Multiresolution Image Fusion Approach For Image Enhancement

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***Abstract* — Image fusion is performed by combining the data from multiple spectrums i.e. red, blue, Near Infra Red (NIR) and green, which results in enhanced image. Line features are clear in the blue and green bands while the red band reveals vein structures. The NIR band shows the palm vein structure as well as partial line information. Multispectral imaging has been employed to acquire more discriminating information. In wavelet transform the features gets affected for limited number of coefficients. The discontinuities across a simple curve affects all the wavelet coefficients on the curve. The advantage of the Curvelet transform is to handle curves using only a small number of coefficients. We can obtain the better fusion efficiency for the fusion of curved shapes using Curvelet transform. Fusion results were evaluated and compared according to different measures of performance. These performance measures show that curvelet based image fusion algorithm provides better fused images than wavelet.**

***Keywords*— Curvelet; Image Fusion; Multispectral; NIR; Spectrum; Wavelet**

INTRODUCTION

The human palm contains rich in formation which can be used to recognize individuals. This information mainly includes the principal lines, the wrinkles and the fine ridges. The ridge pattern can be captured using high resolution scanners and is generally used for offline identification in forensics. The principal lines and wrinkles can be acquired with low resolution sensor and are suitable for user authentication. In addition to the superficial features in a palm, there is presence of subsurface features i.e. palm veins, visible under infrared light. While palm lines are comparatively thin, they are in dense presence over the palm. On the other hand, palm veins are thick, while their pattern may be quite sparse over the same region. The availability of such complementary features i.e. palm lines and veins allows for increased discrimination between the individuals. Moreover the subsurface features are also useful for liveness detection for the prevention of spoof attacks [1]. Using multispectral imaging (MSI), it is possible to simultaneously capture images of an object in the visible spectrum and beyond. MSI has been extensively used in the fields of remote sensing, medical imaging and computer vision to analyze information in multiple bands of the electromagnetic spectrum. Multispectral images of the palm can be acquired using noncontact sensors such as digital cameras. Non-contact biometrics is user friendly and socially more acceptable. A monochrome camera and illuminations in different bands can be used to capture multispectral images of the palm [2]. Palm-print recognition approaches are mainly focused on line-like feature detection; subspace learning or texture based coding [5]. Line detection based approaches generally extract palm lines using edge detectors. Huang et al. proposed a palm print verification technique based on principal lines [6]. Recognition based solely on the use of palm lines is insufficient since two individuals can have highly similar palm lines making it difficult to discriminate between them. [7]Although line detection can effectively extract palm lines, it may not be equally useful for the extraction of palm veins due to their weak intensity profile and broad structure. A subspace projection can capture the global characteristics of a palm. However, the finer local details are not well preserved. [13][14][15] Image fusion provides a solution to the aforementioned enhancement difficulty. The objective of image fusion exists in combining multiple source images into a fused image that exhibits more useful information than the individual source image. Image fusion has emerged a promising image processing technique in many fields, like remote sensing and medicine. Out of various image fusion techniques , the fusion based on wavelet transform has been proven to be an active research focus in recent years because of its excellent performance [13][14] [15]. Image fusion improves robustness and accuracy of the palm based recognition system and attempt to combine the correlative and complementary information of multi-spectral images by pixel level and feature level fusion. A Palm print is a unique and reliable biometric characteristic with high usability as multispectral palm images have richer and denser pattern for recognition. The structural similarity index (SSIM) was proposed by [19]. The SSIM is a method that combines a comparison of luminance, contrast and structure and is applied locally in an 8x8 square window. This window is moved pixel-by-pixel over the entire image. At each step, the local statistics and the SSIM index are calculated within the window. The values vary between 0 and 1. Values close to 1 show the highest correspondence with the original images. The objective is to find the fused image with the optimal combination of spectral characteristics preservation

