The PET-MRI Brain Image Fusion Using Wavelet Transforms

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Abstract:

In this paper, PET and MRI brain images are fused using wavelet transforms. After wavelet decomposition and gray level fusion, by applying our method good fused result can be obtained, by adjusting structural information in gray matter (GM) area and patching the spectral information in white matter (WM) area. For testing and comparison we have used three datasets: normal axial, normal coronal, Alzheimer's disease brain images. The performance of our fusion method in terms of spectral discrepancy (SD) and average gradient (AG) proved to be better both visually and quantitatively.

Keywords— **PET image, MR image, image fusion, wavelet transform, average gradient (AG), spectral discrepancy (SD).**

I. Introduction

There are many medical image imaging methods with different imaging equipments, by which different medical images are produced. The images generated from Magnetic resonance imaging (MRI), positron emission tomography (PET), Computerized Tomography (CT), are used in the clinical treatments. The image data retrieved by different sensors have limit and difference in the geometry, spectrum, time and space resolutions, so it is hard to use just one type of image data. In order to have the more complete and accurate comprehension and knowledge of the target, one must find a technical method to make use of the different types of image data. So it is important to combine different types of

image data. Consider PET and MRI images, the former reveals the biochemical changes in color without anatomical information and latter reveals high-resolution anatomical information in gray intensity. The PET and MRI images are used by the doctors in order to diagnose the brain diseases as they contain important complementary information.

There are many methods for fusing PET and MRI images like principal component analysis (PCA), High-pass iltering (HPF), Intensity-hue-saturation (IHS) transform based fusion, wavelet transforms (WT) those are generally used. One of the method is HIS substitution method with which rich anatomical structural information can be obtained but color distortion occur [2,3]. Many multiresolution methods have been proposed to get fused result with less color distortion but the detailed structural information was found to be still missing. In order to regain missing information a new method is proposed where the image fusion based on wavelet transform is done by which good fusion result can be generated by adjusting the structural information in the gray matter (GM) area, and then atching the

spectral information in the white matter (WM) area. The performance of our fusion method is better in terms of two metrics spectral discrepancy (SD) and average gradient (AG).

II. **Image Fusion Based On Wavelet Transform**

The features of image which are sensitive to human visual system exist in different scales. It is necessary to preserve all the salient features in source images and should not introduce any artifacts or inconsistency that distracts human observer.

The decomposition and reconstruction of wavelet pyramid of source images are based on Mallat's MRA theories. The most important step for fusion is the formation of fusion pyramid. The wavelet-based approach is useful in performing fusion tasks for the following reasons. (1) It is a multi scale (multi resolution) approach well suited to manage the different image resolutions.

(2) The discrete wavelets transform (DWT) allows the image decomposition in different kinds of coefficients preserving the image information. Such coefficients from

different images are combined to obtain correct information from original images. (3) Once the coefficients are merged the final fused image is achieved by applying inverse discrete wavelet transforms.
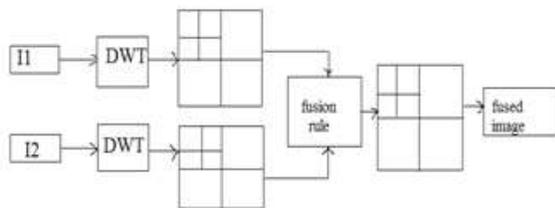
There are many advantages of image fusion The image fusion has several advantages in the field of digital image processing. The useful information can be gathered into a single image from multiple images which reduce the time complexity of processing. The image fusion improves the reliability of the resultant image by grouping the redundant Information into a single image. The capability of the image can be improved by having the complementary information in the fused image.

