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Image enhancement using fusions by Wavelet Transform, Laplacian Pyramid and combination of both.

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Abstract-This paper represents idea of combining multiple image modalities to provide a single, enhanced image is well established different fusion methods have been proposed in literature. This paper is based on image fusion using wavelet transform, laplacian pyramid and combination of laplacian pyramid and wavelet transform method. Images of same size are used for experimentation. Images used for the experimentation are standard images and averaging filter is used of equal weights in original images to burl. Performance of image fusion technique is measured by mean square error, normalized absolute error and peak signal to noise ratio. proposed method is compared with wavelet transform method and laplacian pyramid method, from the performance analysis it has been observed that MSE is decreased in case of all three the methods where as PSNR Increased, NAE decreased in case of laplacian pyramid and Combination of laplacian pyramid and wavelet transform where as constant for wavelet transform method.

Keyword- Image fusion, Laplacian pyramid, wavelet transform, Mean Square Error, Normalized Absolute Error and Peak Signal to Noise Ratio.

I Introduction

Image fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more enhanced than any of the input images. The concept of image fusion has been used in wide variety of applications like medicine, remote sensing, machine Vision, automatic change detection, bio metrics etc. With the emergence of various image-capturing devices, it is not possible to obtain an image with all the information. Sometimes, a complete picture may not be always feasible since optical lenses of imaging sensor especially with long focal lengths, only have a limited depth of field. Image fusion helps to obtain an image with all the information. Image fusion is a concept of combining multiple images into composite products, through which more information than that of individual input images can be revealed.

II Motivation

The concept of data fusion goes back to the 1950's and 1960's with the search for practical methods of merging images from various sensors to provide a composite image which could be better identify natural and manmade objects. In the past decade, medical imaging, night vision, military and civilian avionics, autonomous vehicle navigation, remote sensing, concealed weapons detection and various security and surveillance systems are only some of the applications that have benefited from such multi sensor arrays [3]. Motivation for image fusion is mainly the step toward recent technological advances in the fields of image fusion technique method. Improved quality and increased resolution of modern imaging sensors and, more significantly, availability at a lower cost, have made the use of multiple sensors common in a range of imaging applications [4].implemented image fusion technique can take comparative analysis laplacian pyramid, wavelet transform and combination of two method [9].GUI of these implemented combination method can done using GUI tools [10].

III Image fusion techniques theory

This technique of image fusion having two input images and these two images used for combination of laplacian pyramid and wavelet transform based image fusion. From this method of image fusion we get a single image which has better quality than previous two input images. Single image after fusion of two images get the more enhanced than two input images.

A) Image fusion by using dwt

The wavelet transform decomposes the image into low-high, high-low, high-high spatial frequency bands at different scales and the low-low band at the coarsest scale. The L-L band contains the average image information whereas the other bands contain directional information due to spatial orientation. Higher absolute values of wavelet coefficients in the high bands correspond to salient features such as edges or lines [7]. First the images are transformed to the wavelet domain with the function dwt2.m*;* the dwt2 command performs single-level two-dimensional wavelet decomposition with respect to either a particular (‘wname’,’type’) or particular wavelet decomposition filters (Lo-D and Hi-D) show in fig.1

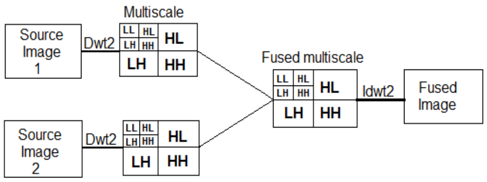


Figure.1 schematic of wavelet based fusion

The DWT is applied to both images and a decomposition of each original image is achieved. This is represented in the multi scale illustration where different bars (horizontal, vertical, diagonal and none) represent also different coefficients. The different boxes, associated to each decomposition level, are coefficients corresponding to the same image spatial representation in each original image, i.e. the same pixel or pixels positions in the original images. Only coefficients of the same level and representation are to be fused, so that the fused multi scale coefficients can be obtained [5]. This is displayed in the diagonal details where the curved arrows indicate that both coefficients are merged to obtain the new fused multi scale coefficients. This is applicable to the remainder coefficients. Once the fused multi scale is obtained, through the IDWT, the final fused image is achieved [6].

B) Image fusion by using Laplacian Pyramid

The image pyramid is a data structure designed to support efficient scaled convolution through reduced image representation. It consists of a sequence of copies of an original image in which both sample density and resolution are decreased in regular steps. These reduced resolution levels of the pyramid are themselves obtained through a highly efficient iterative algorithm. The bottom, or zero level of the pyramid, A_0, is equal to the original image [2].This is low pass- filtered and sub sampled by a factor of two to obtain the next pyramid level, A_1. A_1 is then filtered in the same way and sub sampled to obtain A_2. Further repetitions of the filter/subsample steps generate the remaining pyramid levels. To be precise, the levels of the pyramid are obtained iteratively as follows.

