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MODIFIED PRIMITIVE IMAGE FUSION TECHNIQUES FOR THE SPATIAL DOMAIN

MODIFICIRANO SPAJANJE JEDNOSTAVNIH SLIKA ZA PROSTORNU DOMENU

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Abstract
The aim of Image fusion is to combine the information from number of images of the same scene from different images with focus on different objects. The result of image is more informative and of better quality often the entropy content of the resultant image is poor due to improper local fusing. In this paper a comparative study and modified spatial domain approach is presented by fixing the contrast values of pixel in between the Average -minimum, and Average-Maximum to get better fusion capabilities. Experimental results demonstrates that the few of the proposed techniques outperform the existing techniques in terms of SNR and PSNR.

Sažetak
Cilj fuzije slika je kombinirati podatke iz više fotografija iste scene sa raznih slika s naglaskom na različite objekte. Rezultat je slika koja je više informativna i kvalitetnija, ali često sadržajno entropija finalne slike je slaba zbog nepravilnog lokalne fuzije. U ovom radu provedeno je komparativno istraživanje i pristup modificiranja prostorne domene, predstavljeno kroz učvršćivanje kontrasta vrijednosti piksela između prosječnog minimalnog i prosječno maksimalnog da bi dobili bolje fuzijske karakteristike. Eksperimentalni rezultati pokazuju da neke od predloženih tehnika nadmašuju postojeće tehnike u smislu SNR i PSNR.

I. INTRODUCTION

Image fusion in resent time become an important sub area of digital image processing. Image fusion is the process of combining information from two or more source images of the same scene so that the resultant source image whose quality is superior to any of the input images. Hence further image processing tasks such as segmentation, feature extraction, and target recognition may be performed /**1**/. Input images consists of multi sensor, multimodal, multifocal or multi temporal. Image fusion techniques broadly classified in to three categories depending on the stage at which fusion takes place; it is often divided in to three levels, namely: low or pixel, middle or feature, and high or decision levels of representation /**2**/, /**3**/. The pixel-level method works on spatial domain or transform domain. Pixel level image fusion operates directly on the pixels obtained at imaging sensor outputs. While feature level image fusion operate on features extracted from the source images. The feature-level algorithms typically segment the image into contiguous regions and fuse the regions together using their properties. Decision level image fusion uses the outputs of initial object detection and classification as inputs to the fusion algorithm to perform the data integration. Feature level fusion and decision level image fusion may result in inaccurate and incomplete transfer of information.

The proposed approach uses the pixel based method of image fusion to fuse multi-focus images using primitive and principal component analysis. Select max, mid-max, aver, mid-min, and min are the primitive level fusion methods proposed. Pixel level Fusion works directly on the pixels of source image. Generally, the methods of pixel-level image fusion can be divided into three kinds as following: The first is a simple fusion method including calculating the weighted average value of the two space-registered images directly. The second is based on pyramid decomposition and reconstruction /**4**/. The third is a method of image fusion based on wavelet transforms /**5**/. This technique is required in many areas of application including computer vision, medical imaging, remote sensing, image Classification, Aerial and Satellite imaging, Robot vision, Concealed weapon Detection, Multi-focus image fusion, Digital camera application and Battle field Monitoring. Image fusion is generally performed in spatial domain or transform domain. The rest of the paper is organized as follows. Briefly surveys the different fusion techniques Section II, proposed approaches of fusion techniques section III, with the image quality metrics Section IV. The resultants are discussion in Section V, and conclusion is drawn in Section VI.

