International Journal on Emerging Technologies 11(4): 104-107(2020)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

Fusion of Images using BCV and DWT

Shaik Shaheala Banu[1], Ch. Hima Bindu[2], M. Kranthi[3] and K. Jamal[4]
[1]PG Scholar, Department of ECE, QIS College of Engineering and Technology, Ongole (Andhra Pradesh) India.
[2] Professor, Department of ECE, QIS College of Engineering and Technology (Andhra Pradesh) India.
[3]Assistant Professor, Department of ECE, PACE (Andhra Pradesh) India.
[4]Assistant Professor, Department of ECE, GRIET, Hyderabad (Telangana), India.

(Corresponding author: Ch. Hima Bindu)
(Received 24 April 2020, Revised 09 June 2020, Accepted 13 June 2020)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Image Fusion has gained attention in the sphere of Image Processing. This paper addresses the fusion of images using Discrete Wavelet Transforms and BCV. Discrete Wavelet Transform is applied to obtain the image with multi-resolution representation which is localized in both spatial and frequency domains. In the next stage, we employ the BCV technique to extract the details of pixels of source image. In the extraction of sharp details of pixels of the frequency bands of source images, we employ the BCV technique. In the meanwhile, Averaging Filtering is done for improving the contrast of the fused image. Fusion of images with proper consistence of block information without loss of individual image details is always a big task. Finally, the fused result is developed by constructing inverse DWT to the resultant frequency bands. By comparing, the experimental results such that the proposed method is superior.

Keywords: Discrete Wavelet Transform, Block Consistency Verification, Inverse Discrete Wavelet Transform

Abbreviations: DWT, Discrete Wavelet Transform, IDWT, Inverse Discrete Wavelet Transform, BCV, Block Consistency Verification, MRI, Magnetic Resonance Imaging, CT, Computed Tomography, PET, Positron Emission Tomography, SPECT, Single-Photon Emission Computerized Tomography, NSML, New Multiscale Sum Modified Transform.

I. INTRODUCTION

An image is a representation of two-dimensional functions. Processing the image with the help of a computer is generally named as digital image processing. Image Fusion is nothing but a gathering of important and relevant information of multi images into one single image and the large information is in the resultant image than the previous one. Nowadays Image Fusion is having wide applications such as remote sensing, computer vision, medical imaging, robotics and medical imaging [4, 11]. Fusion Categories are of five types namely Multi view, Multi-time, Multimodal, Multi focus and Fusion for Image Restoration [4]. Here, we discussed multimodal medical images captured with various scanners MRI scan, CT scan, PET scan, and SPECT scan. Here the CT images give information about hard tissues of bones and MRI Images gives us knowledge on soft tissues of the brain. But we don't gain complete information. So, applying the fusion process to the images had complete knowledge about brain [5]. Fusion Techniques are classified based on the processing and acquisition of the image. They are Pixel-level, Block-level, Feature level and decision level [8]. F. Zhou *et al.,* [1] implemented image fusion on Multifocus images using the techniques such as fast guided filter and focus pixel detection. For getting fused results, many techniques have been implemented such as NSML, BCV filter in the decision map learning stage and ND filter in the fusion stage. Here focus pixels are detected from source image using the NSML technique directly. Guided Filter is used for edge filtering and it is easy to implement and visual quality is better than that of the Bilateral Filter. But obtained fused result is not fulfilling the requirements. So opted advanced transform techniques for getting better results. Shifali M Patil [5] apply DWT for the fusion of images. For required fused results, the evolved high-frequency components will undergo gradient and smoothness techniques to protect the edges and area of uniformness in the fused image.

"The current challenges in the fusion process restoring the high quality data in the resultant image. The basic standard techniques with DWT and averaging can't maintain the proper consistency in data handling. This is the major challenge to address in current scenarios."

The paper is organized in three subsections, Section II & III discussed the preliminaries of the work i.e., DWT, BCV; section IV discussed the proposed work; section V framed the results and performance measures. The conclusion is presented in section VI.

II. DISCRETE WAVELET TRANSFORM

The method in which an image is filtered in different scales by a series of digital filters is called Discrete Wavelet Transform. The resolution of an image is changed by performing scaling operation by the process of subsampling. Convolution-based process or lifting-based process is used for computing DWT [3]. Input sequences in these methods are decomposed into low & high-frequency sub-bands with half the elements [9]. DWT is used to overcome the temporal resolution in Fourier Transform capturing both frequency and information [6]. Finite duration oscillatory functions with zero average values are called Wavelets. Any wavelet transforms for which the wavelets are discretely sampled is called Discrete Wavelet Transform.