For $0 < l < N$:

$$Al(i,j) \sum \sum w(m,n) Al - 1(2i + m, 2j + n)$$
(1)

However, it is convenient to refer to this process as a standard DECREASE operation, and is given by A_l = DECREASE [A_l-1].We call the weighting function w (m, n) in equation 1 as the "generating kernel." For reasons of computational efficiency this should be small and separable. A five-tap filter was used to generate the Gaussian pyramid in Figure.2. Pyramid construction is equivalent to convolving the original image with a set of Gaussian-like weighting functions. The convolution acts as a low pass filter with the band limit reduced correspondingly by one octave with each level. Because of this resemblance to the Gaussian density function we refer to the pyramid of low pass images as the "Gaussian pyramid."

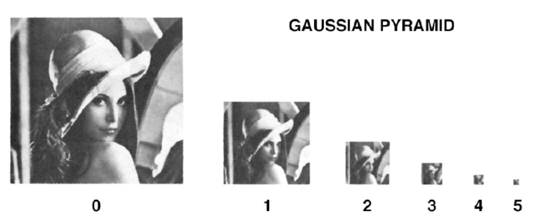


Fig.2First six levels of the Gaussian pyramid for the "Lady" image. [11]

The original image, level 0, measures 256 by 256 pixels and each higher level array is roughly half the dimensions of its predecessor. Thus, level 5 measures just 8 by 8 pixels [11].Band pass, rather than low pass, images are required for many purposes. These may be obtained by subtracting each Gaussian (low pass) pyramid level from the next lower level in the pyramid. Because these levels differ in their sample density it is necessary to interpolate new sample values between those in a given level before that level is subtracted from the next-lower level. Interpolation can be achieved by reversing the DECREASE process. We call this an INCREASE operation. Let $A_{l,k}$ be the image obtained by Increasing $A_{l,}$ k times.

Then

$A_{l,k}$ = INCREASE [A $A_{l,k-1}$]

Or, to be precise,

$A_{l,0} = A_l$, and for k>0,

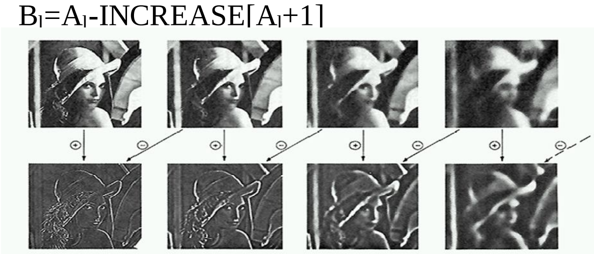
$$A(l,k)(i,k) = 4\sum_m \sum_n A(l,k-1)(2i + \frac{m}{2}, 2j + \frac{n}{2})$$

(2)

Here in equation 2 only terms for which (2i+m)/2 and (2j+n)/2 are integers contribute to the sum. The INCREASE operation doubles the size of the image with each iteration, so that $A_{l,1}$, is the size of $A_{l,1}$ and $A_{l,1}$ is the same size as that of the original image.

The levels of the band pass pyramid, B_0, B_1... B_n may now be specified in terms of the low pass pyramid levels as follows:

B_l=A_l-INCREASE[A_l+1]



The first four levels are shown in Figure.3 Just as the value of each node in the Gaussian pyramid could have been obtained directly by convolving a Gaussian like equivalent weighting function with the original image, each value of this band pass pyramid could be obtained by convolving a difference of two Gaussians with the original image. These functions closely resemble the laplacian operators commonly used in image processing for this reason we refer to the band pass pyramid as a "Laplacian pyramid."An important property of the laplacian pyramid is that it is a complete image representation: the steps used to construct the pyramid may be reversed to recover the original image exactly. The top pyramid level, B_n, is first expanded and added to Bn-1 to form A_{n-1} then this array is expanded and added to B_n-2 to recover A_n-2.

c) Image fusion using combination of laplacian pyramid and wavelet transform.

