International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 5 Issue: 5 440 – 445

Quality Assessments of Various Digital Image Fusion Techniques

D.A. Deshmukh
PG Scholar
Department of Electronics and Telecommunication
PRMIT and R, Badnera, Amravati
Maharashtra, India

Prof. Dr. P.V. Ingole
Professor,
Department of Electronics and Telecommunication
PRMIT and R, Badnera, Amravati
Maharashtra, India

Abstract— Image Fusion is a process of combining the relevant information from a set of images into a single image, where the resultant fused image will be more informative and complete than any of the input images. The goal of image fusion (IF) is to integrate complementary multisensory, multitemporal and/or multiview information into one new image containing information the quality of which cannot be achieved otherwise. It has been found that the standard fusion methods perform well spatially but usually introduce spectral distortion, Image fusion techniques can improve the quality and increase the application of these data. In this Project we use various image fusion techniques using discrete wavelet transform and discrete cosine transform and it is proposed to analyze the fused image, after that by using various quality assessment factors it is proposed to analyze subject images and draw a conclusion that from which transformation technique we can find the better results. In this project several applications and comparisons between different fusion schemes and rules are addressed.

Keywords- *image fusion, wavelet transform, discrete cosine transform, fused image*

*****

I. Introduction

Nowadays, image fusion has become an important subarea of image processing. For one object or scene, multiple images can be taken from one or multiple sensors. These images usually contain complementary information. Image fusion is the process of detecting salient features in the source images and fusing these details to a synthetic image. Through image fusion, extended or enhanced information content can be obtained in the composite image, which has many application fields, such as digital imaging, medical imaging, remote sensing, and machine vision. The standard image fusion techniques, such as IHS based method, PCA based method and Brovey transform method operate under spatial domain. However, the spatial domain fusions may produce spectral degradation. This is particularly crucial in optical remote sensing if the images to fuse were not acquired at the same time. Therefore, compared with the ideal output of the fusion, these methods often produce poor result. Over the past decade, new approaches or improvements on the existing approaches are regularly being proposed to overcome the problems in the standard techniques. As multiresolution analysis has become one of the most promising methods in image processing, the wavelet transform has become a very useful tool for image fusion. It has been found that wavelet-based fusion techniques outperform the standard fusion techniques in spatial and spectral quality, especially in minimizing color distortion. Schemes that combine the standard methods (HIS or PCA) with wavelet transforms produce superior results than either standard methods or simple wavelet-based methods alone.

However, the trade-off is higher complexity and cost. Image fusion has been used in many application areas. In remote sensing and in astronomy, multisensory fusion is used to achieve high spatial and spectral resolutions by combining images from two sensors, one of which has high spatial resolution and the other one high spectral resolution. Plenty of applications which use multisensor fusion of visible and infrared images have appeared in military, security, and surveillance areas. In the case of multiview fusion, a set of images of the same scene taken by the same sensor but from different viewpoints is fused to obtain an image with higher resolution than the sensor normally provides or to recover the 3D representation of the scene. The multitemporal approach recognizes two different aims. Images of the same scene are acquired at different times either to find and evaluate changes in the scene or to obtain a less degraded image of the scene. The former aim is common in medical imaging, especially in change detection of organs and tumours, and in remote sensing for monitoring land or forest exploitation. The acquisition period is usually months or years. The latter aim requires the different measurements to be much closer to each other, typically in the scale of seconds, and possibly under different conditions. It also finds application in the area of navigation guidance, object detection and recognition. The present work offers a more extensive discussion of the approach and proposes a formalism as well as quality criteria

II. LITERATURE REVIEW

To study the concept of quality assessments of various digital image fusion techniques we have studied many papers. Here discussing some previous papers from which authors view and proposed method have been implemented.

Richang Hong,Wenyi Cao,Jianxin Pang,Jianguo Jiang **[1]**has extended the work in image quality evaluation to a novel metric for objective evaluation of image fusion. The input images and the fused image are firstly converted into local sensitive intensity (LSI) by Radon transform. We then employ the sensitive intensity for measuring how much information have been transferred from each source into the fused result by the difference of LSI. All the LSI pairs are finally incorporated into the expression according to the Weber–Fechner law. Experimental results demonstrate that our proposed metric outperforms other metrics while it is consistent with the subjective evaluation. In this projection-based metric for the quantitative evaluation of pixel-level Image fusion is proposed. We project the input images onto the fused image's signal characterization to obtain project vector and measure the difference between the source images and the fused image by the projection vectors. Different from other quantitative evaluation methods, our proposed metric firstly introduce this type of methodology to evaluate the performance of image fusion by comparing the difference between the fused images and the source images. The experimental results demonstrated that this metric corresponds well to the subjective judgment and outperforms some other quantitative evaluation metrics.