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and spatial improvement. As a third step two different quantitative methods are chosen to quantitatively measure the quality of the spatial improvement.[20].The appropriate number of decomposition level facilitates the selection and combination of salient features. More decomposition levels do not necessarily produce better result because by increasing the analysis depth the neighboring features of lower band may overlap. This gives rise to discontinuities in the composite representation and thus introduces distortions, such as blocking effect or ringing artifacts into the fused image. The considerable work has been done in case of pixel based image fusion; but less work has been explored at feature level and region level image fusion. [22]A new universal objective image quality index is easy to calculate and applicable to various image processing applications. Experimental results indicate that it outperforms the MSE significantly under different types of image distortions. Such a simple mathematically defined quality index performs so well without any HVS model explicitly employed. As it has strong ability in measuring structural distortion occurred during the image degradation processes. This is a clear distinction with MSE, which is sensitive to the energy of errors, instead of structural distortions. [26]Author proposed a novel objective non-reference quality assessment algorithm for fused images that utilizes local measures to estimate how well the salient information from the inputs is present in the fused images.
This metric is based on an image quality index introduced by Wang and Bovik. The proposed metric do not require a ground-truth or reference image. Different simulations performed by the author shows that his metrics are compliant with subjective evaluations and can therefore are used to compare different image fusion methods. The new index outperforms the MSE, and this is due to the index's ability of measuring structural distortions, in contrast to the MSE which is highly sensitive to the L^2 energy of errors.

MULTISPECTRAL PALM IMAGE FUSION

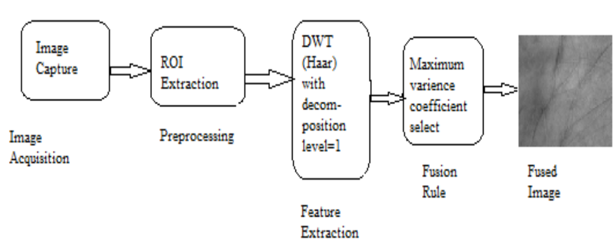

Fig.1 Multispectral palm image Fusion System

REGION OF INTEREST (ROI)

PolyU (contact based) data base is used for experimentation [8]. In order to extract an ROI from the non-contact images, it is necessary to define some reference landmarks from within the image which describe the relative translation, scale and rotation between different image samples, repeatedly and accurately. Among the various features commonly used in hand geometry recognition, the valley between the fingers are a suitable choice for the landmarks due to their invariance to the movement of the hand.

[1]A region of interest (ROI) will be extracted from palm print image which can reduce the influence of rotation and translation of the palm. After ROI extraction, the translation or rotation is usually small between two images. Thus, no more registration procedure is necessary [1].

DATABASE USED

PolyU palm print database [11] there is totally 600 palm-print images of 100 different palms in the database. Six samples from each of these palms were collected in two sessions, where 3 samples were captured in the first session and the other 3 in the second session. The average interval between first and second collection was two months. After preprocessing input palm print image is normalized to 128x128 sub images [11]. (D. Zhang) Here the multispectral PolyU (Hong Kong Polytechnic University) database is used. The Biometric Research Centre (UGC/CRC) at The Hong Kong Polytechnic University has developed a real time multispectral palm print capture device which can capture palm print images under blue, green, red and near-infrared (NIR) illuminations, and has used it to construct a large-scale multispectral palm print database.

IMAGE FUSION

Image fusion is implemented by integrating multiple source images with redundant and complementary information. Hence redundancy can be reduced, while complementary information can be utilized more effectively. According to application purpose of image fusion it can be divided into pixel level, feature level and decision level fusion. Most wavelet based image fusion algorithm research on that how to select the high frequency detail coefficients of the image, however, low frequency approximation coefficients are processed by “Average” method. To some extent, the contrast of the image is reduced, low frequency components including major energy of the image; determine the outline of the image. Therefore choosing the right low frequency coefficients can improve the visual effects of the image [10]. Considering to the quality of fused image and speed of execution, a new image fusion algorithm based on lifting wavelet transform is proposed. The fused image is better preserved the details and edge of the input image, the result of fused image is excellent. This algorithm chooses a different rule to fuse the images. Low frequency coefficients are combined by neighborhood spatial frequency and consistency check. The absolute maximum value based fusion rule is selected for high frequency coefficients selection. Fused image is obtained by using inverse lifting wavelet transform [11].

