

Image Error Reduction by Fusion Using Dual Tree Discrete Wavelet Transform

Pragya Nema^{#1}, Rajendra Patel^{#2}, Anand Vardhan Bhalla^{#3}

^{#1}M.Tech scholar, Babulal Tarabai Institute of Research and Technology, Sironja, Sagar, Madhya Pradesh, India.

^{#2}Assistant Professor, Electronics and Communication Engineering Department, Babulal Tarabai Institute of Research and Technology, Sironja, Sagar, Madhya Pradesh, India.

^{#3}Assistant Professor, Electronics and Communication Engineering Department, Babulal Tarabai Institute of Research and Technology, Sironja, Sagar, Madhya Pradesh, India.

¹pragyanema09@gmail.com

²rajendraellectronics17@gmail.com

³anandvardhanbhalla@gmail.com

Abstract— This paper is related to an image fusion system based on Dual Tree Discrete Wavelet Transform. This system reduces error in the fused image. The various error parameters analyzed are Mean Square Error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Normalized Absolute Error (NAE), Maximum Difference (MD).

Keywords— Image fusion, Dual Tree Discrete Wavelet Transform (DT-DWT), Wavelet Transform (WT), Mean Square Error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Normalized Absolute Error (NAE), Maximum Difference (MD).

I. INTRODUCTION

The image fusion research is mainly due to the contemporary developments in the fields of multi-spectral, high resolution, robust and cost effective image sensor design technology. Since last few decades, with the introduction of these multi-sensory imaging techniques, image fusion has been an emerging field of research in remote sensing, medical imaging, night vision, military and autonomous vehicle navigation, remote sensing, concealed weapons detection, various security and surveillance systems applications. There has been a lot of improvement in dedicated real time imaging systems with the high spatial, spectral resolution as well as faster sensor technology. The solution for information overloading can be met by a corresponding increase in the number of processing units, using faster Digital Signal Processing (DSP) and larger memory devices. This solution however, can be quite expensive. Pixel-level image fusion algorithms represent an efficient solution to this problem of operator related information overload. Pixel Level fusion effectively reduces the amount of data that needs to be processed without any significant loss of useful information and also integrates information from multi-spectral sensors. Explicit inspiration for the research work has come from the necessity to develop some competent image fusion techniques along with the enhancement of existing fusion technologies. Furthermore, a Non-Destructive Testing (NDT) has been a popular analysis technique used in industrial product evaluation and for troubleshooting in research work without causing damage which can also save both money and time. The proposed

novel fusion methods in this work also exhibit improvement with respect to objective as well as subjective evaluation point of view as compared to some of the existing image fusion techniques.

PCA and other image fusion techniques are not so efficient and had numerous limitations. Thus to overcome them a new enhancement is made. The main disadvantage of Pixel level method is that this method does not give guarantee to have a clear objects from the set of images. These methods are complex in fusion algorithm, required good fusion technique for better result and final fused image has a less spatial resolution. To overcome all the issues a new implementation is done using dual tree discrete wavelet transform (DT-DWT) technique. In this work image fusion system using DT-DWT technique is proposed. By using DT-DWT various errors introduced in the image either during capturing or during transmission are reduced and hence quality of the fused image is enhanced.

II. DUAL TREE DISCRETE WAVELET TRANSFORM (DT-DWT)

The classical discrete wavelet transform (DWT) provides a means of implementing a multiscale analysis, based on a critically sampled filter bank with perfect reconstruction. However, questions arise regarding the good qualities or properties of the wavelets and the results obtained using these tools, the standard DWT suffers from the following problems described as below:

1. *Shift sensitivity*: It has been observed that DWT is seriously disadvantaged by the shift sensitivity that arises from down samples in the DWT implementation.
2. *Poor directionality*: an m-dimension transform ($m > 1$) suffers poor directionality when the transform coefficients reveal only a few feature in the spatial domain.
3. *Absence of phase information*: filtering the image with DWT increases its size and adds phase distortions; human visual system is sensitive to phase distortion. Such DWT implementations cannot provide the local phase information.

In other applications, and for certain types of images, it is necessary to think of other, more complex wavelets, which

gives a good way, because the complex wavelets filters which can be made to suppress negative frequency components. The complex wavelet transform has improved shift-invariance and directional selectivity. This analyzes the signal by two different DWT trees, with filters chosen so that at the end, the signal returns with the approximate decomposition by an analytical wavelet. The dual-tree structure has an extension of conjugate filtering in 2-D case. Because of the existence of two trees the second noise coefficients moments from such decomposition can be precisely characterized. The DT-DWT ensures filtering of the results without distortion and with a good ability for the localization function and the perfect reconstruction of signal. Moreover, the dual-tree DWT can be used to implement 2D wavelet transforms where each wavelet is oriented, which is especially useful for image processing.