Marcelino Anguiano-Morales, E. Noé Arias, G. Garnica, A. Martínez[2] has presented a method to extract shape and color information simultaneously of a colorful object by projecting sequentially sinusoidal fringe patterns onto object's surface. Distorted fringe patterns are captured by digital CCD color camera. It is applied the phase shifting method to evaluate the phase of the projected fringes. We obtain both topography details and color texture information. Also we introduced a three-step color phase-shifting method for measuring 3D shapes of color objects, using commercial CCD camera and DLP projector. Surface texture plays an important role in several engineering applications for shape analysis in industrial inspection, because it provides vital information of the object. This technique can be a great help to test the performance for the textures manufactured by machining processes. Although, our method may be impractical when capturing very unstable objects; this will be our next task. Implementing a high speed camera can be applied to dynamic events

Xiaoli Zhang, Xiongfei Li, Yuncong Feng[3] has presented a new image fusion performance measure, which consists of two parts: the first one is a similarity measure for predicting the amount of information transferred form original images to fused image in Riesz domains; the other is a measure for characterizing the contrast of the fused image. Considering that different morphological components share different importance in Human Visual System, a gradient based image content partition algorithm is adopted to segment original images and fused images into three parts, and according the partition results, different weights are given to different pixels in the process of similarity measure calculating. Experimental results demonstrate the superiority of our measure compared with conventional measures in terms of computation complexity and accuracy.

Ming Yin,Wei Liua, Xia Zhaob, Yanjun Yinc, Yu Guoa[4] have proposed a novel sum-modified-Laplacian (NSML), which can extract more useful information from source images, is employed as the measurement to select bandpass sub-band coefficients. Finally, the fused image is obtained by performing the inverse NSST on the combined coefficients. The proposed fusion method is verified on several sets of multi-source images, and the experimental results show that the proposed approach can significantly outperform the conventional image fusion methods in terms of both objective evaluation criteria and visual quality for the band-pass sub-bands, we present a select rule by using a novel sum-modified-Laplacian. Several sets of experimental results show that the proposed method can capture the edge detail information of the source image and reduce the 'artificial information' and the impact of registration error, and improve the visual effect of the fused image

Alex Pappachen James,Belur V. Dasarathy [5] have provided a factual listing of methods and summarizes the broad scientific challenges faced in the field of medical image fusion. We characterize the medical image fusion research based on (1) the widely used image fusion methods, (2) imaging modalities, and (3) imaging of organs that are under study. This review concludes that even though there exists several open ended technological and scientific challenges, the fusion of medical images has proved to be useful for advancing the clinical reliability of using medical imaging for medical diagnostics and analysis, and is a scientific discipline that has the potential to significantly grow in the coming years.

Guang Zhu, Shu-Xu GuoSt[6] have proposed an active contour model (snake) based on image fusion, which is used in object detection and object tracking. Firstly, a multi-resolution image fusion with wavelet transform is applied to obtain the multi-resolution fused images. Secondly, in the low-frequency sub-image, a snake is applied with the Sobel operator to detect the object's contour; and in other high-frequency sub-images, a wavelet-based snake is applied. The two convergent snakes are fused in a multi-resolution scheme to obtain a fused snake in the fused image in an original resolution. Experiment results indicate this fused snake's detection or tracking accuracy is improved greatly. Moreover, a snake fusion scheme is also devised based on a multi-resolution active contour with the Sobel operator and wavelet-based active contour, to improve the detection or tracking accuracy of our fused active contour. This fused multi-resolution active contour can be widely applied in object detection or tracking with complicated image backgrounds in the military or safety science.

III. PROPOSED METHODOLOGY

In computer vision, Multisensory Image fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more informative than any of the input images.Multisensor data fusion has become a discipline which demands more general formal solutions to a number of application cases. Several situations in image processing require both high spatial and high spectral information in a single image. This is important in remote sensing.

However, the instruments are not capable of providing such information either by design or because of observational constraints. One possible solution for this is data fusion.