IMAGE FUSION TECHNIQUES:

[28]The principal component analysis (PCA) image fusion method is based on the statistical principle. It transfers the

spatial detail from the high spatial resolution image using the statistical properties of the high spatial resolution image. [28] Image merging methods do not take into account the contextual spatial information. And do not make use of the complementary characteristics of the images.[29]Component substitution methods are the high distortion of the original spectral information[30][31].[27] Entropy, average gradient, standard deviation of fused image using a trous wavelet transform are all higher than the results of Mallat's wavelet transform. It means the a trous algorithm integrates more information and details into the fused image than the Mallat's algorithm [27].

ALGORITHM FOR WAVELET BASED IMAGE FUSION

1. Input Red palm, Green palm, Blue palm and near infrared images.
2. Apply haar wavelet transform with single level decomposition.
3. Calculate approximate, horizontal, vertical and diagonal components of the input image .
4. For every A, V, H, D component calculate variance of image using 3x3 window.
5. Add cumulatively the variance of all the blocks.
6. Compare the variances of components and select the component with largest variance.
7. Image with larger variance contains more information, which will enhance information content in the resulting palm print image.

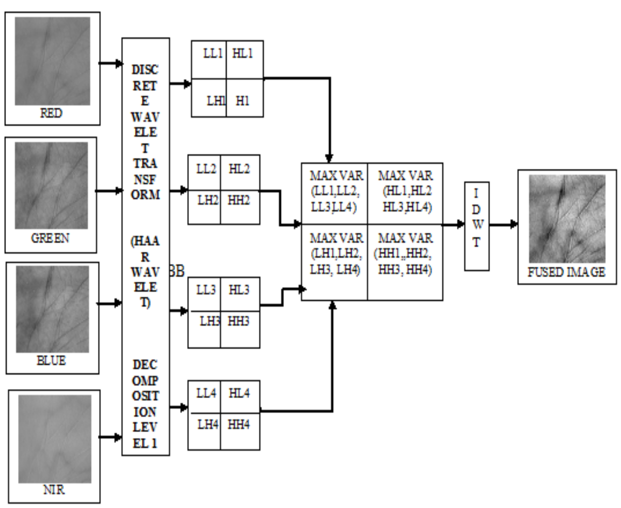

Fig.2 Wavelet Based Image Fusion

ALGORITHM FOR CURVLET BASED IMAGE FUSION

1. Input red palm, green palm, blue palm and near infrared images.
2. Calculate Curvelet components of Red, Green, Blue and Infrared palm image.
3. Extract the entire Curvelet component from its structure.
4. For every component calculate variance of images. Compare the variances of components and select the component with largest variance. Image with a larger variance contains more information, which will enhance the information content in the resulting palm print image.
5. Gather all components with highest variances to get single Structure.
6. Inverse Curvelet transform is obtained to get the fused image.

QUALITY ASSESSMENT

Objective image quality metrics can be classified according to the availability of an original (distortion-free) image, with which the distorted image is to be compared. Most existing approaches are known as full-reference, meaning that a complete reference image is assumed to be known. In many practical applications, however, the reference image is not available such as in image fusion case, and a no-reference or "blind" quality assessment approach is desirable. In a third type of method, the reference image is only partially available, in the form of a set of extracting features made available as side information to help evaluate the quality of the distorted image. This is referred to as reduced-reference quality assessment.

A large number of objective measures have been proposed to evaluate fusion performance. Objective measure classified into four categories:

A. Methods based on statistical characteristics;

B. Methods based on information theory; and

C. Methods based on important features.

The widespread use of image fusion methods, in military applications, in surveillance, in medical diagnostics, etc., has led to an increasing need for pertinent performance or quality assessment tools in order to compare results obtained with different algorithms or to obtain an optimal setting of parameters for a given fusion algorithm. In most cases, image fusion is only a preparatory step to some specific task, such as human monitoring, and thus the performance of the fusion algorithm has to be measured in terms of improvement of the subsequent tasks.

a) Average Gradient

[11]Average gradient can reflect the contrast level of image detail and feature of texture variation, and also reflects the image clarity. In general, the value of the average gradient is larger, the image is clearer. [11] Average gradient can reflect the contrast level of image detail and feature of texture variation, and also reflects the image clarity.