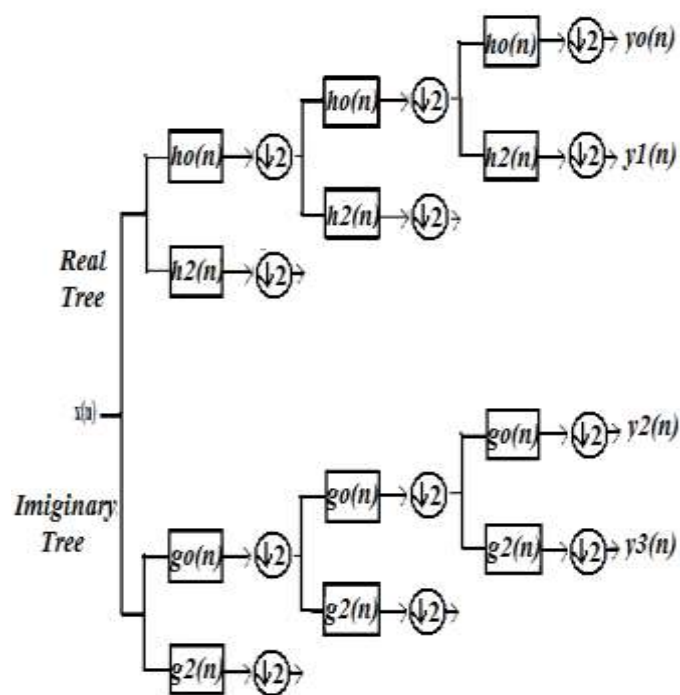


Figure 1: Implementation of Dual-Tree Discrete Wavelet Transform.

III. PARAMETERS UNDER CONSIDERATION

Image Quality is a characteristic of an image that measures the perceived image degradation (typically, compared to an ideal or perfect image). Imaging systems may introduce some amounts of distortion or artifacts in the signal, so the quality assessment is an important problem. There are several techniques and metrics that can be measured objectively and automatically evaluated by a computer program. Therefore, they can be classified as Full Reference Methods (FR) and No-Reference Methods (NR). In FR image quality assessment methods, the quality of a test image is evaluated by comparing it with a reference image that is assumed to have perfect quality. NR metrics try to assess the quality of an image without any reference to the original one. The image quality indices try to figure out the some or the combination of the various factors that determine the quality

of the image. Some of the parameters analyzed in this dissertation work are

1. Mean Square Error (MSE):

$$MSE = \frac{1}{mn} \sum_{i=1}^m \sum_{j=1}^n (A_{ij} - B_{ij})^2$$

Where m is the height of the Image implying the number or pixel rows.

n is the width of the image, implying the number of pixel columns.

A_{ij} being the pixel density values of the perfect image.

B_{ij} being the pixel density values of the fused image.

Mean square error is one of the most commonly used error projection method where, the error value is the value difference between the actual data and the resultant data. The mean of the square of this error provides the error or the actual difference between the expected/ideal results to the obtained or calculated result.

Here, the calculation is performed at pixel level. A total of $m*n$ pixels are to be considered. A_{ij} will be the pixel density value of the perfect image and B_{ij} being that of the fused image. The difference between the pixel density of the perfect image and the fused image is squared and the mean of the same is the considered error. MSE value will be 0 if both the images are identical.

2. Maximum Difference (MD)

$$MD = \max(|A_j - B_j|), i=1,2,...,m; j=1,2,...,n$$

Where m is the height of the Image implying the number or pixel rows

n is the width of the image, implying the number of pixel columns.

$A(i,j)$ being the pixel density values of the perfect image.

$B(i,j)$ being the pixel density values of the fused image.

Maximum Difference is a very simple metric that gives us the information of the largest of the corresponding pixel error. The difference between each of the corresponding pixel densities is calculated. The biggest difference value of these is considered as the metric here. This metric reflects a high value when in any part of the two images, a significant difference exists.

