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Image Fusion Based on Medical Images Using DWT and PCA Methods

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Abstract:

Image fusion is the process of combining relevant information from a set of images into a single image in which the fused image contains more information than any of the input images. This technique improves the quality of data. Image fusion is one of the important re-processing steps in digital image reconstruction. Now-a-days, medical image fusion is one of the upcoming fields which helps in easy diagnostics and helps to bring down the time gap between the diagnosis of the disease and the treatment. In Magnetic Resonance Image (MRI), anatomy and soft tissues are visible and it has high spatial resolution. In Computed Tomography (CT) images bony structures appears brighter. Analysis is done to determine the image fusion algorithm which is more suitable for clinical diagnosis. Analysis is also done on image quality assessment parameters of image fusion. This paper presents image fusion techniques and image quality assessment parameters such as primitive fusion (Averaging Method, Select Maximum, and Select Minimum), Discrete Wavelet transform based fusion, Principal component analysis (PCA) based fusion etc. Comparison of all the techniques concludes the better approach for its future research.

Keywords : - **Image Fusion, Discrete Wavelet Transform (DWT), Principal Component Analysis (PCA), Mean Square Error (MSE), Peak signal to noise ratio (PSNR).**

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INTRODUCTION :

Image Fusion is a process of combining the relevant information from a set of images, into a single image, such that the resultant fused image will be more informative and complete than any of the input images. For example, CT and MR images may be fused as an aid to medical diagnosis. MR and visible images may be fused as an aid to pilots landing in poor weather condition or microwave and visible images may be fused to detect weapons. The fusion process must satisfy the following requirements such as it should preserve all relevant information in the fused image, should reduce noise and should minimize any artifacts in the fused image. There are two approaches to image fusion, namely Direct Fusion and Multi resolution fusion. In Direct fusion, the pixel values from the source images are summed up and taken average to form the pixel of the composite image at that location. Multi resolution fusion uses pyramid or wavelet transform for representing the source image at multi scale. Because of the characteristic of image fusion technology, it has recently been widely applied in various fields such as auto target recognition, computer vision, Concealed weapon detection and medical image processing etc. The advantages of image fusion are improving reliability and capability.

I. FUSION TECHNIQUES

A. *Discrete Wavelet Transform (DWT)*

The Discrete Wavelet Transform (DWT) [2][5] also converts the image from the spatial domain to frequency domain. The image is divided by vertical and horizontal lines and represents the first-order of DWT, and the image can be separated with four parts those are LL1, LH1, HL1 and HH1. In additional, those four parts are represented four frequency areas in the image. For the low- frequency domain LL1 is sensitively with human eyes. In the frequency domains LH1, HL1 and HH1 have more detail Information more than frequency domain LL1.

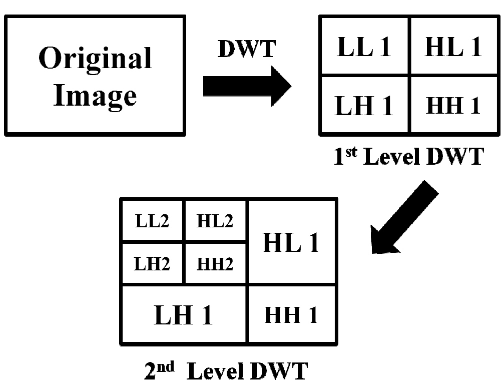

Fig1: Frequency distribution of DWT

1) Algorithms of DWT

Wavelet transform is first performed on each source images to generate a fusion decision map based on a set of fusion rules. The fused wavelet coefficient map can be constructed from the wavelet coefficients [7][9]of the source images according to the fusion decision map. Finally the fused image is obtained by performing the inverse wavelet transform.

The algorithm of image fusion using DWT [8] has following common steps applicable to proposed methods of fusion.

a) Accept the two input images.
b) Resize both the images to 256 x 256.
c) Convert to Gray scale image.
d) Convert to double precision format.
e) Take Discrete Wavelet Transform of both the images.
f) Let for first image OUT bands be HHa, HLa, LHa, LLa and for second image be HHb, HLb, LHb, LLb.

B. *Principal Component Analysis (PCA):*

It is a mathematical tool from applied linear algebra .It is a simple non-parametric method of extracting relevant information from confusing data sets. PCA [3][6] is a useful statistical technique that has found application in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension. The origins of PCA lie in multivariate data analysis, it has a wide range of other applications PCA has been called, 'one of the most important results from applied linear algebra and perhaps its most common use is as the first step in trying to analyses large data sets. In general terms, PCA uses a vector space transform to reduce the dimensionality of large data sets.

Using mathematical projection, the original data set, which may have involved many variables, can often be interpreted in just a few variables (the principal components).