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$$Mx=l(i+I,J)-l(i,J) \quad (1)$$

My=l(i,J+I)-l(i,J) (2)

In the formula, M, N respectively expresses the rows and columns of the image; 1 (i, J) represents the gray value of the image pixel (I, J).

b) Edge Intensty

It gives the actual brightness of the image. In this experiment edge factor is important parameter such that depending on the palm lines structure it conclude that the edge intensity of Curvelet is maximum as compared to wavelet.

c) Shannon Entropy (EN)

The Shannon Entropy is the term which quantifies the expected value of the information contained in the msg. Entropy is the statistical measure of randomness that can be used to characterize the texture of input image.

$$\mathrm{H}(x)^n = \sum_{i=1}^{N} \mathrm{Iw(Pi)} \quad (3)$$

where Pi is weighting coefficient.

Entropy is an index to evaluate the information quantity contained in an image. 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=− $pilog2L$−1i=0pi Where L is the total of grey levels, p={$p0$,$p1$,…..pL−1 } is the probability distri Distribution of each level.

RESULTS

A novel palm print feature extraction approach is used. The novelty lies in extracting two intra modal discriminative features; lines like principal lines using the same wavelet decomposition of the palm print ROI. Integrating information deep inside skin with appearance in the context of hand biometrics is considered. The advantages of feature level fusion are appearance as well as inner information of hand is combined to form one solo representation, enforcing the security of the whole system. Multispectral palm

The work focused on two important methods of Image fusion namely wavelet transform and Curvelet transform. The POLYU database is used for experimentation. The different Red, Green, Blue and NIR images of palm are used for fusion. This work presents the idea of multispectral palm image enhancement using image fusion for biometric application. print capture device was designed to offer illuminations of Red, Green, Blue and Infrared channels. By using an image fusion in multispectral palm images we get more discriminating features which have finally improved accuracy of the method.

TABLE 1 Comparison of curvelet and wavelet fusion

Fusion Method	Avg Grad	Edge_ Intens	Shannon Entropy	Q0	SD	CORR
Curvelet	**3.864**	**33.748**	**7.103**	0.973	**147.80**	**0.700**
Wavelet	1.804	13.365	7.102	**0.999**	130.566	0.530

CONTRIBUTION

[22] Ying Hao, has considered two band palm images i.e. visible and NIR band for fusion. The author used CASIA multispectral contactless palm images. The same approach is used in the present work; four band data i.e. red, blue, green, near infrared are used. Using fusion more information can be extracted from four bands as compared to 2 bands. But instead of two bands we fused four bands images so as to get more useful information. We used PolyU (contact based) database for our experimentation so as to avoid the rotation and translation problems [8]. In our proposed system we have considered feature based approach to get maximum and accurate information from individual input images.

CONCLUSION AND FUTURE SCOPE

Image Fusion algorithm based on fast Wavelet and second generation Curvelet transform is used. Feature level fusion is used for multispectral palm image enhancement. The experimental result shows that Curvelet based fusion is better in extracting edge information; edge based metric clearly reflects that. Also the contrast of the fused image improves. Curvelet transform is able to handle curves discontinuities efficiently. Also it handles curves using only small number of coefficients. Wavelet is useful in extracting linear edges effectively, but Curvelet is giving good results for curved edges. Average gradient, edge intensity, standard deviation (SD), universal image quality index (UIQI) based parameters indicating it clearly. In Curvelet transform the curve portions and curved edges are clearer than wavelet transform method.

FUTURE SCOPE

Main focus should be on effective fusion strategy. Multi wavelets based image fusion can be performed to achieve a better image fusion quality. Multi wavelet is an expansion of traditional wavelet and has more advantages. It is most important that a multi wavelets system can simultaneously have these characteristics that are preserving length (orthogonality), good performance at the boundaries because of linear phase symmetry, and a high order of approximation named vanishing moments. Due to lack of reference image sets efficiency of the fusion cannot be better assessed. A learning algorithm like neural networks and more specifically Support Vector Machine could be devised in assigning weights to the image quality metrics so as to assess them.

REFERENCES:

[1] D. Zhang, Z.Guo, G.Lu, L. Zhang, W. Zuo, "An Online System of Multispectral Palmprint Verification", IEEE transactions on instrumentation and measurement, vol. 59, no. 2, pp 480-490, 2010.

[2] A. Jain, A. Ross and S. Prabhakar, "An Introduction to biometric recognition, " IEEE transactions on Circuits and Systems for Video Technology, Vol. 14, no. 1, pp. 4-20,2004.

