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Comparison of Performance of Image Fusion Algorithms for Fusion of Multimodal Images

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Abstract: Now a day, multimodality medical image fusion has drawn lots of attention with the increasing rate at which multimodality medical images are available in many clinical application fields. The main motivation is to capture most relevant information from sources into a single output, which plays an important role in medical diagnosis. CT scans and MRI scans contains details regarding soft and hard tissues. For medical diagnosis, CT provides the better information on denser tissue with less distortion, while MRI offers better information on soft tissue with more distortion. In this paper, different methods of image fusion are implemented for multimodal medical images as well as satellite images, such as RGB method, PCA method, Wavelet Transform method and Contourlet transform method. To evaluate the performance of each fusion method four evaluation parameters are calculated. Then visual comparison and statistical comparison is done to show that which fusion method is more accurate for medical image fusion. This paper provides an effective way to enable more accurate analysis of multimodality images.

- **Background:** usually single image from any sensor is not sufficient to provide an accurate information related to any disease in clinical application field. So, several algorithms may be used to fetch correct information from image.
- **Objective:** to extract different parameter from medical images by using several algorithms related to information
- **Method:** four different image fusion Method are used to compare results based on few parameters

Keywords: Multimodal medical image fusion, Discrete Wavelet Transform, Contourlet Transform.

1. INTRODUCTION

The information science research associated with the development of sensory system focuses mainly on how information about the world can be extracted from sensory data. In general, a single sensor is not sufficient to provide an accurate view of the real world. For the improvement in the capabilities of the intelligent machines and systems, concept of multiple sensors was presented. As a result, in the past few years multi-sensor fusion has become an important area of research and development. Hence, the single representation of different sources of sensory information is called multi-sensor fusion. Multi-sensor fusion can occur at the signal, image or feature. Most of the advanced sensors of today, produce images. For example, optical cameras, millimeter wave (MMW) cameras, infrared cameras, x-ray images, radar imagers etc. So, the information, which we are getting from the advance sensors, is in the form of images. In image-based application fields, image fusion has emerged as a promising research area. image fusion is the process by which we combine two or more images into single image having important features from all. This fused image contains a more accurate description of the scene than any of the individual source images.

The simplest way for image fusion is pixel-by-pixel gray level average of the source images[1]. However, this way leads to undesirable side effects such as reduced contrast. In the recent years, many image fusion methods have been proposed, such as Statistical and Numerical Methods, Principal Component Analysis (PCA) method, Image Gradient Pyramid and multiresolution methods, RGB Method, Brovey Method, Wavelet Method, and Contourlet Method[2,3,4,5]. Statistical and Numerical Methods involve huge computation using floating point arithmetic. So, these methods are time and memory consuming. In PCA method, original images are transformed into uncorrelated images and then fused by choosing maximum value among all. PCA is frequently used for fusion because of its ability to compact the redundant data into fewer bands.

In the recent years, medical imaging has attracted increasing attention due to its critical role in health care. However, different types of imaging techniques such as X-ray, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Magnetic Resonance Angiography (MRA), etc. provide limited information where some information is common and some are unique. For example, X-ray and Computed Tomography (CT) can provide dense structures like bones and implants with less distortion, but it cannot detect physiological changes[2]. Similarly, normal and pathological soft tissue can be better visualized by MRI image whereas PET can be used to provide better information on blood flow and flood activity with low spatial resolution. As a result, the anatomical and functional medical images are needed to be combined for a compendious view. For this purpose, the multimodal medical image fusion has been identified as a promising solution which aims to integrating information from multiple modality images to obtain a more complete and accurate description of the same object. Multimodal medical image fusion not only helps in diagnosing diseases, but it also reduces the storage cost by reducing storage to a single fused image instead of multiple-source images[6].

2. IMAGE FUSION TECHNIQUES

2.1 RGB Method of Image Fusion

In this method, for the fusion of color images first color image (RGB) transform into hue-saturation-intensity (HSI) image and then algorithm of RGB fusion is applied on all the parts of source image[2]. Once image fused, hue, saturation and intensity of all three-part found out then apply inverse HIS transform to construct the fused RGB image. The procedure for RGB image fusion is given in figure 1.

