Image Fusion of PET and CT Images based on Wavelet Transform

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ABSTRACT
Image fusion is one of the important branches of data fusion. Its purpose is to combine multi-image information in one scene which is more suitable to human vision or more adapt to further image processing such as target identification. In this paper image fusion algorithm based on wavelet transform is proposed to improve quality of image and meet the needs of applications of vision. Two or more images to be fused should be firstly decomposed into sub images with different frequencies. Then, the sub images are fused to reconstruct image. PET/CT medical image fusion has important clinical significance. As the wavelet transform has several particular advantages in comparison with scalar wavelets on image processing. Experimental results show that fusion image combines information of source images, adds more details and texture information and a good fusion result.

Keywords
PET/CT images, Image fusion, Wavelet Transform.

1. INTRODUCTION
Image fusion is the process which fuses multiple images. It aims to improve the quality of image. Firstly, images are decomposed using wavelet transform. Then, images in approximate channel and detail channel are fused according to proposed assumption. Finally, decomposed are synthesized to form fused image. [2] In the pixel-level image fusion, the fusion takes place directly at the pixel level. Medical Image Fusion is a sort of data fusion and developed from that into a new data fusion technology. Computed tomography (CT), and positron emission tomography (PET) provide data conditioned by the different technical, anatomical and functional properties of the organ or tissue being studied, with values of sensitivity, specificity and diagnostic accuracy variations between them. Their fusion enables the "unification" of the various technique-dependent data, thus "summing" the diagnostic potential of each individual technique.[4] Because of the image fusion technology which can effectively integrate the image information, the fusion images are more intelligible and readable and have more information than the images that are got through single channel, and this technology has been concentrated very much, and has had a great development.[6] PET and CT fusion on the same machine is a typical representative of the multimodal medical image fusion technology. One image can get PET and the corresponding parts of CT. It combines the advantages of both and provides a reliable basis for diagnosis. PET/CT image fusion has become a research hotspot at present. [7]There are many multimodal medical image fusion methods. Because of the good sub-frequency features in the transform domain, the wavelet transform has been widely used. Multi wavelet is an extension from wavelet theory, and has several particular advantages in comparison with scalar wavelets on image processing. [12] It can simultaneously posses many desired properties such as short support, symmetry and smoothness. The purpose of image fusion is to reduce the ambiguities and maximize the fusion information. Medical image fusion is to collect the information of multimodality image together to express information got multi-modal images in one image at the same time to highlight their respective advantages, to carry out complementary information and to provide comprehensive morphology and functional information which reflects physiological and pathological changes.[14] In order to obtain good fusion images , the pixel level fusion algorithms have been improved from the weighted average method, principal component analysis and pyramid image fusion algorithm to the wavelet transform.[15] However, wavelet transform has its own short comings, such as shift sensitivity and lack of orientation selectivity.

2. COMPUTED TOMOGRAPHY
A computed tomography (CT) scan, also called a CAT scan, uses x-rays to take pictures of the head from many different angles. The pictures provide a detailed, cross-sectional view of specific areas of the brain. CT scans are widely used and less expensive than other scanning technologies. A CT scan shows changes in bone better than any other imaging method. It is also the only scanning technique that shows images of bone, blood vessels etc. at the same time. A CT scan is often used in emergency rooms because it can be performed quickly to screen people who have had some type of trauma, a stroke or other life-threatening condition. CT scans are used to help diagnose many medical conditions including strokes, head trauma, tumors, hydrocephalus, blood clots, cerebral atrophy, internal bleeding, skull fractures, brain aneurysms, and hearing loss. CT scans are not used to diagnose Alzheimer's disease. They are used to confirm or rule out other causes of dementia in people who show signs of memory loss.

3. POSITRON EMISSION TOMOGRAPHY
A PET image helps to diagnose various diseases such as brain tumors or torn ligaments. PET scan is a test that provides very clear pictures of structures inside the body. PET image provides clear soft tissues information but no bones information. That is to say, the same object in the two medical images appears very distinctly. Hence, in order to support more accurate information for diagnosis and treatment it is necessary to fuse them by using their complementary information.

