are therefore represented as levels in a parallelepiped, with the spatial resolution becoming coarser at each higher level and the size remaining the same.

Stationary Wavelet Transform (SWT) is similar to Discrete Wavelet Transform (DWT) but the only process of down-sampling is suppressed that means the SWT is translation-invariant. The 2-D SWT decomposition scheme is illustrated in Figure 2.

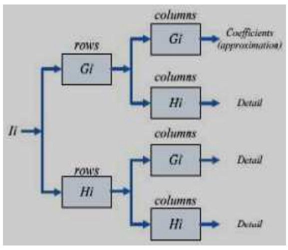


Fig.2: SWT decomposition scheme

The 2D Stationary Wavelet Transform (SWT) is based on the idea of no decimation. It applies the Discrete Wavelet Transform (DWT) and omits both down-sampling in the forward and up-sampling in the inverse transform. More precisely, it applies the transform at each point of the image and saves the detail coefficients and uses the low frequency information at each level. The Stationary Wavelet Transform decomposition scheme is illustrated in Figure 2 where Gi and Hi are a source image, low pass filter and high-pass filter, respectively. Figure 2 shows the detail results after applying SWT to an image using SWT at 1 to 4 levels.

4. ALGORITHM

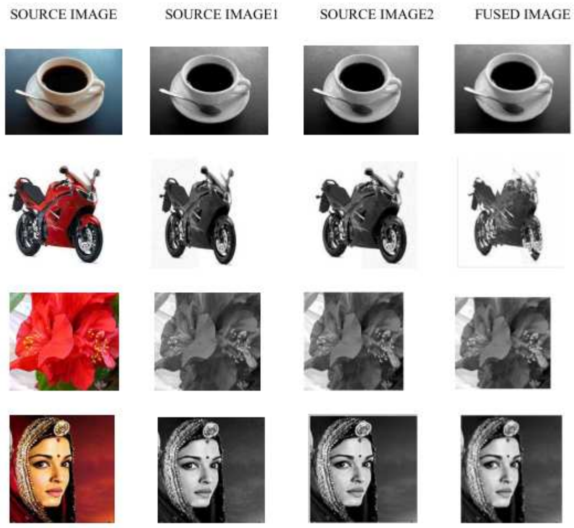
1. Decompose the two source images using SWT at one level resulting in three details subbands and one approximation subband (HL, LH, HH and LL bands).
2. Then take the average of approximate parts of images.
3. Take the absolute values of horizontal details of the image and subtract the second part of image from first.

   D = (abs (H1L2)-abs (H2L2))>=0
4. For fused horizontal part make element wise multiplication of D and horizontal detail of first image and then subtract another horizontal detail of second image multiplied by logical not of D from first.
5. Find D for vertical and diagonal parts and obtain the fused vertical and details of image.
6. Same process is repeated for fusion at first level.
7. Fused image is obtained by taking inverse stationary wavelet transform.

5. RESULTS

SOURCE IMAGES	PSNR USING WAVELETS				
	Harr	Db4	Bior1.3	Coif1	Sym2
COFFEE CUP	21.4770	21.5002	21.5949	21.4887	21.4885
BIKE	13.8652	13.9282	13.9076	13.9163	13.9151
FLOWER	10.5179	10.5247	10.5203	10.5225	10.5223
BRIDE	14.5210	14.5471	14.5404	14.5572	14.5606

6. SOURCE IMAGES USED FOR THE EXPERIMENTS



7. CONCLUSION

In this paper, a method of image fusion is proposed. It is based on the use Stationary Wavelet Transform (SWT), compared with some simple edge Detection methods. From the experiments, we evaluate the Performance results of our proposed method using the PSNR values and found that our proposed fusion method provides good results. In addition, our proposed method can be applied to other features in the noisy image source.

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