II. IMAGE FUSION TECHNIQUES

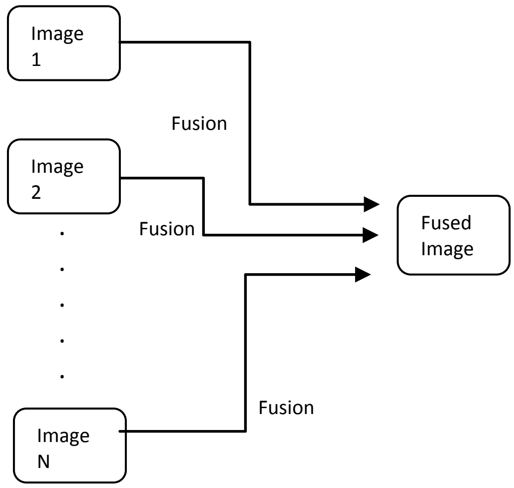


Fig.1. Spatial domain Image Fusion

The goal of image fusion is to integrate complementary information from multimodal images so that the new images are more suitable for the purpose of human visual perception and computer processing. Each of the given images are fused together to form a resultant image, whose quality is superior to one any of the input images. Image Fusion method can be broadly classified into two methods. They are spatial domain fusion method and Transform domain fusion method. The process of spatial domain image fusion is shown in fig 1. The Spatial domain directly deals with the position of pixels of the input image. The pixel values are directly manipulated to achieve desired result. In the transform domain, the image is first transferred to transform domain i.e. the Fourier transform of the image is computed first. All the Fusion operations are performed on the Fourier transform of the image and then the inverse Fourier transform is performed to get the resultant image. Simple fusion and principal component analysis (PCA) /**6**/, /**7**/ is the spatial domain techniques. Simple fusion consists of Select Max/min /**8**/. These methods fall under spatial domain techniques. The select max/min, and principal component analysis (PCA), source mage are direct, fused into the intensity values. The disadvantage of spatial domain approaches is that they produce spectral distortion and spatial degradation in the fused image. Spectral distortion becomes a negative factor while we go for further processing such as classification problem /**9**/. The PCA methods produce considerable spectral distortion /**10**/.

Image fusion using spatial domain fusion produces spectral degradation /**11**/. Image fusion using pixel level methods are affected by blurring effect which directly affects the contrast of the image /**12**/.

A. Principal Components Analysis (PCA)

In 1901 Karl Pearson as an analogue of the principal axes theorem in mechanics was invented Principal component analysis. But in this year 1930 it was developed by Harold Hotel ling. This method is mostly used as a tool in exploratory data analysis and for making predictive models. PCA can be done by Eigen value decomposition of a data covariance or correlation matrix or singular value decomposition of a data matrix, is usually after mean centering and normalizing the data matrix for each and every attribute. The results of a PCA are usually discussed in terms of component scores. It is sometimes called as factor scores i.e. the transformed variable values corresponding to a particular data point, and loadings the weight by which each standardized original variable Characteristic between the fused images and the original low resolution Images /**13**/.

B. Simple Fusion

The primitive image fusion techniques mainly perform a very basic function such as pixel selection, addition, subtraction and averaging of the pixel intensities of the source images to be fused. These spatial domain methods are not always effective but are at times critical based on the kind of image under consideration. A selection process is performed here where in, for every corresponding pixel in the input images, the pixel with maximum, mid-max, average, mid-min and minimum intensity is selected, respectively, and is put in as the resultant pixel of the fused image.

Simple Maximum and Minimum Method: In this method, the resultant fused image is obtained by selecting the maximum and minimum intensity of corresponding pixels from both the input image /**14**/, /**15**/. Select Minimum Method Pixel level method is affected by blurring effect which directly effect on the contrast of the image /**16**/, /**17**/. Simple maximum and simple minimum method is defined as,

$$F\,(i,j) = \sum_{i=1}^{N}\sum_{j=1}^{N} \max A(i,j)B(i,j) \quad (1)$$

$$F\,(i,j) = \sum_{i=1}^{N}\sum_{j=1}^{N} \min A(i,j)B(i,j) \quad (2)$$

Where A and B are source images and F is fused image.

Simple mid-Maximum Method: In this method the resultant fused image is obtained by taking the mid-max intensity of corresponding pixels from both the source image.

$$F\,(i,j) = \sum_{i=1}^{N}\sum_{j=1}^{N} \max[A(i,j)B(i,j)\times 3]\div 4 \quad (3)$$

Where A and B are source images and F is fused image.