We can implement the Discrete Wavelet Transform using filter bank and lifting scheme. Sub-band coding is nothing but subdividing the input signal into several frequency groups. This is possible with the filter bank. It is a set of filters, which have either a common input or common output. The bank of filters distributes equally in the domain sub-bands [7, 13].

The two-channel filter bank consists of 2 sections namely analysis section and synthesis section. Here the functionality of Analysis section is to decompose the signal into a set of sub-band components and synthesis section is to reconstruct/ regain the signal from its components [7]. Analysis filter bank divides the signal into two equal frequency bands i.e., $Ho[z]$and$H_1[z]$ acts as low-pass filters and high-pass filters respectively.

$\{X[Z].H_0[Z]$ (1)

$\{X[Z].H_1[Z]$ (2)

Now the signal is sampled with high frequency then the half of the samples are eliminated due to down sampling operation. After employing the decimation process, apply Z-transform.

$Y[z]$=1/2$\{X[z^{1/2}].H_0[z^{1/2}]+X[-z^{1/2}].H_0[-z^{1/2}]\}$ (3)

$Y[z]$= 1/2$\{X[z^{1/2}].H_1[z^{1/2}]+X[-z^{1/2}].H_1[-z^{1/2}]\}$ (4)

Synthesis filter bank reconstructs the signal from the two filtered and decimated signals. In this filter, we employ interpolation.

$X[z]$= 1/2$\{x[z].Ho[z]+X[-z].Ho[-z]\}$ (5)

$X[z]$= 1/2$\{x[z].H_1[z]+X[-z].H_1[-z]\}$ (6)

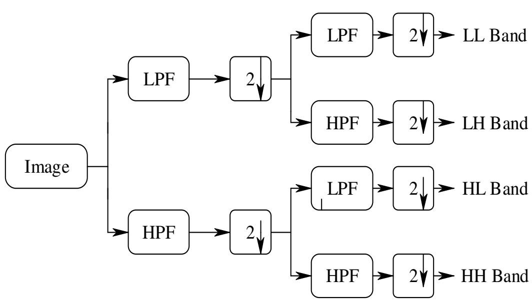

Fig. 1. DWT Representation.

III. BLOCK CONSISTENCY VERIFICATION

The Block Consistency process can be done with a block-by-block comparison of the image coefficients. Initially find the block-by-block sum of the image coefficients [1]. The maximum value of the block sum of the respective image is compared and the resultant image is going to replace the high sum value of the block. The mathematical representation of the image is shown below.

Consider two images $f_1(x,y)$and$f_2(x,y)$.

$f_1(x,y)$= $Concat_{b=1}^{\frac{M\times N}{m\times n}}(f_{1b}(x,y))$ (7)

$f_2(x,y)$= $Concat_{b=1}^{\frac{M\times N}{m\times n}}(f_{2b}(x,y))$ (8)

Where MxN presents the size of the image and mxn presents the size of the block. Where b is number blocks in the images $f_1(x,y)$and $f_2(x,y)$.

S_{1b}= $Concat_x Concat_y f_{1b}(x,y)$ (9)

S_{2b}= $Concat_x Concat_y f_{2b}(x,y)$ (10)

Where b vary from 1 to $\frac{M\times N}{m\times n}$.

$$f_{Rb}(x,y)=\begin{cases} f_{1b}(x,y) & if\ S_{1b}>S_{2b} \\ f_{2b}(x,y) & \text{else} \end{cases} \quad (11)$$

After the summation process, Apply above rule for $S_{1b}$and S_{2b}. Then the resultant image $f_{Rb}(x,y)$ contains the high coefficient values [10].

IV. PROPOSED METHOD

Firstly, consider various multi-source & multi-focus images for the fusion process. The proposed fusion algorithm is explained below and flow process is shown in Fig. 2.