The idea is perform pyramid decomposition on both input images. Using pyramid these reduced resolution levels of the pyramid are themselves obtained through a highly efficient iterative algorithm. The bottom, or zero level of the pyramid, G_0, is equal to the original image [2].This is low pass- filtered and sub sampled by a factor of two to obtain the next pyramid level, This is low pass- filtered and sub sampled by a factor of two to obtain. Obtained sub sampled images next apply DWT2 on these two low pass images. The images are transformed to the wavelet domain with the function dwt2.m*;* the dwt2 command performs single-level two-dimensional wavelet decomposition with respect to either a particular ('wname','type') or particular wavelet decomposition filters (Lo-D and Hi-D). The DWT is applied to both images and a decomposition of each original image is achieved. This is represented in the multi scale illustration where different bars horizontal (LH), vertical (HL), diagonal (HH) and (none) represent also different coefficients. The different boxes, associated to each decomposition level, are coefficients corresponding to the same image spatial representation in each original image, i.e. the same pixel or pixels positions in the original images. Only coefficients of the same level and representation are to be fused, so that the fused multi scale coefficients can be obtained

[5]. This is displayed in the diagonal details where the curved arrows indicate that both coefficients are merged to obtain the new fused multi scale coefficients. This is applicable to the remainder coefficients. Once the fused multi scale is obtained, through the IDWT, the fused image is achieved [6].Expand the fused image using pyramid syntax using up sampling get input size equal final fused image structure of proposed model show in figure4.

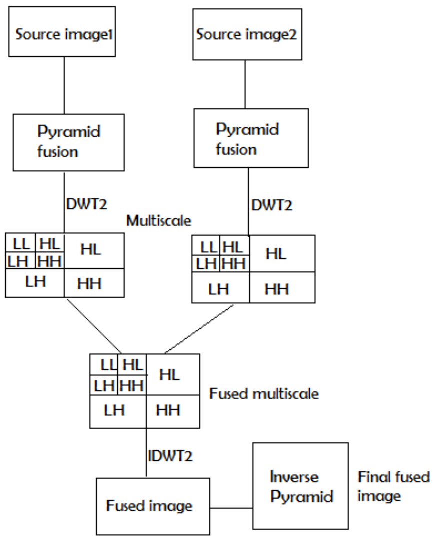


Figure4.Schematic structure of proposed combination method

IV. Experimental result and discussion

a) Implementation for wavelet transforms.

The discrete wavelets transform (DWT) allows the image decomposition in different kinds of coefficients preserving the image information [5].Such coefficients coming from different images can be appropriately combined to obtain new coefficients, so That the information in the original images is collected appropriately

Once the coefficients are merged, the final fused image is achieved through the inverse discrete wavelets transform (IDWT), where the information in the merged coefficients is also preserved [1].The key step in image fusion based on wavelets is that of coefficients combination, namely, the process of merge the coefficients in an appropriate way in order to obtain the best quality in the fused image. This can be achieved by a set of strategies. The most simple is to take the average of the coefficients to be merged [6].filter used in wavelet is db1

b) Implementation for laplacian pyramid.

Implemented laplacian pyramid fusion first construct the laplacian pyramid of two input images to be fused. Take the average of the two pyramids corresponding to each level and sum them. The resulting image is simple average of two low resolution images at each level. Decoding of an image is done by expanding, then summing all the levels of the fused pyramid which is obtained by simple averaging. A more efficient procedure is to expand B_n once and add it to B_n – 1, then expand this image once and add it to B_n – 2, and so on until level 0 is reached and g_0 is recovered. This procedure simply reverses the steps in Laplacian pyramid generation. The input arguments of this function are: Source images (im1, im2): must have the same size, and are supposed to be same size example both image of (m*n) matrix size. Number of scales (ns): an integer that defines the number of pyramid decomposition levels. The reduce operation is a two-dimensional convolution with the Gaussian filter followed by a down sampling by two. Expand, as the opposite operation of reduce, performs an up sampling by two followed by a two dimensional convolution with the same Gaussian filter [8]. Steps followed for fusion is given below table I.

Table I, steps for Laplacian pyramid fusion

a1l = reduce (image1) , a2l = reduce (image2)
a1l-1 = expand (a1l) , a2l-1 = expand (a2l)
B1 = image1 – a1l-1 , B2 = image2 – a2l-1
B = maximum (B1, B2)
Last level of the pyramid,fusion1 = average (a1l, a2l)

Reconstruct fusion image, Fusion = expand (fusion1) + B

c) Implementation for combination method.