4. PROCESS OF IMAGE FUSION

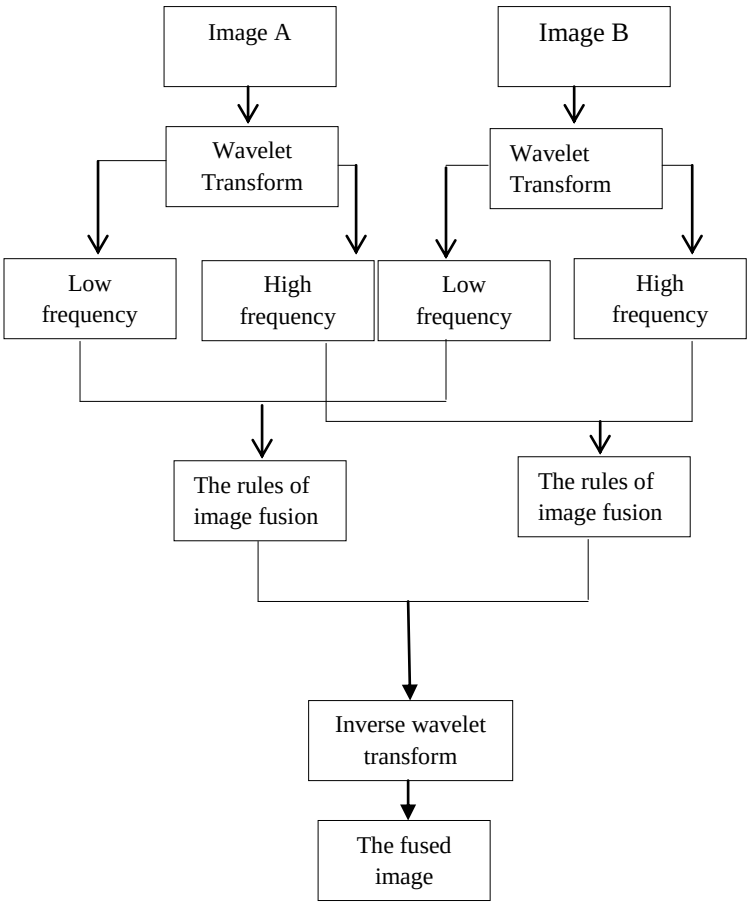


Figure 1: Process of image fusion

Figure 1 explained that how image fusion performs firstly load image 1 then load image 2 after that use wavelet transform, after that apply the fusion rules and then take inverse discrete wavelet transform to get the fused image with better quality and reliability and also for the clear vision.

4.1 Discrete Wavelet Transform

Wavelet transform provides a framework in which a signal is decomposed, with each level corresponding to a coarser resolution or lower frequency band, and higher frequency bands. There are two main groups of transforms, continuous and discrete. Of particular interest in DWT, which applies a two channel filter bank (with down sampling) iteratively to the low pass band (initially the original signal). The wavelet representation then consists of the low pass band at the lowest resolution and the high pass band obtained at each step. This transform is invertible and non redundant. The DWT is a spatial domain decomposition that provides a flexible multi resolution analysis of an image. In a 2-D DWT, a 1-D DWT is first performed on the rows and then columns of the data by separately filtering and down sampling, this result in one set of approximation coefficients.

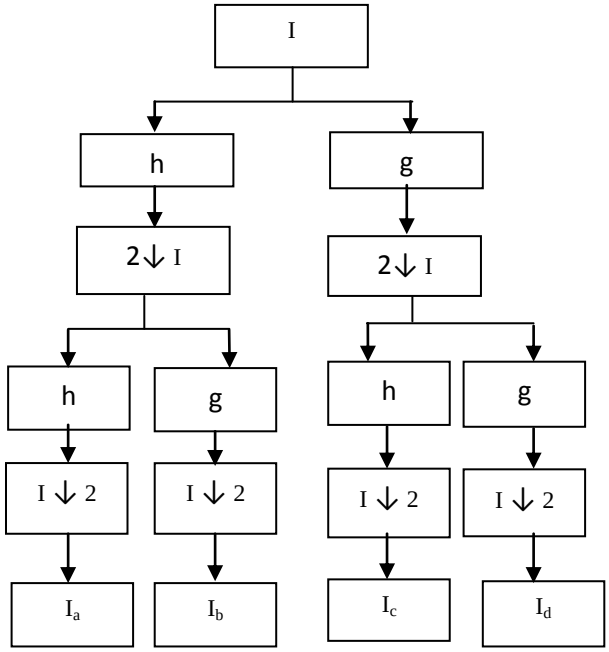


Figure 2: structure of 2D-DWT

In the language of filter theory, these four sub images correspond to outputs of low-low (I_a), low-high (I_b), high-low(I_c), and high-high (I_d) bands. By recursively applying the scheme to the LL sub band multi resolution decomposition with a desire level can be achieved.