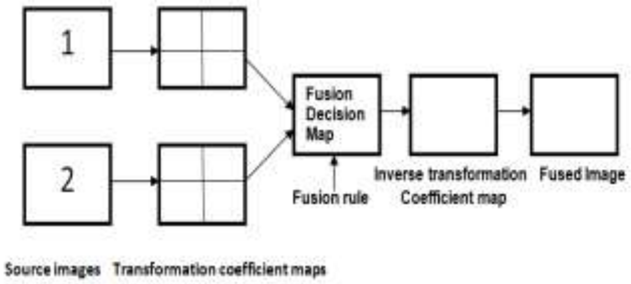


Fig:- Block diagram of a generic image fusion approach

Transformation coefficient is first performed on each source images, and then a fusion decision map is generated based on a set of fusion rules. The fused transformed coefficient map can be constructed from the wavelet coefficients of the source images according to the fusion decision map. Finally the fused image is obtained by performing the inverse wavelet transform. From the above diagram, we can see that the fusion rules are playing a very important role during the fusion process. Here we use different types of transformation for image fusion these are given below.

There are various types of transformation. In this we have mainly use wavelet transformation (WT) and cosine transformation (CT). In wavelet we used discrete wavelet transforms, Lifting Wavelet transform and Stationary wavelet transform.

i) Discrete wavelet transforms (DWT):- Wavelet transforms are multi-resolution image decomposition tool that provide a variety of channels representing the image feature by different frequency sub bands at multi-scale. It is a famous technique in analyzing signals. When decomposition is performed, the approximation and detail component can be separated 2-D Discrete Wavelet Transformation (DWT) converts the image from the spatial domain to frequency domain.

ii) Lifting wavelet transforms (LWT):- Lifting wavelet transform (LWT) is based on the theory of lazy wavelet and completely recoverable filter banks, improving the wavelet and its performance through the lifting process under the condition of maintaining the feature of the wavelet compared with the classical constructions (DWT) is rely on the Fourier transform.

Iii) Stationary Wavelet Transform (SWT):-We know that the classical DWT suffers a drawback: the DWT is not a time invariant transform. This means that, even with periodic signal extension, the DWT of a translated version of a signal X is not, in general, the translated version of the DWT of X.How to restore the translation invariance, which is a desirable property lost by the classical DWT? The idea is to average some slightly different DWT, called decimated DWT, to define the stationary wavelet transform (SWT). This property is useful for several applications such as breakdown point's detection. The main application of the SWT is denoising.

iv)Discrete Cosine Transforms (DCT):- A discrete cosine transform (DCT) expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are important to numerous applications in science and engineering, from lossy compression of audio (e.g. MP3) and images (e.g. JPEG) (where small high frequency components can be discarded), to spectral methods for the numerical solution of partial differential equations. The use of cosine rather than sine functions is critical for compression, since it turns out (as described below) that fewer cosine functions are needed to approximate a typical signal, whereas for differential equations the cosines express a particular choice of boundary conditions. In particular, a DCT is a Fourier related transform similar to the discrete Fourier transform (DFT), but using only real numbers. The DCTs are generally related to Fourier series coefficients of a periodically and symmetrically extended sequence whereas DFTs are related to Fourier series coefficients of a periodically extended sequence. DCTs are equivalent to DFTs of roughly twice the length, operating on real data with even symmetry (since the Fourier transform of a real and even function is real and even), whereas in some variants the input and/or output data are shifted by half a sample. There are eight standard DCT variants, of which four are common.

IV. QUALITY ASSESMENT FACTORS

Several computational image fusion quality assessment metrics are proposed in recent years. It is necessary to evaluate the fusion performance from both subjective visual evaluation and objective image quality assessment. There are different performances measures from which we use following parameters.

In this project, Digital image correlation, Histogram, Peak Signal to Noise Ratio (PSNR) of image data are chosen.

i) Digital image correlation*:* - Digital image correlation and tracking is an optical method that employs tracking and image registration techniques for accurate 2D and 3D measurements of changes in images. This is often used to measure deformation (engineering), displacement, strain, and optical flow, but it is widely applied in many areas of science and engineering. One very common application is for measuring the motion of an optical mouse.