The input arguments of this function are: Source images (im1, im2): must have the same size, and are supposed to be same size example both image of (m*n) matrix size. Number of scales (ns): an integer that defines the number of pyramid decomposition levels. The reduce operation is a two-dimensional convolution with the Gaussian filter followed by a down sampling by two [11]. The discrete wavelets transform (DWT) allows the image decomposition in different kinds of coefficients preserving the image information [5].Such coefficients coming from different images can be appropriately combined to obtain new coefficients, so That the information in the original images is collected appropriately

Once the coefficients are merged, the final fused image is achieved through the inverse discrete wavelets transform (IDWT) [1]. Expand, as the opposite operation of reduce, performs an up sampling by two followed by a two dimensional convolution with the same Gaussian filter and get the final fused image.

b) Performance analysis

Three performance metrics were used during experimentation to evaluate the efficiency of the proposed algorithm. The proposed algorithm was tested with two pairs of images (Figure5), images used for experimentation is standard gray scale images. Averaging filter of (5, 5) of equal weights are used to burl the input images to find out enhancement with the performance metrics. Performance analysis of the original images and fused image can be identifying by these three measures Peak Signal to Noise Ratio (Table II), Mean Square Error (Table III) and Normalized Absolute Error (Table IV). These parameter are compare with wavelet transform and laplacian pyramid based fusion method and combination of wavelet transform and laplacian pyramid based fusion show in the tables below all three parameter compare with three image methods by wavelet transform method, laplacian pyramid method and combination of wavelet transform and laplacian pyramid method.

Name	Image A	Image B
rice.png (256*256)	 Input image	 Fused image
cameraman .tif (256*256)	 Input image	 Fused image

Figure 5.Tested images

Table II. Peak Signal to Noise Ratio of fused image

Image	Rice.png	Cameraman.tif
Input image	17.8706	18.869
Wavelet Transform	19.8132	20.0654
Laplacian Pyramid	24.4916	23.6317
Proposed method	23.9209	23.0832

Table III. Mean Square Error of fused image

Image	Rice.png	Cameraman.tif
Input image	1.0701e+03	851.17
Wavelet Transform	684.1625	645.567

Laplacian Pyramid	232.9831	283.9938
Proposed method	265.6970	0.1348

Table IV. Normalized Absolute Error of fused image

Image	Rice.png	Cameraman.tif
Input image	0.2498	0.2501
Wavelet Transform	0.2501	0.2501
Laplacian Pyramid	0.1310	0.1298
Proposed method	0.1351	0.1348

V Conclusion

The proposed method is combination of wavelet transform and Laplacian pyramid. It is reliable image fusion method. Image enhancement is realized by observing three parameters mean square error, normalized absolute error and peak signal to noise ratio. the proposed method provides increasing peak signal to noise ratio and decreasing mean square error and normalized absolute error comparing individually with wavelet transform method and Laplacian pyramid method. From this performance analysis parameter implemented method is good. Image fusion using combination wavelet transform and laplacian pyramid has been simulated using MATLAB software.

REFERENCES

[1] Gonzalo Pajares, Jesus Manuel De Lacruz "A wavelet – based image fusion tutorial" the journal of the pattern recognition society, pattern recognition 37(2004)

[2] Qiang Zhang, Long Wang, Huijuan Li Zhaokun Ma " Similarity-based multi modality image fusion with shiftable complex directional pyramid" pattern recognition letters 32(2011)1544-1553

[3] V. Aslantas , R.kurban "Fusion of multi- focus images using differential evolution algorithm" expert system application 37(2010)8861-8870.

[4] Anjali Malviya, S.G.Bhirud "Image fusion of digital image" International journal of recent trends in engineering, vol.2, no.3, November 2009

[5] Krishta Amoliny,Yun Zang, Peter Dare "Wavelet based image fusion techniques an introduction review and comparison" department of geology and geometrics engineering,universityofnewBrunswick ,sciencedirect.com(12 July 2002 available) .

[6] Jing Tain, Lichen "Adaptive multi-focus image fusion a wavelet-based statistical sharpness measure" school of computer and technology, Wuhan University of science, chaina.sciencedirect.com (8 Jan 2012).

[7] Shutao Li, Bin Yang "Multi-focus image fusion by combining curvelet and wavelet transform" pattern recognition letters 29(2008) 1295-1307

[8] Se-hwan.yun, Jin Heon Kim and Suki Kim, Senior member ieee "Image enhancement using a fusion framework of histogram equalization and laplacin pyramid" contributed paper electronic version published 0098 3663/10/ 2010 IEEE

[9] Zhigun Wang, Djemel Ziou, Costas Armenakis , Derenli and Aingaum Li " A comparative analysis of image fusion methods" IEEE transaction on geosciences and remote sensing ,vol 43 ,no 6,June 2005.

[10] Daniel Muller, Anthomy Maeder and Peter O'shere "The graphical image fusion toolkit" GIFTMICCAI-2006 open science workshop, sciencedirect.com (June 2006).

[11] Peter J. Burt and Edward H.Adelson" The Laplacian Pyramid as a Compact Image Code" IEEE Transactions on

Communications, Vol. Com-3l, No. 4,
Pages 532-540, April 1983