Simple Aver Method: In this method the resultant fused image is obtained by taking the average intensity of corresponding pixels from both the source image. Average method it leads to undesirable side effect such as reduced contrast. With this method some noise is easily introduced in to the fused image, which will reduce the resultant image quality consequently.

$$F\,(i,j) = \sum_{i=1}^{N}\sum_{j=1}^{N} ave[A(i,j)B(i,j)]\div 2 \quad (4)$$

Where A and B are source images and F is fused image.

Simple mid-Minimum: In this method the resultant fused image is obtained by taking the mid-min intensity of corresponding pixels from both the source image.

$$F(i,j) = \sum_{i=1}^{N}\sum_{j=1}^{N} \min[A(i,j)B(i,j)] \div 4 \quad (5)$$

Where A and B are source images and F is fused image.

III. PROPOSED MAMP APPROACH

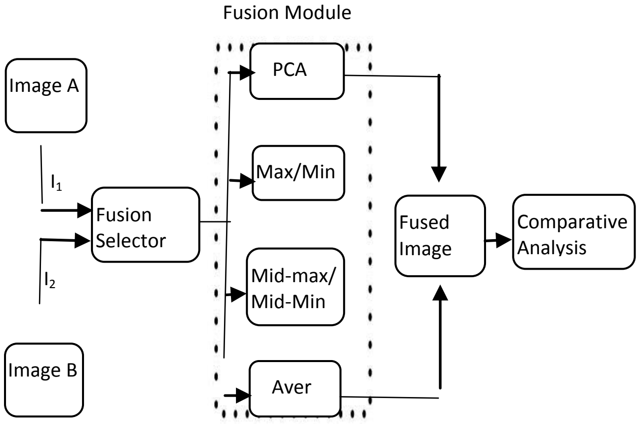


Fig.2. Proposed MAMP Approach

Although the fusion can be performed with more than two input images, this method considers only two input images. In this approach simple special fusion techniques such as two blur input images (Image A and Image B) are applied to the fusion stage. Image fusion stage is combined together to yield a fused image. Shown in fig.2 MAMP based simple Image Fusion method. Fused image function is the resultant fused image is obtained by selecting the max, mid-max, aver, mid- min and min intensity of corresponding pixels from both the input image (Image A and Image B). Finally we get fused image performs better in both visually and quantitatively.

Primitive i.e. the simple max, mid-max, aver, mid-min and min methods in which the all non-focused objects are obtained to be focused in the single output image. From each of the input images, the corresponding values of pixels are added. After obtaining their sum we then take its max, mid-max, aver, mid-min and min. The final output image of the corresponding pixel, this max, mid-max, aver, mid-min and min value is assigned. This process is continuing for all the pixel values.

The principal component analysis of all input intensities are PCA. It produces the coefficients of optimal weighting with respect to the information content and also the removal of redundancy without loss of information. Then the performing of a PCA to the covariance matrix, the weightings for each input image are obtained from the eigenvector to the corresponding of the largest Eigen value.

IV PERFORMANCE MEASURES

The following parameter is used to analyzing the performance evaluation of above fusion methods. The performance measures used in this paper provide some quantitative comparison among different fusion schemes, mainly aiming at measuring the definition of an image.

Entropy (EN): Entropy is a measure of information quantity contained in an image /**18**/, /**19**/. 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:

$$E = -\sum_{i=0}^{L-1} p_i \log_2 p_i \quad (6)$$

Where L is the total of grey levels, $p = \{P_0, P_1, P_2 \ldots\ldots P_{L-1}\}$ is the probability distribution of each level.

Overall cross entropy (OCE): It can reflect the difference between fused image and the two source images. The smaller the OCE is the better fusion result that is obtained /**20**/.

Signal-to-noise Ratio (SNR): The fused image is basically the ideal image (signal) along with the noise image (difference between the ideal image and the fused image). The larger the Peak Signal-to-noise Ratio value, better the fused result. The PSNR is defined as

$$SNR=\frac{Psignal}{Pnoise}$$

(7)

Where P is source image, P signal is ideal image and P noise is noise image.