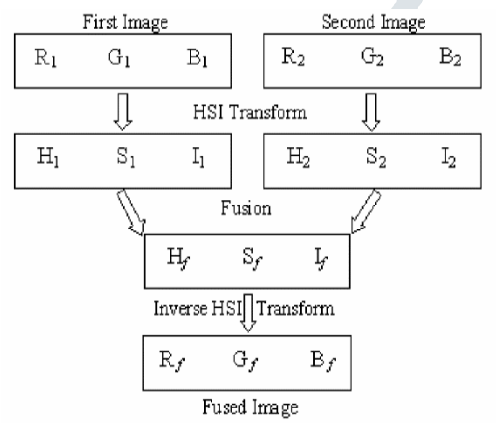


Fig. 2.1 RGB Method of Image Fusion

2.2 Principle Component Analysis Method (PCA) of Image Fusion

Principle Component Analysis (PCA) is a vector space transform often used to reduce multidimensional data sets to lower dimensions for analysis. PCA is the simplest and most useful of the true eigenvector-based multivariate analyses, because its operation is to reveal the internal structure of data in an unbiased way. If a multivariate dataset is visualized as a set of coordinates in a high-dimensional data space PCA supplies the user with a 2D picture, a shadow of this object when viewed from its most informative viewpoint.

Also, principle component analysis is a mathematical tool which transforms a number of correlated variables into a number of uncorrelated variables. The PCA is used extensively in image compression and image classification. The PCA involves a mathematical procedure that transforms several correlated variables into several uncorrelated variables called principal components. It computes a compact and optimal description of the data set. The first principal component accounts for as much of the variance in the data as possible and each succeeding component accounts for as much of the remaining variance as possible. First principal component is taken to be along the direction with the maximum variance. The second principal component is constrained to lie in the subspace perpendicular of the first. Within this Subspace, this component points the direction of maximum variance. The third principal component is taken in the maximum variance direction in the subspace perpendicular to the first two and so on. The PCA reduces the multidimensional data set into lower dimension for analysis. This method determines the weight for each source. The image using the eigenvector corresponding to the largest eigen value of the covariance matrix of each source image. The PCA is also called as Karhunen-Loève transform or the Hotelling transform or sub space method. The procedure for RGB image fusion is given in figure 3**.**

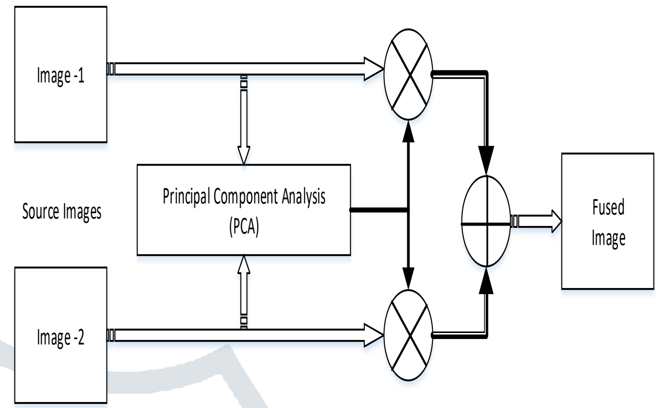


Fig. 2.3 PCA Method of Image Fusion

2.3 Discrete Wavelet Transform Method of Image Fusion

In the discrete case, the wavelet function is sampled at discrete mesh-points. Filters of different cut off frequencies are used to analyze the signal at different scales. The signal is passed through a series of high pass filters (moving difference) to analyze the high frequencies and through a series of low pass filters (moving average) to analyze the low frequencies. Correlations can be performed in the physical or Fourier space, the former has a preference when the support of a wavelet function is small (i.e., it is non-zero on a limited number of grid points). Within the discrete wavelet transform, discrete wavelet transforms can be distinguished based on[1, 2]:

- Redundant discrete systems (frames)
- Ortho-normal (and other) bases of wavelets

Some examples of well-known algorithms for discrete wavelet transform are Mallat's multi-resolution analysis, Feaveau's non-dyadic resolution factor, a trous and pyramidal algorithms. Discrete wavelet transforms are mostly implemented using digital filters. For example, if the multi-resolution image fusion is 2-dimensional, hence first the filters are applied to each row and afterwards to each column. The procedure for RGB image fusion is given in figure 2.