Flowchart:

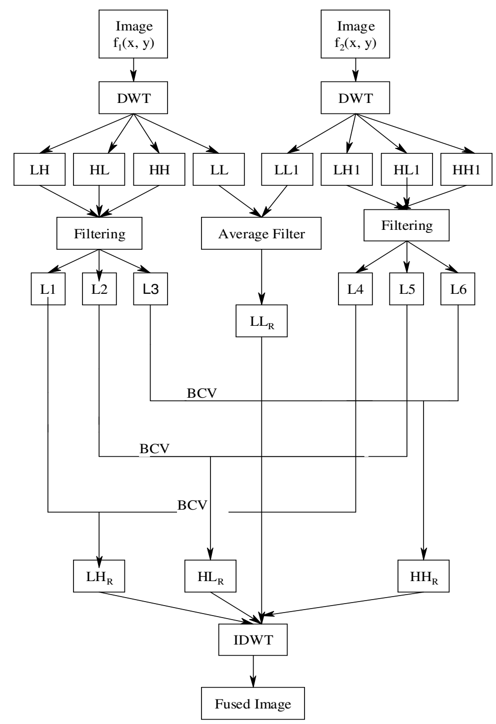

Fig. 2. Flowchart of the proposed method

(*L1, L2, L3, L4, L5, L6 – Filter Outputs

Algorithm:

Input: Multi Focus/ Multi-Model Images $f_1(x,y)$ and $f_2(x,y)$.

Step 1: The images are divided into 2 sub-bands namely low and high-frequency sub-bands sub-bands using DWT

[LL, LH, HL, HH] = DWT ($f_1(x,y)$)

[LL1, LH1, HL1, HH1]= DWT ($f_2(x,y)$) (12)

Step 2: Perform the Filtering to the sub-bands LH, HL, and HH of images $f_1(x,y)$and $f_2(x,y)$

Step 3: Perform the block consistency verification process for the above coefficients as per discussion in section IV.

Step 4: Apply the averaging filter for low-frequency bands of source images.

LL_R= (LL+LL1) / 2 (13)

Step 5: Apply IDWT to the above resultant coefficients to obtain a fused image.

Fused Image=IDWT (LL_R, LH_R, HL_R, HH_R) (14)

Step 6: The Fused image.

V. RESULTS AND DISCUSSION

MATLAB 2016b latest version is used in the evaluation of images. MRI gives information about the soft tissues such as the brain, spinal cord and detecting tumors [12]. CT gives bone information. PET gives us information about how the blood will flow in the body. The proposed work quality is compared with basic image fusion with DWT and averaging method. The results are given in Figs. 3 & 4 as input and output images. The tabulated results in Table 1 are shown in Fig. 5 as bar chars.

A. Mutual Information

A quantity in which it tells how much a random variable tells us about another. This type of measuring is called Mutual Information. It gives information about the amount of information that one variable carry about the other [2].

$$I(X;Y) = \sum_{x\in\mathcal{X}} \sum_{y\in\mathcal{Y}} P(x,y) \log \frac{P(x,y)}{P(x)P(y)}. \quad (15)$$

Where P(X) & P(Y) are Marginal distribution of X, Y respectively.

B. Peak to Signal Noise Ratio

The logarithmic [2] expression is as follows.

$$\mathrm{PSNR} = 10\log\left|\frac{255^2}{\frac{1}{MN}\sum\sum(G(m,n)-Z(m,n))^2}\right| \quad (16)$$

C. Correlation

The correlation coefficient can be calculated by

$$\mathrm{Corr} = \frac{\sum_i^M \sum_j^N (F(i,j)-\bar{F})(R(i,j)-\bar{R})}{\sqrt{\left(\sum_i^M \sum_j^N (F(i,j)-\bar{F})^2\right) \sum_i^M \sum_j^N ((R(i,j)-\bar{R})^2)}} \quad (17)$$

D. Quality Factor:

It is a measure of performance.

$$Q^{I_1 I_2/I_F} = \frac{\sum_{n=1}^N \sum_{m=1}^M \left(Q^{I_1 I_F}(n,m) W^{I_1}(n,m) + Q^{I_2 I_F}(n,m) W^{I_2}(n,m)\right)}{\sum_{n=1}^N \sum_{m=1}^M \left(W^{I_1}(n,m) + W^{I_2}(n,m)\right)} \quad (18)$$

Quality Factor ranges from 0 to 1.