The two r_{ij} dimensional discrete cross correlation can be defined several ways, one possibility being:

$$r_{ij} = \frac{\sum_m \sum_n [f(m+i, n+j) - \overline{f}][g(m,n) - \overline{g}]}{\sqrt{\sum_m \sum_n [f(m,n) - \overline{f}]^2 \sum_m \sum_n [g(m,n) - \overline{g}]^2}}$$

ii) Peak Signal to Noise Ratio (PSNR):- The PSNR computes the peak signal to noise ratio, in decibels, between two images. This ratio is often used as a quality measurement between the original and a compressed image. The higher the PSNR, the better the quality of the compressed or fused image. The Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) are the two error metrics used to compare image compression quality. The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. The lower the value of MSE, the lower the error.

To compute the PSNR, the block first calculates the mean squared error using the following equation

$$MSE = \frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M*N}$$

In the previous equation, *M* and *N* are the number of rows and columns in the input images, respectively. Then the block computes the PSNR using the following equation:

$$PSNR = 10\log_{10}\left(\frac{R^2}{MSE}\right)$$

In the previous equation, *R* is the maximum fluctuation in the input image data type. For example, if the input image has a double precision floating point data type, then *R* is 1. If it has an 8-bit unsigned integer data type, *R* is 255.

iii) Entropy (EN): Entropy is a measure of information quantity contained in an image. It reflects the amount of information in the fused image. The larger the EN is, the more information the image carries. If the value of entropy becomes higher after fusing, it indicates that the information increases and the fusion performances are improved. Entropy is defined as,

$$E = -\sum_{i=0}^{255} P_i \log_2 P_i$$

iv)Mean Square Error (MSE): The Mean Square Error (MSE) is a well known parameter to evaluate the quality of the fused image which is defined as,

$$MSE = \frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M * N}$$

It represents amount of deviation present in fused image compared to reference image. Smaller value of Mean Square Error indicates better fusion results. The Mean Square Error is calculating between fused image and standard reference image.

v)Standard Deviation: - It is known that standard deviation is composed of the signal and noise parts and it is more efficient in the absence of noise. It measures the contrast in the fused image. An image with high contrast would have a high standard deviation.

$$\sigma^2 = \frac{1}{N-1} \sum_i^n (x - \mu)^2$$

vi)Signal to Noise Ratio (SNR):- The quality of a signal is often expressed quantitatively with the signal-to-noise ratio. SNR is used to measure the ratio between information and noise of the fused image. Higher value indicates that both the reference and fused images are similar.

$$\mathrm{SNR} = 10\log_{10}\left(\frac{\mathrm{Energy}_{\mathrm{signal}}}{\mathrm{Energy}_{\mathrm{noise}}}\right)$$

Where Energy signal is the sum of the squares of the signal values and Energy noise is the sum of the squares of the noise samples.

V. RESULTS

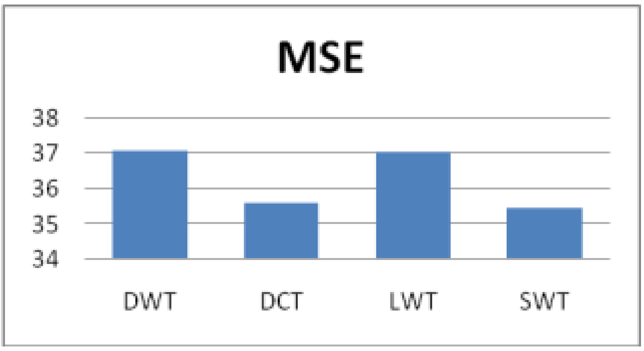
Here in following tables there are average values of images with their quality assessment values using each method are given.

Sr.No.	Quality Parameters	DWT	DCT	LWT	SWT
1	MSE	37.09337	35.61377	37.06197	35.4507
2	RMSE	2.394827	2.376967	2.394387	2.365313
3	PSNR	33.13248	33.24569	33.13551	33.35592
4	CORRELATION	0.92038	0.927807	0.9204	0.932347
5	SNR	9.659627	9.660593	9.66012	9.98388
6	ENTROPY	6.7122	6.619673	6.712193	6.647613
7	STANDARD DEVIATION	10.07953	10.27308	10.08081	10.13255

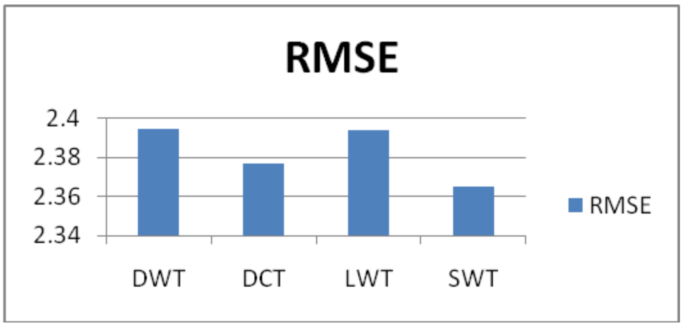
After calculating values for each method,The plot Average value graph for all the parameters.