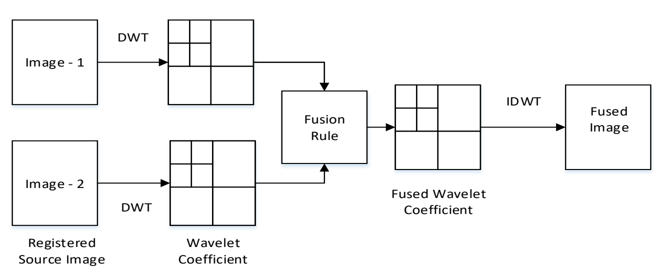


Fig. 2.2 DWT Method of Image Fusion

2.4 Contourlet Transform Method of Image Fusion

The contourlet transform[3, 4, 5]is inspired by the human visual system and curvelet transform which can capture the smoothness of the contour of images with different elongated shapes and in variety of directions. However, it is difficult to sampling on a rectangular grid for curvelet transform since curvelet transform was developed in continuous domain and directions other than horizontal and vertical are very different on rectangular grid. Therefore, the contourlet transform was proposed initially as a directional multiresolution transform in the discrete domain. The contourlet transform uses a double filter bank structure to get the smooth contours of images. In this double filter bank, the Laplacian pyramid (LP) is first used to capture the point discontinuities, and then a directional filter bank (DFB) is used to form those point discontinuities into linear structures. The Laplacian pyramid (LP) decomposition only produce one bandpass image in a multidimensional signal processing, that can avoid frequency scrambling[7]. And directional filter bank (DFB) is only fit for high frequency since it will leak the low frequency of signals in its directional sub bands. This is the reason to combine DFB with LP, which is multiscale decomposition and remove the low frequency. Therefore, image signals pass through LP sub bands to get bandpass signals and pass those signals through DFB to capture the directional information of image. This double filter bank structure of combination of LP and DFB is also called as pyramid directional filter bank (PDFB), and this transform is approximate the original image by using basic contour, so it is also called discrete contourlet transform.

3. PERFORMANCE EVALUATION PARAMETER

3.1 Entropy

The way of expressing entropy is to consider the spread of states which a system can adopt. As the entropy of the image is decreased, so is its information content. We moved from a full gray scale image, with high entropy, to a threshold binary image, with low entropy, to a single-valued image, with zero entropy. If the pixels of an image were inspected and found to be the same. This information could have been communicated in a very short message. The information content is said to be low simply because it can be communicated in a short message. If the pixels are changing in unexpected ways, however, longer messages are required to communicate this fact and the information is said to increase. This assumes, of course, that all changes in the image are meaningful[7].

Entropy is the measure of information quality contained in an image. If the value of entropy becomes higher after fusion, then the information quality will increase mathematically, entropy is defining as

$$H = \sum_{i=0}^{N-1} P_i \ log_2 P_i \qquad (2)$$

Where, Pi is the probability of the pixel value i
N is the total number of pixels in the image

3.2 Mutual Information

Mutual information is the measure the information that x image and y image share, it measure how much knowing one of those variable reduce uncertainty about the other. In image fusion performance measures that make use of mutual information in order to measure the amount of information that is fused image contains about the source image.

$$I(X,Y) = \sum_{y \in Y} \sum_{x \in X} p(x,y) \log \left(\frac{p(x,y)}{p(x)p(y)}\right)$$

Where, p (x, y) is the joint probability distribution function of X and Y image
P(x) and P(y) is the marginal distribution function of X and Y image.

3.3 Peak signal to noise ratio

Peak signal-to-noise ratio (PSNR) is defined as the ratio between the maximum possible value (power) of a signal and the power of distorting noise that affects the quality of its representation. Because many signals have a very wide dynamic range, (ratio between the largest and smallest possible values of a changeable quantity) the PSNR is usually expressed in terms of the logarithmic decibel scale. Saying that one method provides a better quality image could vary from person to person. For this reason, it is necessary to establish quantitative measures to compare the effects of image fusion algorithms on image quality. Using the same set of tests images, different image fusion algorithms can be compared systematically to identify whether a particular algorithm produces better results. The metric under investigation is the peak-signal-to-noise ratio. From PSNR we can more accurately conclude that which is a better algorithm for fusion.

$$PSNR = 20 \ \log_{10}\left(\frac{MAX_f}{\sqrt{MSE}}\right) \qquad (2)$$

$$MSE = \frac{1}{mn}\sum_{0}^{m-1}\sum_{0}^{n-1}\|f(i,j) - g(i,j)\|^2 \qquad (3)$$

f represents the matrix data of our original image
g represents the matrix data of our degraded image in question
m represents the numbers of rows of pixels of the images and i represent the index of that row
n represents the number of columns of pixels of the image and j represents the index of that column
MAX_f is the maximum signal value that exists in our original “known to be good” image.

3.4 Quality Factor

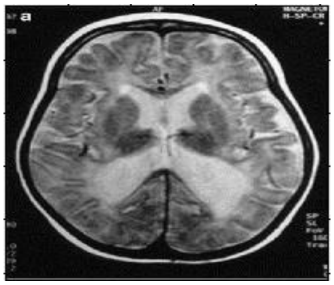
Image quality factor is a characteristic of an image that measures the perceived image degradation it reflect image edge and texture detail presentation.