Source Images:

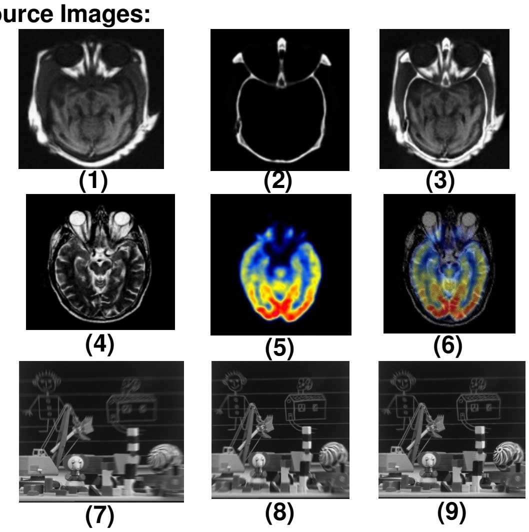

Fig. 3. (1) MRI image(2) CT image (3) ground tooth image (4) MRI [3] (5) PET [3] (6) ground tooth image (7) Toy1 (8) Toy2 and (9) ground tooth image.

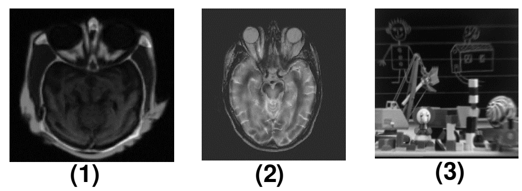

Fig. 4. Fusion Results of (1) MRI image and CT image (2) MRI [3] and PET [3] (3) Toy1 and Toy2.

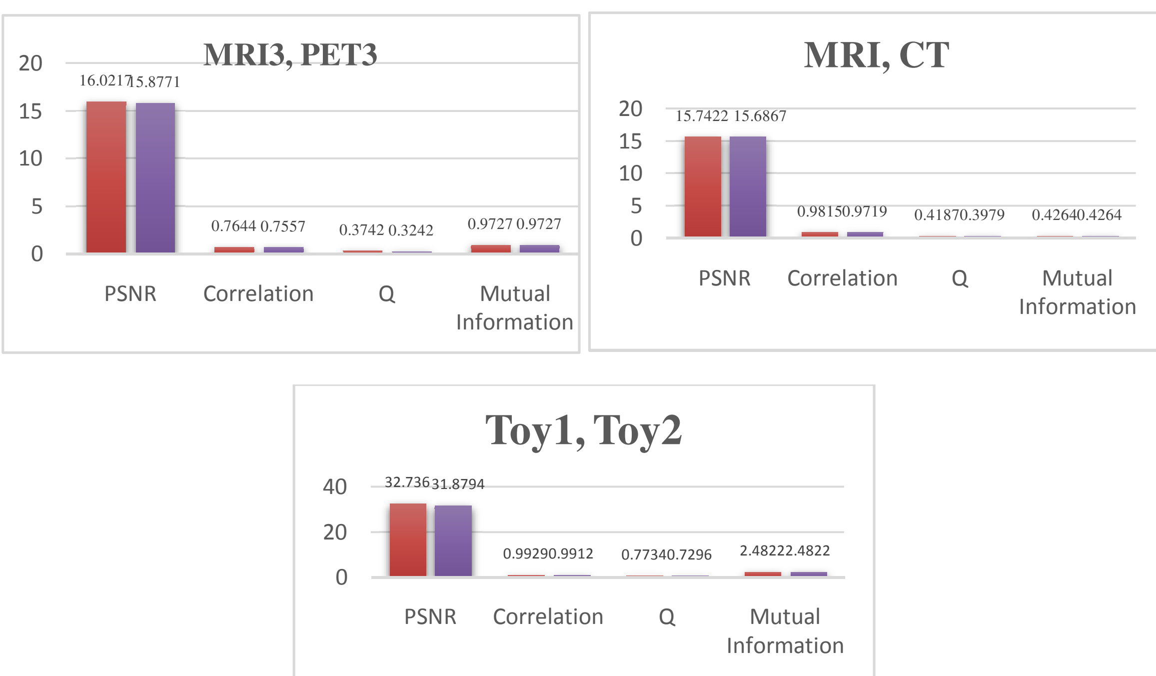

Fig. 5. Performance measure of different data sets

Table 1: Performance Calculation of different data sets.

Type of the image	PSNR		Correlation		Quality Factor		Mutual Information	
	Fusion with DWT & averaging	Proposed	Fusion with DWT & averaging	Proposed	Fusion with DWT & averaging	Proposed	Fusion with DWT & averaging	Proposed
MRI, CT	15.7422	15.6867	0.9815	0.9719	0.4187	0.3979	0.4264	0.4264
MRI3, PET3	16.0217	15.8771	0.7644	0.7557	0.3742	0.3242	0.9727	0.9727
Toy1, Toy2	32.7360	31.8794	0.9929	0.9912	0.7734	0.7296	2.4822	2.4822

By observing Table 1, we conclude that the proposed method maintaining proper consistency in the fused data. The results are compared with standard methods with three basic quantitate measures.