3. Root Mean Square Error (RMSE)

A commonly used reference based assessment metric is the RMSE. The RMSE will measure the difference between a reference image, R, and a fused image, F, RMSE is given by the following equation

$$RMSE = \sqrt{\frac{1}{MN} \sum_{n=1}^M \sum_{n=1}^N (R(m,n) - F(m,n))^2}$$

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

4. Normalized Absolute Error (NAE)

$$NAE = \frac{\sum_{i=1}^m \sum_{j=1}^n (|A_{ij} - B_{ij}|)}{\sum_{i=1}^m \sum_{j=1}^n (A_{ij})}$$

Where m is the height of the Image implying the number or pixel rows.

n is the width of the image, implying the number of pixel columns.

$A(i,j)$ being the pixel density values of the perfect image.

$B(i,j)$ being the pixel density values of the fused image.

This is a metric where the error value is normalized with respect to the expected or the perfect data. That is, the net sum ratio between the error values and the perfect values is calculated. The net sum of the error value which is the difference between the expected values and the actual obtained values is divided by the net sum of the expected values.

5. Mean Absolute Error (MAE):

The mean absolute error (MAE) is a quantity used to measure how close forecasts or predictions are to the eventual outcomes. The mean absolute error is given by

$$MAE = \frac{1}{n} \sum_{i=1}^n |f_i - y_i| = \frac{1}{n} \sum_{i=1}^n |e_i|$$

the mean absolute error is an average of the absolute errors

$$|e_i| = |f_i - y_i|,$$

Where f_i is the prediction and y_i the true value. Note that alternative formulations may include relative frequencies as weight factors.

The MAE measures the average magnitude of the errors in a set of forecasts, without considering their direction. It measures accuracy for continuous variables. Expressed in words, the MAE is the average over the verification sample of the absolute values of the differences between forecast and the corresponding observation. The MAE is a linear score which means that all the individual differences are weighted equally in the average.

IV. STEPS INVOLVED IN THE PROPOSED ALGORITHM

Steps involved in the proposed system are:

1. The test (reference) image and the two images to be fused are read.
2. These images are converted to double data.
3. The two images are fused using DT-DWT first and then by PCA.
4. Original images and the fused images with DT-DWT and PCA are generated at the output.

5. Comparison of fused images (with DT-DWT and PCA both) is done with respect to reference image based on different error parameters like MSE, RMSE, MAE.

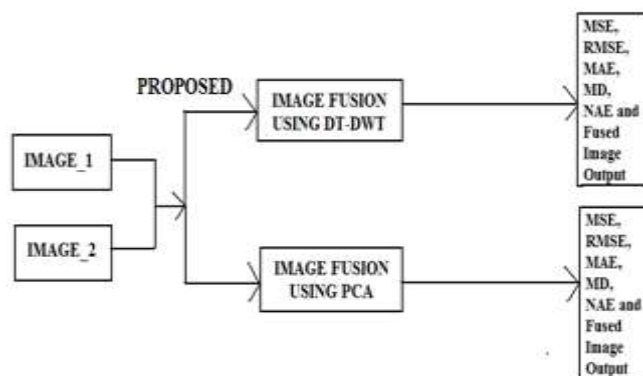


Figure 2: Simulation flow chart.

V. SIMULATION RESULTS

The proposed system simulation outputs are as under.



Figure 3: Original image1 and image2.



Figure 4: Fused image output using PCA.



Figure 5: Fused image output using DTDWT.

The figure 3 shows the original images are to be fused. Figure 4 and 5 shows the fused images outputs using Principle Component Analysis (PCA) and Dual Tree Discrete Wavelet Transform (DTDWT) respectively. From image outputs it can be seen that the image fusion output image with DTDWT is much better than that with PCA.

Table 1: Various error parameters values obtained by image fusion using PCA and DTDWT.

S.NO	METHODS	MSE	RMSE	MAE	NAE	MD
1	PCA	90.8068	9.5293	3.2394	0.0142	107.8362
2	DTDWT	5.0810	2.2541	1.0518	0.0046	36.5738

Table 1 shows values of MSE, RMSE, MAE, NAE and MD obtained by image fusion using PCA and DTDWT. From the table it can be seen that the error in fused image with DTDWT is less as compared to that with PCA. Hence the quality of fused image with DTDWT is higher as compared to PCA.

VI. CONCLUSION

The objective of this work is to develop an efficient image fusion system using Dual Tree Discrete Wavelet Transform (DT-DWT) which can reduce errors in the fused image in comparison to other prevalent traditional image fusion methods like PCA. In the proposed system outputs are derived for image fusion using DTDWT and PCA. Both the methods, are compared on the basis of various error parameters like MSE, RMSE, MAE, NAE and MD. The results show that the proposed system is better than the existing system and hence it can be concluded that the image fusion system performance has increased.