III. **Proposed methodology**

The Image fusion plays an important role in digital image processing and is used to fuse images captured from multiple sensors to enhance the content of image. The main objective of fusion to find the missing anatomical information in the gray matter (GM) and patching the spectral information in the white matter (WM) area, which is based on wavelet transformation and is different from regular simple DWT fusion method.
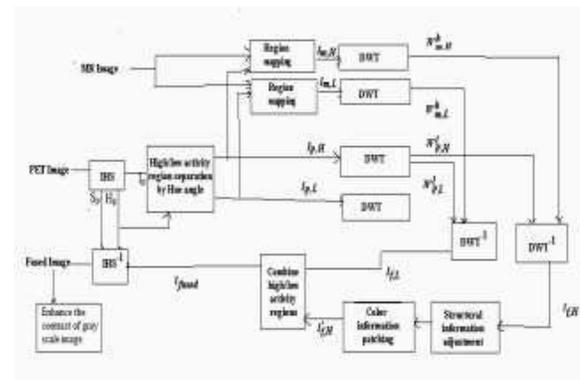

Fig.2The block diagram of proposed method

The fig.2 shows the proposed method. In the first step the PET and MRI images are taken, and HIS transformation is applied such that the PET image is decomposed into intensity, hue and saturation components. In the PET image here is color difference between high and low activity regions, and in order to differentiate between them hue angle is used. The region of interest (ROI) is extracted from the PET and MRI images

using Region-mapping technique. The PET image is color image, in which high activity and low activity region gives structural information and spectral information respectively.

The wavelet transformation is applied to high and low activity regions to obtain good color preservation. Then we combine the wavelet co-efficient of PET and MRI image of high and low activity region separately and inverse wavelet transforms is applied. In the obtained fused result after the inverse wavelet transformation, the high activity region will be lacking some anatomical structural information in the Gray matter (GM) because GM pixel intensity which is near to WM is close to WM pixel intensity. This pixel intensity difference can be adjusted by fuzzy c means algorithm (FCM). FCM is a data clustering technique in which a dataset is grouped into n clusters, where data belongs to a cluster up to certain degree. To find the lacking structural information the average difference (Davg) between the I component pixel intensity of original PET image and gray level fused image is calculated.

$$D_{avg}(x,y) = \frac{\sum\limits_{(m,n) \in R_w \cap B(x,y)} (I_{p,H}(m,n) - I_{fH}(m,n))}{|R_w \cap B(x,y)|}$$

The pixel intensity of high component of fused image (If,H) is higher than high component of pet image (Ip,H), therefore Davg is negative. The intensity level for each non-WM pixel in I component fused image can be lowered down using the below formula.

$$I_{fH}(x,y) = I_{fh}(x,y) + w \times D_{avg}(x,y)$$

Where $I_{f,H}(x,y)$ can be replaced by $I_{p,H}(x,y)$. The pixel intensity for each non WM pixel can be reduced by adjusting w=50% or w=70%. The low and high activity components are combined to obtain If used, which represents I component of fused image. The Sp, Hp, and If used are taken together and inverse HIS transformation is applied. To enhance the contrast of gray scale image, Adapthisteq method is applied on the fused image. The spectral quality of image is measured by spectral discrepancy (SD) of fused image, and spatial resolution of an image is measured by average gradient (AG).

The fusion result is acceptable if SD is smaller and AG is higher [10]. The fusion of PET and MRI images are Performed, SD and AG values are tabulated for different values of w=50% and w=70% and comparison of fused result is done.

IV. Experimental Results

The image fusion provides an easy way to gather the useful information from multiple images. The test data consist of PET and MRI brain images where dataset -1, dataset -2, dataset -3 are normal axial, normal coronal and lzheimer

