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IMPLEMENTATION OF MRI AND PET BRAIN IMAGE FUSION USING DWT AND AHE

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Abstract— Image fusion technique integrates suitable information from various modalities of input images into a fused distinct image where the resultant image provides better information in comparison with the input images which are used for fusion and is more appropriate for visual perception. This work presents an approach for image fusion which performs wavelet decomposition for both PET and MRI brain images with different activity levels. This method generates promising fusion results by varying the structural information in the gray matter area and the spectral information in the white matter area to have better color preservation. Moreover, to produce good spectral resolution, smoothing filters is applied as a part of preprocessing and Adaptive Histogram Equalization(AHE) is performed at the end to obtain a high contrast fused output image. With fast advancement in technology, it is currently conceivable to have data from multi-source images to produce a great fused image. The result of image fusion is always to interchange image that has remaining parts probably the most attractive information and qualities of input image. The key objective of image fusion is to mix information from multiple images of exactly the same picture in order to transport only the useful information.

Index Terms— Image fusion, Multimodal images, Medical imaging, Spatial resolution, IHS Transform, Discrete wavelet transform.

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1 Introduction

MEDICAL images from various modalities frequently contain complementary information which will be highly required in clinical diagnosis. For example, MRI images shows evidently the extent of a tumor in relation to other soft tissues but not describes whether the tumor has invaded any of the bony structures, while CT images shows clearly the bone involvement but gives poor images of the soft tissue extent of the tumor, Positron Emission Tomography (PET) image reveals actual information of flow of blood but lacks boundary information and so on. Image fusion can form a single composite image from the different modalities of images and then provide reliable source to further investigation and diagnosis. But it is necessary to align two images accurately before they can be fused. The resolution of MRI image in gray intensity is high compared to PET image, while PET images gives detailed information of the biochemical changes such fluid flow etc[10]. Fig.1. MRI and PET brain images in coronal view.In medical field, it is highly desired to have both the image characteristics for effective diagnosis and treatment. Thus, fusing two different medical images into a single image with both anatomical structural and spectral information is highly required. The objective of this work is to integrate these processes and to produce satisfactory and promising fusion results. By the process of image fusion the good information from each of the given images is fused together to form a resultant image whose quality is superior to any of the input images .This is achieved by applying a sequence of operations applied on the images that would make the good information in each of the image prominent. The fused image is constructed by combining magnified information from the input images .Image Fusion is helpful in various fields like medical imaging, microscopic imaging, analysis of images from satellite, remote sensing Application, computer graphics vision, roics etc[3].

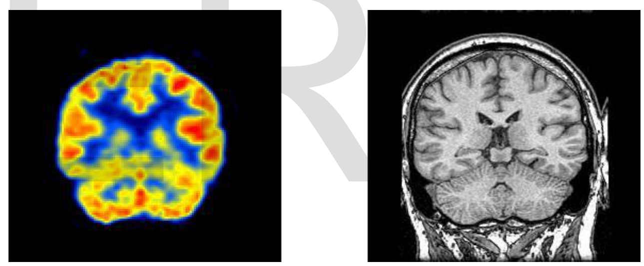

Fig. 1. MRI and PET brain images in coronal view.
Image Courtesy: www.med.harvard.edu[13].

2 Literature Survey

The Bhavana. V and Krishnappa. H.K presented a detailed literature review done on image fusion and also the concepts and materials that helps for clear understanding of various fusion techniques[2].

Rohit Kempanna Atyali and Shivchandra R Khot presented a method consisting of application of Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA) based fusion to multi-modality medical images, resulting in an easy and reliable technique to detect cancerous tissues through image fusion[8].

Maruturi Haribabu, C.H.Hima Bindu, Dr.K.Satya Prasad proposed three methods: pixel level based image fusion in which the input images are fused pixel by pixel, feature-level based image fusion in which the information is extracted from each input image separately and then fused, decision-making based

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image fusion in which the information is extracted from each input image separately and then decisions are made[5].

Tanish Zaveri and Mukesh Zaveri proposes a novel region based image fusion scheme based on high boost filtering concept using discrete wavelet transform[3].

To overcome the limitations observed among several algorithms discussed a new method has been proposed.