4. RESULTS

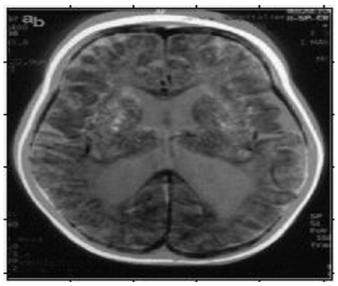
4.1 Visual Comparison of Medical Images

IMAGE 1

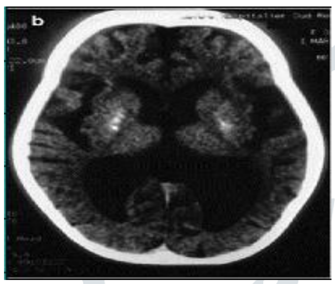
IMAGE 2



RGB METHOD



PCA METHOD



WAVELET METHOD

CONTOURLET METHOD

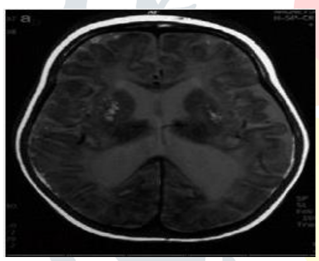


Fig.4.1 visual comparison of fused image for medical image set

4.2 Analysis based on Evaluation Parameter

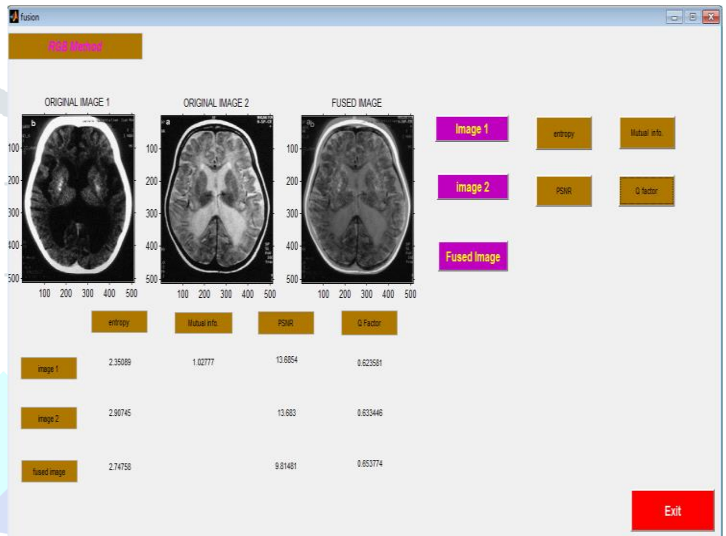
Implemented image fusion algorithm such as RGB method, PCA Method, Wavelet transform method and Contourlet transform method can be compared based on following evaluation parameter.

- Entropy
- Mutual information
- Peak signal to noise ratio
- Quality factor

For each image set medical images all above parameter are calculated as follows.

TABLE I. PARAMETER EVALUATION FOR MEDICAL IMAGE SET 1

Parameter	RGB Method	PCA Method	Wavelet Method	Contourlet Transform
Entropy	2.10596	2.11261	2.37528	1.67087
Mutual information.	1.12909	1.12909	1.12909	1.91667
PSNR	12.519	19.9393	15.9582	22.9277
Q Factor	0.678083	0.67707	0.678087	0.948516