The normalized components PI and P2 are computed from the obtained eigenvector.
The fused image is given by equation,

If(x,y)=P1I1(x,y)+P2I2(x,y)

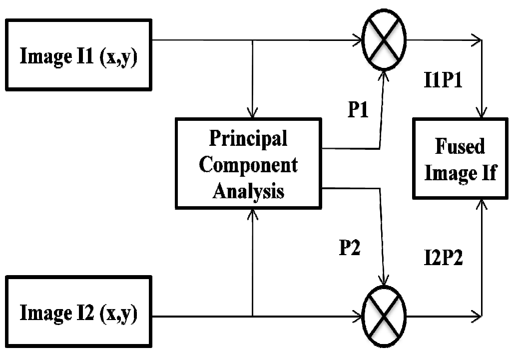

Fig 2: Image Fusion Process using PCA

1. **Algorithm of PCA:**

Let the source images be arranged in two-column vectors. The steps followed to project this data into 2-D subspaces are:
1. From the input images matrices arrange the data into column vectors. The resulting matrix Z is of dimension 2xn.
2. Then Compute the empirical mean along each column. The empirical mean vector Me has a dimension of 1 x 2.
3. Subtracting the empirical mean vector Me from each column of the data matrix S. The resulting matrix X is of dimension 2 x n.
4. Find the covariance matrix C of X i.e. C=XXT mean of expectation = cov(X).
5. Compute the eigenvectors V and eigenvalue D of C and sort them by decreasing eigenvalue. Both V and D are of dimension 2 x 2.
6. Finally consider the first column of V which corresponds to larger eigenvalue to compute PI and P2 as,

$$P_1 = \frac{v(1)}{\sum v} \text{ and } P_2 = \frac{v(2)}{\sum v}$$

II. MRI AND CT ANALYSIS

The paper forms fused images of CT [1][5] and MRI [1] image. Fused images can be created by combining information from multiple modalities, such as Magnetic Resonance Image (MRI) and Computed Tomography (CT).CT images are used more often to as certain differences in tissue density depending upon their ability to block X-rays while MRI [5][11] provides good contrast between the different soft tissues of the body, which make it especially useful in detecting brain tissues, and cancers. The fused image from multiple images produce an image which contains combined complementary and redundant information provided by both the source images i.e. the size of the tumor, the location through the various pixel values of the gray scale images, hence resulting into better visibility of tumor.

III. PERFORMANCE METRICS

Image fusion performance can be divided into two categories one with and one without reference images. In the present work, the performance measures are used to evaluate the performance of various fusion methods such as Peak signal to noise Ratio [6], Mean Square Error, Average Difference [2], Minimum Difference [12], Maximum Difference and Normalized Cross Correlation Methods. MR and CT images

[1] are taken as the reference image in the calculation of performance metric values.

A. Peak signal to noise Ratio

The PSNR is most commonly used as a measure of quality of reconstruction of loss compression codec's (e.g., for image compression). The signal in this case is the original data, and the noise is the error introduced by compression. When comparing compression codec's it is used as an approximation to human perception of reconstruction quality, therefore in some cases one reconstruction may appear to be closer to the original than another, even though it has a lower PSNR [12] (a higher PSNR would normally indicate that the reconstruction is of higher quality).

The PSNR is calculated by using following formula [10].

$$PSNR = 10log10\frac{MAX_I^2}{MSE}$$

After multiplying PSNR by 10 log 10 PSNR is converted into decibel i.e db is a unit of PSNR.

B. Mean Square Error

In a sense, any measure of the center of a distribution should be associated with some measure of error. If we say that the number t is a good measure of center, then presumably we are saying that t represents the entire distribution better, in some way, than other numbers. In this context, suppose that we measure the quality of t, as a measure of the center of the distribution, in terms of the mean square error [8].

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

C. Average Difference

Average Difference (AD) [7]is defined as:

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

The large value of AD means that the pixel values in the reconstructed image are more deviated from actual pixel value [10][3]. Larger value of AD indicates image is of poor quality.

D. Minimum Difference

C = normxcorr2 (template, A) computes the normalized cross-correlation of the matrices template and A. The matrix A must be larger than the matrix template for the normalization to be meaningful. The values of template cannot all be the same. The resulting matrix C contains the correlation coefficients, which can range in value from -1.0 to 1.0.

E. Maximum Difference

Difference between any two pixels such that the larger pixel appears after the smallest pixel. The large value of maximum difference [9] means that image is poor in quality.

$$MD = \max\left(\left|A_{ij} - B_{ij}\right|\right),\ i = 1,2,..m;\ \ j = 1,2,...n$$

F. Normalized Cross Correlation

The Normalized Cross Correlation [12][7] between the reference image R and the fused image F is defined as:

$$NCC = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(A_{ij} * B_{ij}\right)}{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(A_{ij}\right)^2}$$

IV. CONCLUSIONS AND FUTURE WORK

Finally this paper concludes that a image fusion algorithm based on combination of DWT and PCA with morphological processing will improve the image fusion quality and may be the future trend of research regarding image fusion. In this paper we study the Image Fusion techniques such as Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA). In future we discuss on the result occurring by using these techniques experientially and compare those values to check which technique is giving correct result. Thus the two different modality images are fused using the various fusion rules based on the Discrete Wavelet Transform.

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