Peak Signal-to-noise Ratio (PSNR): The PSNR block 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 fused image. The higher value of peak signal-to-noise Ratio, better the fused result. The PSNR is defined as

$$PSNR = 10log_{10} \ (MAX^2I/MSE)$$

(8)

Where MAX_I is the maximum possible pixel value of the image.

Mean Square Error (MSE): The Mean Square Error (MSE) is a well-known parameter to evaluate the quality of the fused image. The Mean Square Error is calculated between fused image K and standard reference image I which is defined as:

$$MSE=\frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left[I(j,j)-K(i,j)\ \right]$$

(9)

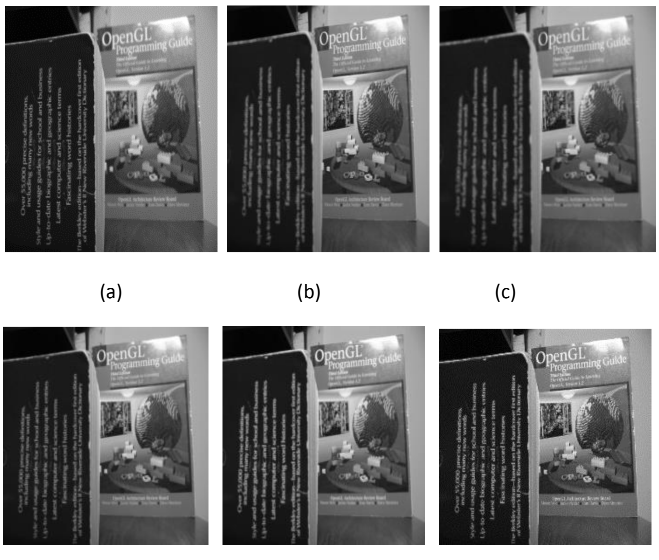
Where I is the input image, K is the fused image to be assessed, i is pixel row index, j is pixel column index, m is number row and n is number of column. Smaller value of Mean Square Error indicates better fusion results.

Maximum difference (MD): Maximum difference is defined as a difference between pixels. The smaller the MD is the better fusion result that is obtained.

$$MD = Max|A_{ij}-B_{ij}|\, i=1, 2,.......m;\ \ j=1, 2,....n$$

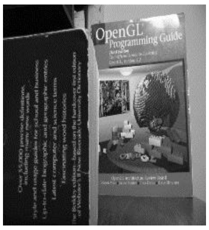
(10)

V. EXPERIMENTAL RESULTS AND DISCUSSION

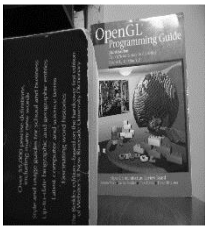


(a) (b) (c)

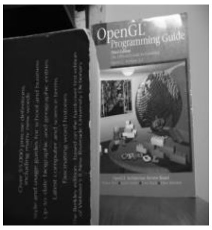
(d) (e) (f)



(g)



(h)



(i)

Fig.3. Book. (a) Original image. (b) Far image. (c) Near image. (d) PCA image. (e) Simple Maximum. (f) Simple mid-Maximum. (g) Simple Average. (h) Simple mid-Minimum. (i) Simple Minimum.

Table-1 Comparison of fused result using Book.