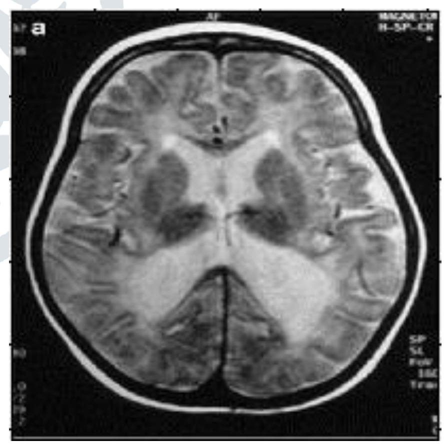
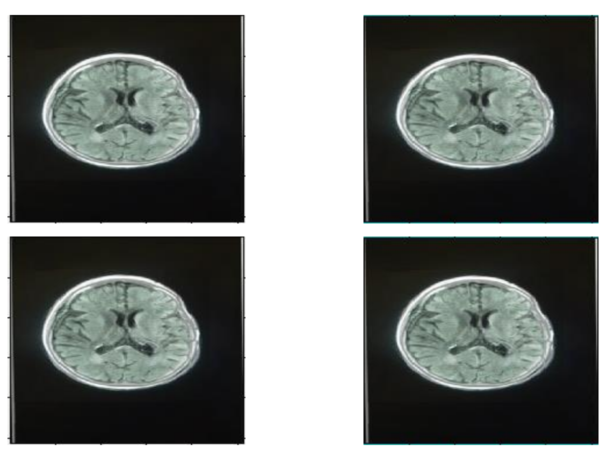
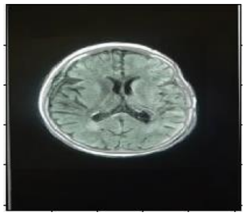
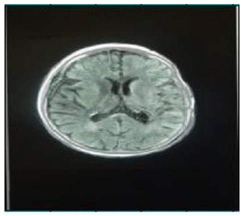
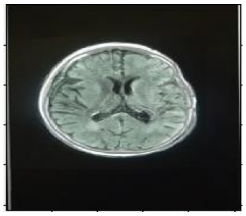
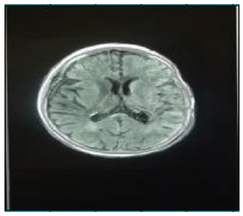


Fig.4.2 resulting window of RGB method



5. DISCUSSION

In all above image fusion method comparison of different evaluation parameter is done and all the result are discuss with radiologist. According to the medical examination of fused image, following are the observations

Remark and comment: for CT and MRI image fusion RGB and DWT method are better than the rest two

Use in medical field: at present dosen't appears to have great role as these are indipendant modalities

Suggestion by radiologist: instead of CT and MRI image fusion CT and PET or MRI and functional MRI may be useful.

6. CONCLUSION

The fused images were verified for their quality based on a perfect image in each of the sets. The quality assessment based on the image metrics developed and visual perception was compared to assess the credibility of the image metrics.

In the total of four image fusion techniques, RGB fusion method, PCA Method, wavelet method and Contourlet transform Methods. By the means of the four-image metrics developed - Entropy, Mutual information, PSNR, Quality factor the Contourlet transform Method is assessed as the fusion algorithm producing a fused image of superior quality compared to the other three. Wavelet method was assessed the next better algorithm. Results of Contourlet transform method are better than RGB method, PCA method and Wavelet transform Method. Also Results of Contourlet are better for all evaluation parameter such as quality factor; mutual information, entropy and PSNR For set of medical images result of Contourlet and wavelet are same in terms of entropy in other case Contourlet is better for image fusion. The finding and conclusion here may not be the perfect one.

REFERENCES

Typical Paper Reference:

- [1] Deepak Kumar Sahu, M.P.Parsai, "Different Image Fusion Techniques –A Critical Review",International Journal of Modern Engineering Research (IJMER), Vol. 2, Issue. 5, pp-4298-4301 Sep.-Oct. 2012.
- [2] Kusum Rani, Reecha Sharma, " Study of Different Image Fusion Alogorithm", International Journal of Emerging Technology And Advanced Engineering, vol.3,no.5, may 2013, pp 288-291.
- [3] KoteswaraRao. Kommu .V.RaviSekhara Reddy, "An Enhanced and robust Multifocus Image Fusion Using Contourlet Transform", International Journal of Engineering Trends and Technology (IJETT) –Vol. 15, No 1 – Sep 2014.
- [4] Michele Saad, "Low-Level Color and Texture Feature Extraction for Content-Based Image Retrieval", Final Project Report, May 09, 2008
- [5] GauravBhatnagar, Q.M. JonathanWu, and Zheng Liu, "Directive Contrast Based Multimodal Medical Image Fusion in NSCT Domain," IEEE transactions on multimedia, vol. 15, no. 5, Aug. 2013.
- [6] P.S. Hiremath, Prema T. Akkasaligar, SharanBadiger, "Performance Comparison of Wavelet Transform and Contourlet Transform based methods for DespecklingMedical Ultrasound Images", International Journal of Computer Application, Vol. 26– No.9,pp 34-41, , July 2011.
- [7] Zhijun Wang, DjemelZiou, Costas Armenakis, Deren Li, and Qingquan Li, "A Comparative Analysis of Image Fusion Methods", IEEE transactions on geoscience and remote sensing, vol. 43, no. 6, pp. 1391-1402, , Jun. 2005.
- [8] Rohan Ashok Mandhare, PragatiUpadhyay,Sudha Gupta, "Pixel-Level Image Fusion Using Brovey Transforme And Wavelet Transform", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 2, Issue 6, pp 2690-2695, June 2013.