REFERENCES

- [1]. Abhinav Krishn, Vikrant Bhateja, Himanshi, and Akanksha Sahu , "PCA Based Medical Image Fusion in Ridgelet Domain", © Springer International Publishing Switzerland 2015. S.C. Satapathy et al. (eds.), Proc. of the 3rd Int. Conf. on Front. of Intell. Comput. (FICTA) 2014 – Vol. 2, Advances in Intelligent Systems and Computing 328, DOI: 10.1007/978-3-319-12012-6_52.
- [2]. Gagandeep kaur , Anand Kumar Mittal , "A New Hybrid Wavelet Based Approach for Image Fusion", International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 4, Issue 1, January 2015.
- [3]. Kaushal Mehta1, Dr. Dilbag Singh, "Designing of Technique of Image Fusion and Comparison with the Existing Techniques", International Journal of Research in Management, Science & Technology (E-ISSN: 2321-3264) Vol. 3, No. 2, April 2015.
- [4]. M.D. Nandeesh and Dr.M. Meenakshi, "Image Fusion Algorithms for Medical Images-A Comparison", Bonfring International Journal of Advances in Image Processing, Vol. 5, No. 3, July 2015.
- [5]. Manpreet Kaur1, Dr. Shiv Kumar Verma2, Gagandeep Kaur3, "Medical Image Fusion Using Wavelet Transform", International Journal For Technological Research In Engineering Volume 2, Issue 11, July-2015.
- [6]. Jyoti Agarwall and Sarabjeet Singh Bedi, "Implementation of hybrid image fusion technique for feature enhancement in medical diagnosis", Agarwal and Bedi Human-centric Computing and Information Sciences (2015) 5:3 DOI 10.1186/s13673-014-0020-z
- [7]. Deepali Sale1, Pallavi Sonare2, Dr.M.A.Joshi, "PCA Based Image Fusion for Multispectral Palm Enhancement", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 2, February 2014.
- [8]. Nayera Nahvi, Deep Mittal," Medical Image Fusion Using Discrete Wavelet Transform", Nayera Nahvi Int. Journal of Engineering Research and Applications www.ijera.com ISSN : 2248-9622, Vol. 4, Issue 9(Version 5), September 2014, pp.165-170.
- [9]. Xin Zhou*, Wei Wang and Rui-an Liu," Compressive sensing image fusion algorithm based on directionlets", Zhou et al. EURASIP Journal on Wireless Communications and Networking 2014, 2014:19.
- [10]. Nisha Gawari, Dr. Lalitha.Y.SComparative ,"Analysis of PCA, DCT & DWT based Image Fusion Techniques", International Journal of Emerging Research in Management &Technology ISSN: 2278-9359 (Volume-3, Issue-5) May201.
- [11]. Dr. S. Narayana Reddy,C. Chandrasekhar," Design and Implementation of Image Fusion Technique Using DWT for Micro Air Vehicle", IJECT Vol. 5, Issue spl-1, Jan - MarCh 2014.
- [12]. Vadher Jagruti," Implementation of Discrete Wavelet Transform Based Image Fusion ", IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834,p-ISSN: 2278-8735.Volume 9, Issue 2, Ver. VIII (Mar - Apr. 2014), PP 107-109 www.iosrjournals.org.
- [13]. Sweta K. Shah, Prof. D.U. Shah ,"Comparative Study of Image Fusion Techniques based on Spatial and Transform Domain", International Journal of Innovative Research in Science, Engineering and Technology Vol.3, Issue 3, March2014.
- [14]. Laxman Tawade1, Abida Bapu Aboobacker2 and Firdos Ghante "Image Fusion Based on Wavelet Transforms", International Journal of Bio-Science and Bio-Technology Vol.6, No.3 (2014), pp.149-162.
- [15]. Xu, Z., "Medical Image Fusion Using Multi-Level Local Extrema.", Elsevier-Information Fusion "19, 38–48 (2014).
- [16]. Singh, R., Khare, "A Fusion of Multimodal Images using Daubechies Complex Wavelet Transform", A Multiresolution Approach. Info. Fusion. 19, 49–60 (2014)
- [17]. Huaxun Zhang , and Huaxun Zhang, "A Way of Image Fusion Based on Wavelet Transform", 2013 IEEE 9th International Conference on Mobile Ad-hoc and Sensor Networks.
- [18]. A., Singh, S., Bhateja, V. "A Robust Approach for Denoising and Enhancement of Mammographic Breast Masses", International