[3] A. Kong, D. Zhang, and M. Kamel, "A survey of palmprint recognition," Pattern Recognition, Vol. 42, no. 7, pp. 1418,2009.

[4] D. S. Huang, W. Jia, and D Zhang,"Palmprint verification based on principal lines," Pattern Recog. Vol.41, no. 4, pp1316-1328,2008.

[5] D. Zhang, Z. Gua, G. Lu, L. Zhang, Y. Liu, and W. Zuo, ”Online joint palmprint and palm vein verification,”Expert Systems with Applications, Vol. 38, no. 3, pp. 2621-2631,2011.
[6] PolyU Multispectral Palmprint Database.[Online] Available: http://www.comp.polyu.edu.hk/~biometrics/MultispectralPalmprint/MSP.htm
[7] Li H., B.S. Manjunath, S.K.Mitra,”Multisensor Image fusion using the wavelet transform,” Graphical Models Image Process. 57(3) 235-245, 1995.
[8] L. Zhang, Z.Wei, X. He,Y.Zhang, G.Liang ,” A New image Fusion Algorithm Based On Wavelet Transform,” third International Conforence on Advanced Computer Theory and Engineering(ICACTE) 2010.
[9] Z.Zang and R.S.Blum, “ A categorization of multiscale decomposition-based image fusion schemes with a performance study for a digital camera application,” Proc. IEEE, vol.87(8),pp. 1315-1326,1999.
[10] V. Petrovic and T. Cootes,” Objectively adaptive image fusion, “Information Fusion, vol.8 (2), pp.168-176, April 2007.
[11] G.Pajares and J. Manual de la Cruz,” A wavelet based image fusion tutorial,” Pattern Recognition, vol.37(9), pp. 1855-1872, September 2004.
[12] [12] X. G. Lu, Y.F.Wang, W.G.Hu and A.L.Jin,”Investigation of Modification at Histogram Equalization Algorithm Based on Visual Characteristic,” Control & Automation, vol.22(5-1),pp229-231,2006.
[13] C. C. Liu, S.B.Hu,J.H.Yang and X. Guo,”A Method of Histogram Incomplete Equalization,” Journal of Shandong University (Engineering Science),vol.33(6),pp.661-664,2003.
[14] R. C. Gonzalez and R. E. Woods,”Digital Image Processing”, 2nd ed. Publishing House of Electronics Industry, pp 88-94, 2002.
[15] Z. X. Qiang, J.X.Peng and H.Q.Wang,”Remote Sensing Image Fusion Based on Local Deviation of Wavelet Transform,”Huazhong Univ. of Sci. & Tech (Nature Science Edition), vol.31 (6), pp.89-91, 2003.
[16] N.G.Kingsbury,”Image processing with complex wavelets,” in: B.Silverman, J.Vassilicos (Eds.), wavelets: The Key to Intermittent Information, Oxford University Press, New York, USA, pp.165-185, 1999.
[17] N. Han, J. Hu, W. Zhang,“Multi-spectral and SAR Images Fusion via Mallat and A Trous Wavelet Transform,” 2008.
[18] C.Pohl and J.I.V. Genderen,”Multisensor Image fusion in remote sensing: concepts,methods and applications,” International journal of remote sensing,vol.19,No.5,pp.823-854,1998.
[19] A.Garzelli,” Wavelet based fusion of optical and SAR image data over urban area, ”ISPRS Commission II Graz, Austria, September 9-13,2002.
[20] V.K.Shettigara,” A generalized component substitution technique for spatial enhancement of multispectral images using a higher resolution dataset,” Photogramm Eng.Remote Sens. Vol.58, pp 561-567, 1992.
[21] P.S.Chavez ,J.Stuart, C.Sides and J.A. Anderson,”Comparison of three different methods to merge multiresolution and multispectral data: Landsat TM and SPOT panchromatic, Photogramm Eng. Remote Sens. Vol.57.
[22] Ying Hao, Zhenan Sun, and Tieniu Tan “Comparative Studies on Multispectral Palm Image Fusion for Biometrics” Y. Yagi et al. (Eds.): ACCV 2007, Part II, LNCS 4844, pp. 12–21, 2007. c_Springer- Verlag Berlin Heidelberg 2007