ISSN: 2321-8169
440 – 445

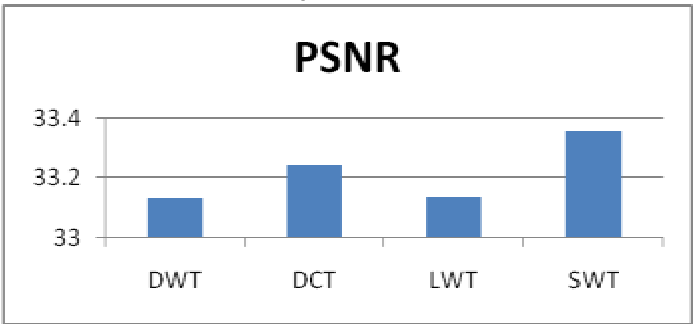
1)Graph for Mean Square Error:-



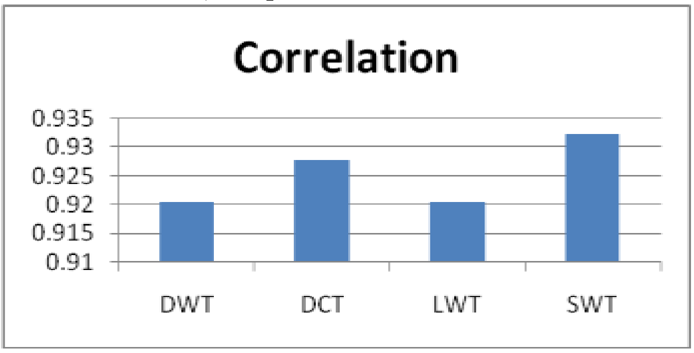
2) Graph for Root Mean Square Error:-



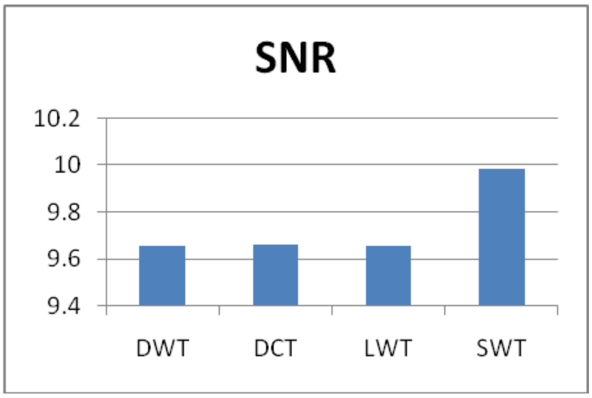
3) Graph for Peak Signal to Noise Ratio:-



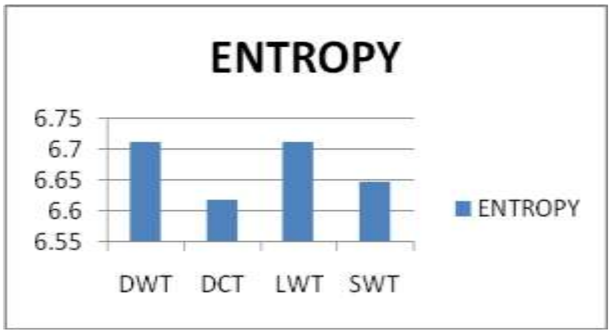
4) Graph for Correlation:-



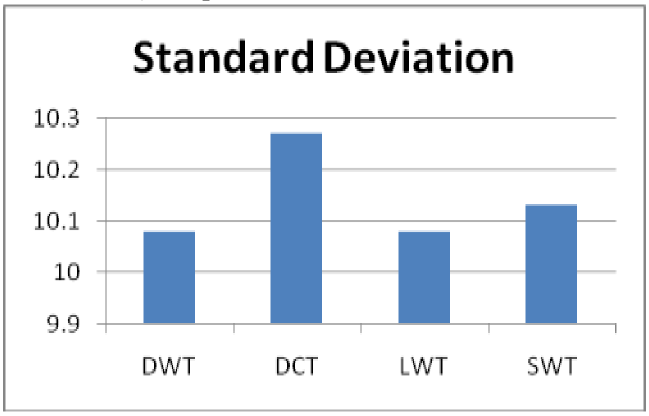
5) Graph for Root Signal to Noise Ratio:-