- Journal on Convergence Computing, Inderscience Publishers 1(1), 38–49 (2013).
- [19]. Kusum Rani1, Reecha Sharma, “*Study of Different Image fusion Algorithm*”, International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 5, May 2013).
- [20]. Kusum Rani1, Reecha Sharma, “*Study of Image Fusion using Discrete wavelet and Multiwavelet Transform*”, International Journal of Innovative Research in Computer and Communication Engineering Vol. 1, Issue 4, June 2013.
- [21]. A. Sasi, L. Parameswaran, Sruthy S, “*Image Fusion technique using DT-CWT*” IEEE, 2013.
- [22]. R.Desale, S.Verma, “*Study and Analysis of PCA,DCT & DWT based Image Fusion Techniques*”, International Conference on Signal processing, Image Processing and Pattern Recognition 2013.
- [23]. K.Rani,R.Sharma, “*Study of Different Fusion Algorithm*”, International journal of Emerging Technology and advanced Engineering , Vol.3, May 2013.
- [24]. Gagandeep Kour1, Sharad P. Singh, “*Image Fusion Parameter Estimation And Comparison Between SVD And DWT Technique*” International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (An ISO 3297: 2007 Certified Organization) Vol. 2, Issue 11, November 2013.
- [25]. Dr.S. S. Bedi, Rati Khandelwal, “*Comprehensive and Comparative Study of Image Fusion Techniques*”, International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-3, Issue-1, March 2013.
- [26]. A.Ufade, M.Kawade, “*Comparision of spatial domain and transform domain image fusion technique for restoration of blur images*”, International Conference on Recent Trends in engineering & Technology, 2013.
- [27]. M.Pradnya,S.Ruikar, “*Image Fusion Based On Stationary Wavelet Transform*”, International Journal on Advanced Engineering Research and Studies 2013.
- [28]. Dr.S.S.Bedi, Mrs.Jyoti Agarwal, Pankaj Agarwal, “*Image Fusion Techniques and Quality Assessment Parameters for Clinical Diagnosis: A Review*”, International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 2, February 2013.
- [29]. Nirosha Joshitha J, R. Medona Selin, “*Image Fusion using PCA in Multifeature Based Palmprint Recognition*”, International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-2, May 2012.
- [30]. Dasarathy, B.V, “*Information Fusion in the Realm of Medical Applications – A Bibliographic Glimpse at its Growing Appeal*”, Information Fusion 13(1), 1–9 (2012).
- [31]. R.Singh, R.Dwivedi, S.Nagi, “*Comparative Evaluation of DWT and DT-CWT for Image Fusion and De-noising*”, International Journal of Applied Information Systems, Vol 4, sept 2012
- [32]. D.Sahu, M.Parsai, “*Different Image Fusion Techniques-A Critical Review*”, International Journal of Modern Engineering Research, Vol.2, Sep/Oct.2012.
- [33]. Abhishek Singh, Mr. Mandeep Saini , Ms. Pallavi Nayyer , “*Implementation & comparative study of different fusion techniques (WAVELET, IHS, PCA)*”, International Refereed Journal of Engineering and Science (IRJES) ISSN (Online) 2319-183X, (Print) 2319-1821 Volume 1, Issue 4(December 2012).
- [34]. K Jaya Priya And R S Rajesh, “*A Hybrid Face Recognition Approach Using Local Fusion Of Complex Dual-Tree Wavelet Coefficients And Ridgelet Transform*”, Ictact Journal On Image And Video Processing, May 2011, Volume: 01, Issue: 04
- [35]. Deepali A.Godse, Dattatraya S. Bormane , “*Wavelet based image fusion using pixel based maximum selection rule*”,International Journal of Engineering Science and Technology (IJEST), Vol. 3 No. 7 July 2011, ISSN : 0975-5462
- [36]. M .Chandana,S. Amutha, and Naveen Kumar, “*A Hybrid Multi-focus Medical Image Fusion Based on Wavelet Transform*”, International Journal of Research and Reviews in Computer Science (IJRRCS) Vol. 2, No. 4, August 2011, ISSN: 2079-2557.
- [37]. S.Krishnamoorthy, K.Soman, “*Implementation and Comparative Study of Image Fusion Algorithms*”, International Journal of Computer Applications, Vol.9, Nov 2010.