diseases respectively, taken and fused based on our proposed method. The spectral discrepancy of fused image gives spectral quality of that image and average gradient is used to measure the spatial resolution of the image. The different values of SD and AG values are calculated by varying the percentage of w for 50% and 70% in our implementation.
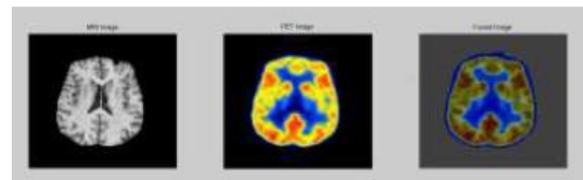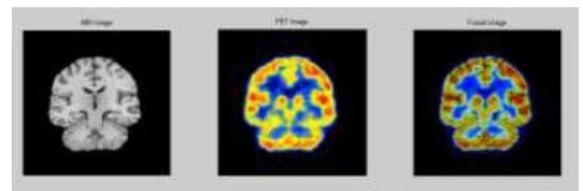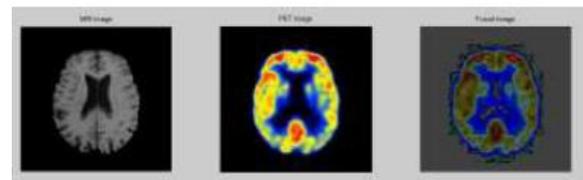

(a)

(b)

(c)
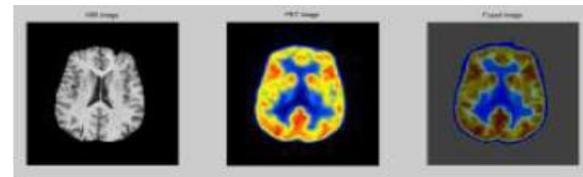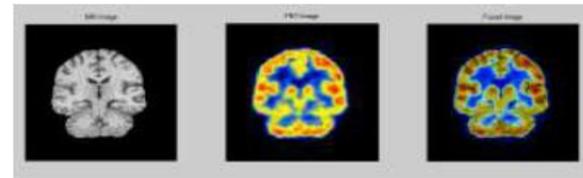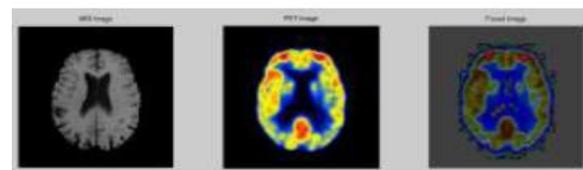
The fig (a), (b), (c) shows the fusion result for the existing method when w=50%

(d)

(e)

(f)

The fig (d), (e), (f) shows the fusion result for our method when w=50%

Table1. Performance comparison based on Average Gradient

Average gradient based on Existing method			
Fusion	Dataset1	Dataset2	Dataset3
When w=0.5	4.6574	7.7659	6.9527
When w=0.7	5.168	8.7693	8.0089
Average gradient based on Our method			
When w=0.5	4.6574	9.9193	6.9527
When w=0.7	5.168	8.6098	9.4414

Table1. Shows the performance comparison based on w=50% and w=70% for the existing method and our method for average gradient (AG) which is increasing when our proposed method is applied.

Table2. Performance comparison based on Spectral Discrepancy

Spectral discrepancy based on existing method			
Fusion	Dataset1	Dataset2	Dataset3
When w=0.5	5.2418	7.7991	2.5911
When w=0.7	2.4176	7.8178	0.3951
Spectral discrepancy based on our method			
When w=0.5	5.2418	5.2768	2.5911
When w=0.7	2.4176	8.3077	0.3951

Table 2 shows the performance comparison based on w=50% and w=70% for the existing method and our method for spectral discrepancy (SD) which is similar for dataset -1and dataset-3 and is decreasing for dataset -2 when our proposed method is applied. The proposed method is suitable for obtaining fused result with high average gradient (AG) which gives spatial resolution of image but fails in obtaining low spectral discrepancy (SD).

V. Conclusion

The image fusion helps in having useful information from multiple images in a single image. The fusion of PET and

MRI brain disease images for the proposed method produces the higher average gradient by which the spatial resolution of image is higher. The spectral discrepancy for dataset 1 and dataset -3 produces same result as the existing method only dataset -2 is changes to lower values. Hence the spatial resolution of the image is higher when used our proposed method. However different techniques may be developed to improve the spectral quality of the image.

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