VI. CONCLUSION

This paper is about to fusion of images using DWT and BCV techniques. Initially, the images are preprocessed to acquire quality images. This method used two-level DWT decomposition and BCV technique to form the final fused image. The LL sub-band images are fused with the average method to protect most information in the resultant. The BCV technique applied to higher sub-bands to remove noisy content in the individual images. Multipurpose fusion type images verified with the proposed work and the fused image consist of more informative than the individual images. The results are compared and proved better in both qualitative and quantitative *analyses*. The tabulated results are shown that the proposed method is giving more fused details than the simple DWT & average fusion methods. The computed four performance values are more than the existed values.

VII. FUTURE SCOPE

This work can be extendable with more advanced transforms and edge-based techniques, which gives better performance than the existing techniques. Mathematical models can be derived which reduces the complexity of the system and improves the efficiency in terms of the fusion of images.

ACKNOWLEDGEMENTS

The authors would like to thank the management, principal and faculty members of QIS College of Engineering and Technology, Ongole, Andhra Pradesh for providing their continual support for completing this project successfully.

Conflict of Interest. The authors declare no conflict of interest.

REFERENCES

[1]. Fuqiang, Z., Xiaoson, L., Juan, L., Wang, R. & Haishu, T. (2019). Multifocus Image Fusion Based on Fast Guided Filter and Focus Pixel Detection. *IEEE Transactions on content mining, 7*: 50780-50796.

[2]. HimaBindu, Ch., & Satya Prasad, K. (2012). Performance of Multi-Source Fused Medical Images Using Multiresolution Transform. *International Journal of Advanced Computer Science and Application, 3(*10)*:* 54-62.

[3]. Shruti, J., Mohit, S., Dubey, P., & Anish, V. (2019). Multi-sensor Image Fusion Using Intensity Hue Saturation Technique. *Springer Communications in Computer and Information Science, 1076:* 147-157.

[4]. Flusser, J., Filip, S., and Barbara, Z. (2007). Image Fusion: Principles, Methods and Applications, *Tutorial EUSIPCO, 5:* 1-60.

[5]. Patil, S. (2016). Image Fusion using Wavelet Transform. *International Journal of Engineering and Advanced Technology, 5*(4): 66-69.

[6]. Roopa, M., Hima Bindu, Ch., & Satya Prasad, K. (2012). Discrete Wavelet Transform Based Medical Image Fusion using spatial frequency Technique. *International Journal of Systems, Algorithms & Applications, 2*(12): 44-49.

[7]. Esakkirajan, K., Jayaraman, S., Veerakumar, T. (2015). *Digital Image Processing. McGraw Hill Education, 5th Edition.* ISBN: 978-0-07-014479-8.

[8]. Tirupal, T., Chandra Mohan, B., & Srinivasa Kumar, S. (2019). Multimodal medical image fusion based on yager's intuitionistic fuzzy sets. *Iranian Journal of Fuzzy Systems, 16*(1): 33-48.

[9]. Ling, T., Zhi-Yu, Q. (2011). An Improved Medical Image Fusion Algorithm Based on Wavelet Transform. *International Conference on Natural Computation (ICNC), Shanghai. 5:* 76 –78.

[10]. Ya-ting, Y., Li, C., Yong-xin, Z., & Shan-shan, L. (2018). Mulitifocus image fusion based on filtering techniques and block consistency Verification. *Proc. IEEE 3rd International conference on Image Vision and Computers (ICIVC). Chongqing, China*, 453-457.

[11]. BikashMeher, Sanjay Agrawal, Rutuparna Panda, & Ajith Abraham (2019). A survey on region based image fusion methods. *Information Fusion, 48*:119-132.

[12]. Shudao, Zhou.,Zhong, Yang., Zhanhua, & Liu., Shangshu, Ren (2018). Image fusion based on wavelet transform and gray-level features. *Journal of Modern Optics, 66*(1): 77-86.

[13]. Faryal, Farooq, & Qamar, Nawaz (2020). DWT Based Image Fusion Technique for Infrared and Visible Images Using Particle Swarm Optimization. *Technical Journal. 25*(1): 66-72.

How to cite this article: Banu, S. S., Bindu, C. H., Kranthi, M. and Jamal, K. (2020). Fusion of Images using BCV and DWT. *International Journal on Emerging Technologies*, *11*(4): 104–107.