4.2 Flow chart of algorithm

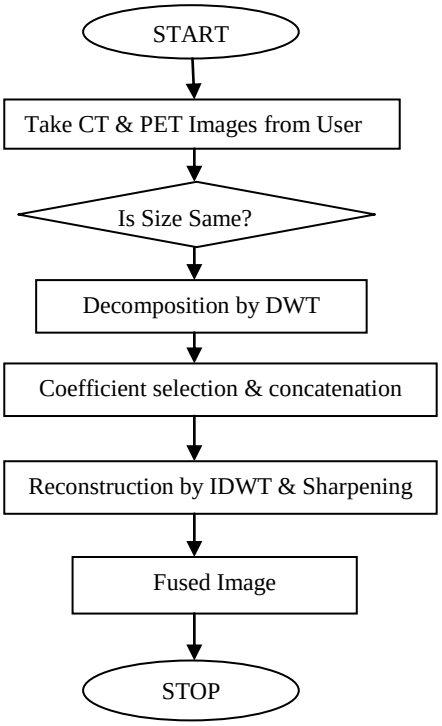


Figure 3: Flow chart

5. MATLAB SIMULATION

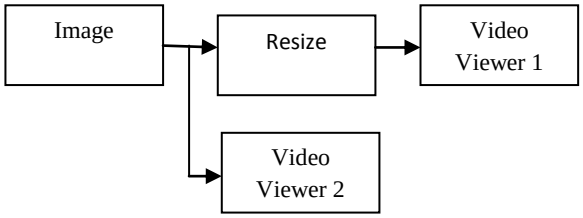


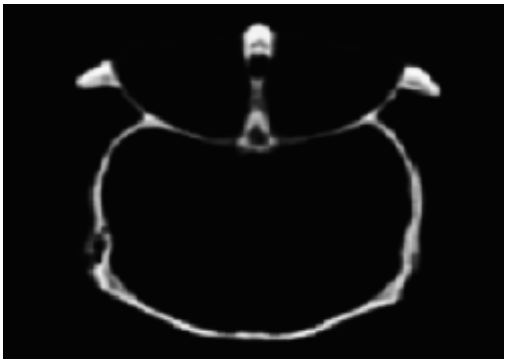
Figure 4: Image Resizing Block

Figure 4 explained that how to resize images before performing the image fusion. To perform image fusion with wavelet toolbox it is required that both images should be of same size and same type.

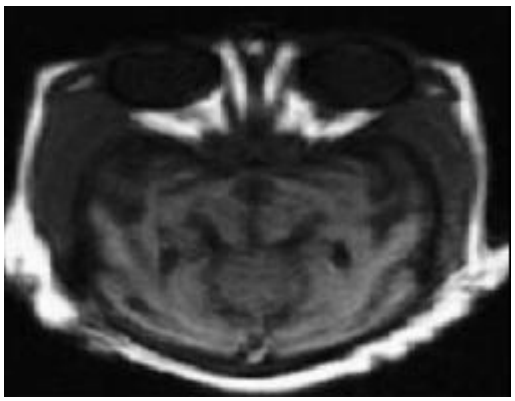
5.1 Performance steps in MATLAB

1. Select 1st input image (CT image) from the location which is of size m*n.
2. Select 2nd input image (PET image) from the location which is of same size m*n.
3. Decompose both the images by using Discrete Wavelet Transform.
4. Select the Wavelet coefficients from both the images and concatenate them to form a single Decomposed image.
5. Reconstruct the image by using inverse discrete Wavelet Transform.
6. Use sharpening algorithm to get final fused image.

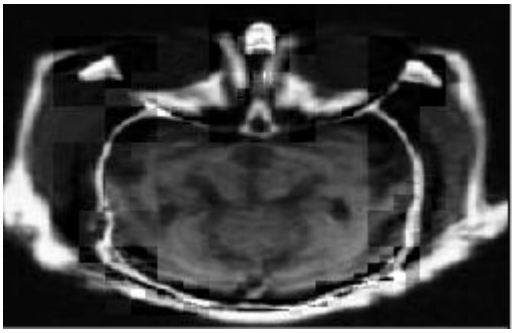
5.2 Experimental Result



Original CT image



Original PET image



Fused image

Table1. Parameters of Input Image

Parameters	CT image	PET image
Entropy	4.5632	5.8631
Mean	70.1758	58.9008
Standard Deviation	50.5395	55.2423
Variance	$2.5468e^{+03}$	$3.2478e^{+03}$

Table2. Parameters of fused image

Parameters	Fused Image
Entropy	0.0032
Mean	80.4382
Standard Deviation	53.4043
Variance	$2.8713e^{+03}$
MSE	$5.4364e^{-07}$
PSNR	61.8984

6. CONCLUSION

In conclusion, using wavelet transform we get a good fusion image of CT/PET compared to the single CT or PET. We can obtain fusion images with more details and more comprehensive information using medical image fusion technology. This kind of image is able to provide reliable basis for the doctor's diagnosis and treatment. We also made the algorithm implementation in this paper. From the experimental results, we can see that the fusion image has more details and the texture is more clearly. So the algorithm proposed in this paper is an effective method for the fusion of medical images.

7. REFRENCES

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