Method	EN	OCE	SNR	PSNR	MSE	MD
Maximum	0.0021	0.0566	0.0010	24.9631	207.3808	**0**
Mid-max	0.0021	0.0557	0.0010	26.9691	130.3688	39
Average	0.0021	0.0547	0.0010	26.8486	106.7136	79
Mid-min	0.0021	0.0537	0.0011	26.7822	136.4153	118
Minimum	0.0055	0.0528	0.0010	24.7170	219.4737	158
PCA	0.0021	0.0536	0.0010	26.8493	102.6013	77

In this section, there are two images of books. First image contains the far image focus, but the near image blurred, which means the near image is non-focused. Second image contains the near image focus, but the far image blurred, which means the far image is non-focused. These images are not Pre registered but have been taken with a still camera, hence they can be considered as registered. Here we represent the results we have obtained, by implementing the algorithms. Once the sample set of input image pairs were fused, the quality of the same were assessed for all fusion algorithms, discussed in section 2 with the image quality metrics, discussed in section 4. The simple mid-mini output has signal-to-noise ratio higher value and simple mid-max output has peak signal-to-noise ratio higher value in fused image, it means the fused image by mid-min and mid-max gives higher information than the fused image produced by simple maximum, aver, minimum and PCA scheme. Here we have made comparison of the spatial domain image fusion methods of simple maximum, mid-max, aver, mid-min, minimum and PCA on discussed in section 2. This can be verified with the help of the metric table 1.

VI. CONCLUSION

This paper is focused on the Comparative study of Image fusion and modified spatial domain image fusion technique. On applying the Simple max, mid-max, aver, mid-min, min and PCA, it is observed. This can be verified with the help of the metric table. The simple mid-min output has signal-to-noise ratio higher value and simple mid-max output has peak signal-to-noise ratio higher value in fused image, it means the fused image by mid-min and mid-max gives higher information than the fused image produced by simple max, aver, min and PCA scheme. The simple min output has entropy higher value and overall cross entropy is smaller value in fused image. The simple maximum output has the lower value of maximum difference. The experimental results demonstrates that the few of the proposed techniques outperforms better in existing spatial domain image fusion techniques.

Notes

/1/ Junli Liang, Yang He, Ding Liu, and Xianju Zeng," Image Fusion Using Higher Order Singular Value Decomposition," *IEEE Transactions On Image Processing*, vol.21, Isume 5, pp.2898-2909, 2012.

/2/ Lindsay I SmithA," Tutorial on Principal Component Analysis," http://www *.cs.otago.ac.nz/ cosc453 / student_tutorials/ principal components .pdf.*, 2002.

/3/ Lau Wai Leung, Bruce King," Vijay Vohora, Comparative image data fusion techniques using entropy and INI," *Department of land surveying and geo-informatics*, Hong Kong PolytechnicUniversity, Hung Hom, Kowloon, 2001.

/4/ VPS Naidu, J.R. Raol," Fusion of Out Of Focus Images Using Principal Component Analysis and Spatial Frequency," *Journal of Aerospace Sciences and Technologies*, vol.60, Isume 3, pp.216-225, 2008.

/5/ Tajinder Singh, Mandeep Kaur, Amandeep Kaur," A Detailed Comparative Study Of Various Image Fusion Techniques Used In Digital Images," *International Journal of Advanced Engineering Technology*, vol.4, Isume 3, pp.50-52, 2012.

/6/ Zhijun Wang, Djemel Ziou, Costas Armenakis,Deren Li, and Qingquan LiA," Comparative Analysis ofImage Fusion Methods," *IEEE Transactions on Geoscience And Remote Sensing*, vol.43, Isume 6 pp.1391-1401, 2005.

/7/ Sukhdip Kaur a, Kamaljit Kaur b," Study and Implementation of Image Fusion Methods," *International Journal of Electronics and Computer Science Engineering*, vol.1, Isume 3, pp.1369-1373, 2011.

/8/ Kusum Rani, Reecha Sharma," Study of Different Image fusion Algorithm," *International Journal of Emerging Technology and Advanced Engineering*, Vol. 3, 2013.

/9/ Gonzalo Pajares, Jesus Manuel de la Cruz," A Wavelet-based image fusion tutorial," *Pattern Recognition Society*, 2004.

/10/ Zhijun Wang, Djemel Ziou, Costas Armenakis,Deren Li, and Qingquan LiA," Comparative Analysis ofImage Fusion Methods," *IEEE Transactions on Geoscience And Remote Sensing*, vol.43, Isume 6 pp.1391-1401, 2005.