6) Graph for Entropy:-



7) Graph for Standard Deviation:-



VI. CONCLUSION

Image fusion is the process of combining relevant information from two or more images into a single informative image containing the complementary information from the source images. The objective of image fusion is to keep maximum spectral information from the original multispectral image while increasing the spatial resolution. Based on the analysis of average value graphs of various quality assessment factors like MSE, PSNR, RSME, Entropy, Standard deviation, SNR and Correlation we found out that there are some criteria from which we estimate that which transformation method will gives the better results. This criteria is given as 1) MSE should be lowest, 2) PSNR should be highest, 3) SNR should be highest, 4) Correlation should be nearer to 1 5) Entropy should be lowest and 6) Standard deviation should be highest. In this work in case of SWT, MSE is second lowest, value of PSNR is highest, the value of correlation is nearly equal to one, Entropy is second lowest and standard deviation is highest. From this it concluded that Stationary wavelet (SWT) transform shows better resemblance with given criteria hence resulting in improved visualization and interpretation.

VII.FUTURE SCOPE

Quality assessment parameters are needed to determine an optimal setting for a certain fusion scheme and to compare results obtained with different algorithms. Goal of image quality assessment is to supply quality metrics that can predict perceived image quality automatically. While visual inspection has limitation due to human judgment, qualitative approach based on the evaluation of “distortion” in the resulting fused image is more desirable in mathematical modeling. In this project major part of testing is performed on multifocus images, which can be further extended to use other types of images like multisensory images medical images and also by using other different types of transformation schemes

ACKNOWLEDGMENT

It is indeed a matter of great privilege to publish this paper on “Quality Assessments of Various Digital Image Fusion Techniques” under the valuable guidance of Prof. Dr.P.V.Ingole.I would like to express our deep sense of gratitude to our guide for this valuable guidance, advice and constant work.

REFERENCES

[1] Richang Hong,Wenyi Cao,Jianxin Pang,Jianguo Jiang,” Directional projection based image fusion quality metric” Information Sciences 281 (2014) 611–619

[2] Marcelino Anguiano-Morales, E. Noé Arias, G. Garnica, A. Martínez,” Image fusion by color texture extraction” Optik 125 (2014) 810– 812K. Elissa, “Title of paper if known,” unpublished.

[3] Xiaoli Zhang, Xiongfei Li, Yuncong Feng,” A new image fusion performance measure using Riesz transforms” Optik 125 (2014) 1427– 1433

[4] Ming Yin,Wei Liua, Xia Zhaob, Yanjun Yinc, Yu Guoa,” A novel image fusion algorithm based on nonsubsampled shearlet transform” Optik 125 (2014) 2274–2282M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

[5] Alex Pappachen James,Belur V. Dasarathy,” Medical image fusion: A survey of the state of the art” Information Fusion 19 (2014) 4–19

[6] Guang Zhu, Shu-Xu GuoSt,” Image-fusion-based multi-resolution active contour modelGuang”Optik 125 (2014) 4955–495

[7] G. Piella ,H. Heijmans,”A new quality metric for image fusion” Image Processing, 2003. ICIP 2003. Proceedings. 2003 International Conference

[8] Guihong Qu, Dali Zhang and Pingfan Yan,”Information measure for
performance of image fusion” ELECTRONICS LETTERS 28th March 2002 Vol. 38 No. 7

[9] Myungjin Choi, Rae Young Kim, Myeong-Ryong Nam, and Hong Oh Kim,” Fusion of Multispectral and Panchromatic Satellite Images Using the Curvelet Transform” IEEE Geoscience and Remote Sensing Letters (Volume: 2,Issue:2,April2005)

[10]]M. Fallah Yakhdani , A. Azizi,”Quality assessment of image fusion techniques for multi sensor high resolution satellite images” Centre of Excellence for Natural Disaster Management, Department of Geomatics Engineering, College of Engineering, University of Tehran, Iran - (mfallah84@gmail.com, aazizi@ut.ac.ir) Commission VII, WG VII/6