- [38]. S.Li, B.Yang, J.Hu, “*Information Fusion*”, Elsevier, 2010.
- [39]. S. M. Mahbubur Rahman, M. Omair Ahmad and M.N.S Swamy, “*Constant-based fusion of noisy image using discrete wavelet transform*”, IET Image Process, Vol. 4, Iss.5, 2010.
- [40]. K.Jaya Priya and R.S Rajesh, “*Local fusion of complex dual-tree wavelet coefficients based face recognition for single sample problem*”, Procedia Computer Science, Elsevier, Vol. 3, pp. 94–100, 2010.
- [41]. Yufeng Zheng, “*Multi-scale Fusion Algorithm Comparisons: Pyramid, DWT and Iterative DWT*”, 12th International Conference on Information Fusion Seattle, WA, USA, July 6-9, 2009
- [42]. Ge Wen , Gao Liqun, “*Multi-modality medical image fusion algorithm based on non-separable wavelet*,” App lication Research of Computers, Vol. 26, No. 5, May, 2009.
- [43]. V.Naidu, J.Roal, “*Pixel-level Image Fusion using Wavelets and Principal Component Analysis*”, Defence Science Journal,Vol.58, No.3, May 2008.
- [44]. Wolfgang Wein, Shellby Brunke, Ali Khanmene., “*Automatic CTUltrasound registration for diagnostic imaging and image-guide intervention*”, Medical Image Analysis, 2008,12:577-585.
- [45]. Yan Li-ping, Liu Bao-sheng and Zhou Dong-hua, “*Novel image fusion algorithm with novel performance evaluation method*,” Systems Engineering and Electronics, Vol.29, No.4, pp.509-513, Apr 2007.
- [46]. I. De, B. Chanda, “*A simple and efficient algorithm for multifocus image fusion using morphological wavelets*”, Signal Processing, Vol. 86, No. 5, 924-936, 2006.
- [47]. P. Y. Barthez, I. A. Schaafsma, Y. W. E. A. Pollak, “*Multimodality image fusion to facilitate anatomic localization of (99m) tc-pertechnetate uptake in the feline head*”, Veterinary Radiology & Ultrasound, Vol. 47, No. 5, 503-506, 2006.
- [48]. R. S. Blum, “*The Cramer-Rao bound applied to image fusion*,” in Proceeding of the 8th International Conference on Information Fusion, Philadelphia, PA, July 2005.
- [49]. F. Sadjadi, “*Comparative Image Fusion Analysais*”, IEEE Computer Society Conference on Computer Vision and Pattern Recognition, Vol. 3, June 2005.
- [50]. R. S. Blum, “*The Cramer-Rao bound applied to image fusion*,” in Proceeding of the 8th International Conference on Information Fusion, Philadelphia, PA, July 2005.
- [51]. I.Selenic, R.Baraniuk, N.Kingsbury, “*The dual-tree complex wavelet transform*”, IEEE signal processing magazine, november 2005.
- [52]. Taylor RH, Stoianovici D. “*Medical robotics in computer_ intergrated surgery*”, IEEE Transactions on Robotics and Automation 2003,19(5): 765-781.
- [53]. Vickers JP, Burnham KJ, Dil “*A.Knowledge-based organ segmenhation in low constrast medical computed to mography images*” Proceedings of the International Conference on System Science[C],2001(3): 381-388.
- [54]. Paul Hill, Nishan Canagarajah and Dave Bull, “*Image Fusion using Complex Wavelets*”, Dept. of Electrical and Electronic Engineering The University of Bristol Bristol, BS5 1UB, UK BMVC2002.
- [55]. Tu, T.M., Su, S.C., Shyu, H.C., Huang, P.S., “*A New Look at IHS-Like Image Fusion Methods. Information Fusion*” ,2(3), 177–186 (2001).
- [56]. W. Zhao, R. Chellappa, A. Rosenfeld, and P.J.Phillips, “*Face Recognition: A Literature Survey*”, Technical Report CAR-TR-948, Univ. of Maryland, 2000.
- [57]. M. Turk and A. Pentland, “*Eigenfaces for recognition*”, Journal of Cognitive Neuroscience, Vol.3, No.1, pp.71–86,1991.
- [58]. Xu Qing, Xing Shuai, Tan Bing, Li Jiansheng, Geng Zexun, “*Complex Wavelets and its Application to Image Fusion*”, Department of Remote Sensing Information Engineering, Zhengzhou Institute of Surveying and Mapping, No.66 Longhai Middle Road, 450052, ZhengZhou City, Henan Province, China-(xuqing, xingshuai)@chxy.com.