/11/ S. S. Bedi, Rati Khandelwal," Comprehensive and Comparative Study of Image Fusion Techniques," *International Journal of Soft Computing and Engineering*, vol.3, Isume 1, pp.300-304, 2013.

/12/ Dr. H.B. Kekre, Dhirendra Mishra, Rakhee Sabooe," Review On Image Fusion Techniques And Performance Evaluation Parameters, *International Journal of Engineering Science and Technology*, vol.5, Isume 4, pp.880-889, 2013.

/13/ Nupur Singh , Pinky Tanwar," Image Fusion Using Improved Contourlet Transform Technique," *International Journal of Recent Technology and Engineering*, vol.1, Isume 2. pp.131-136, 2012.

/14/ Dr. H.B. Kekre, Dhirendra Mishra, Rakhee Sabooe," Review On Image Fusion Techniques And Performance Evaluation Parameters, *International Journal of Engineering Science and Technology*, vol.5, Isume 4, pp.880-889, 2013.

/15/ S. S. Bedi, Rati Khandelwal," Comprehensive and Comparative Study of Image Fusion Techniques," *International Journal of Soft Computing and Engineering*, vol.3, Isume 1, pp.300-304, 2013.

/16/ Dr. H.B. Kekre, Dhirendra Mishra, Rakhee Sabooe," Review On Image Fusion Techniques And Performance Evaluation Parameters, *International Journal of Engineering Science and Technology*, vol.5, Isume 4, pp.880-889, 2013.

/17/ S. S. Bedi, Rati Khandelwal," Comprehensive and Comparative Study of Image Fusion Techniques," *International Journal of Soft Computing and Engineering*, vol.3, Isume 1, pp.300-304, 2013.

/18/ A.S.Ufade, B.K.Khadse, bambhori, Jalgaon,S.R.Suralkar," Comparison Of Spatial Domain And Transformation Domain Image Fusion Technique For Restoration Of Blur Images," *International journal of innovative research & development*, vol.2, Isume 1, pp.290-299, 2013.

/19/ Jon Shlens," A Tutorial on Principal Component Derivation Discussion and Singular Value Decomposition, *Technical Report*, vol.1, Isume 25.

/20/ Shivsubhamani, K. P. Soman," Implementation and Comparative Study of Image Fusion Algorithms, *International Journal of Computer Applications*, vol.9, Isume 2, pp.25-35, 2010.

Literature

1. Deepak Kumar Sahu, M.P. Parsai," Different Image Fusion Techniques–A Critical Review," *International journal of modern Engineering Research*, Vol.2, pp.4298-4301, 2012.
2. Sunil Kumar Panjeta, Deepak Sharma, " A Survey On Image fusion Techniques used to Improve Image, Quality,*International Journal of Applied Engineering Research*, vol.7, Isume 11, 2012.
3. A.S.Ufade, B.K.Khadse, bambhori, Jalgaon,S.R.Suralkar," Comparison Of Spatial Domain And Transformation Domain Image Fusion Technique For Restoration Of Blur Images," *International journal of innovative research & development*, vol.2, Isume 1, pp.290-299, 2013.
4. Keyur N.Brahmbhatt, Ramji M. Makwanna," Comparative study on image fusion methods in spatial domain," *International Journal of Advance Research in Engineering and Technology*, vol.4, Isume 2, pp.161-166, 2013.
5. Chetan K. Solanki Narendra M. Patel," Pixel based and Wavelet based Image fusion Methods with their Comparative Study," *National Conference on Recent Trends in Engineering & Technology*, 13-14 May 2011.
6. S.S.Hana b, H.T.Lia, H.Y. Gua b," The Study On Image Fusion For High Spatial Resolution Remote Senscing Images," *The International Archives of the Photogrammetry Remote Sensing and Spatial Information Sciences*, Beijing, vol.37, Isume 7, 2008.
7. Ningyu Zhang A, Quanyuan Wub," Effects of Brovey Transform and Wavelet Transform on the Information Capacity of SPOT Imagery, 2007.