3 Proposed Method

The system architecture of the proposed method is shown in Fig. 2 Here, MRI and PET images are taken as its input for preprocessing and fusion.PET image is firstly decomposed into its Intensity Hue Saturation (IHS) transform and thus the information of high activity region is differentiated from the low activity region of PET image by making use of "hue angle" obtained from the IHS transform[1]. PET image contains different activity levels represented by different colours. In some region of the brain, there will be very fast blood flow,oxygen flow or at some part of the brain, there may be high metabolism rate. These represents high activity region. After preprocessing, the quality of the input PET image is enhanced by Gaussian filters. The enhanced image is then fused based on Discrete Wavelet Transform (DWT) for brain regions with different activity levels[2]. When wavelet transform is applied over a 2-D signal on an image, the image is decomposed into different frequency filters. Then we combine low frequency coefficients of MRI and PET images and perform the inverse DWT to obtain the fused result for the fused low frequency output. Similarly by combining high frequency coefficients of PET and MRI images into a complete set of wavelet coefficients and performing the inverse DWT, we can obtain the fused result for the high activity region[3].

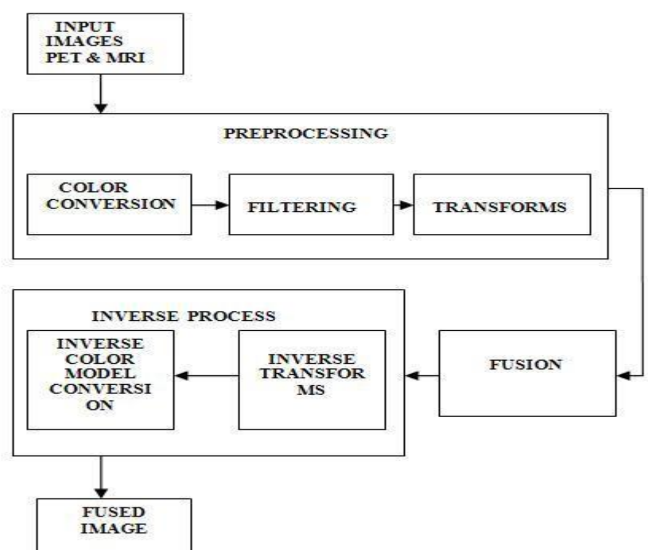

Fig.2. System Architecture

The image processing based approach is developed in MATLAB. The steps included are as follows[4]:

- Input images
- Preprocessing
- Fusion
- Inverse process
- Fused Image

Input Images: MRI and PET images are taken as its input for preprocessing and fusion.

Preprocessing: It is necessary to align two images accurately before they can be fused.PET image is firstly decomposed into its IHS transform and thus the information of high activity region is differentiated from the low activity region of PET image by making use of "hue angle" obtained from the IHS transform.

Fusion: The enhanced image is then fused based on Discrete Wavelet Transform (DWT) for brain regions with different activity levels.

Inverse Process: Separately combine low and high frequency coefficients of MRI and PET images and perform the inverse DWT to obtain the fused result.

Fused Image: Fused output image should be obtained with less color distortion.

4 Result

The demonstrated application has been experimented with various inputs and the results are analyzed for its performance indices like Mean Square Error (MSE),Peak Signal to Noise Ratio (PSNR),Spectral Discrepancy(SD)and Average Gradient (AG)[5].The experimental dataset includes PET and MRI images taken from the website[13] www.med.harvard.edu for pre processing and fusion.A total of 2 set of brain diseases like Normal Axial and Normal Coronal disease are used as the experimental datasets for fusion. This work is executed in MATLAB which provides an easy to- use platform for a wide range of computational problems. Graphic User Interface (GUI) is developed which helps the user to interact with the system .GUI will ask for the default parameters in a message box for the corresponding modules chosen by the user.GUI displays the input PET and MRI images, various processes including filtering, color conversion, wavelet transform, fusion and adaptive histogram equalization for obtaining high contrast fused output image. GUI also enables to identify all four performance indices such as Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Spectral Discrepancy (SD) and Average Gradient (AG). The screen shot of the GUI Screen is shown in Fig. 3.

Fig. 3. GUI when the application is started

Fig. 4 and Fig. 5 shows the GUI performing various processes such as color conversion, wavelet transform, inverse wavelet transform, image fusion, enhanced fusion output using adaptive histogram equalization and to analyze various performance indices such as PSNR, MSE, AG and SD for Normal Axial and Normal Coronal brain diseases[6].

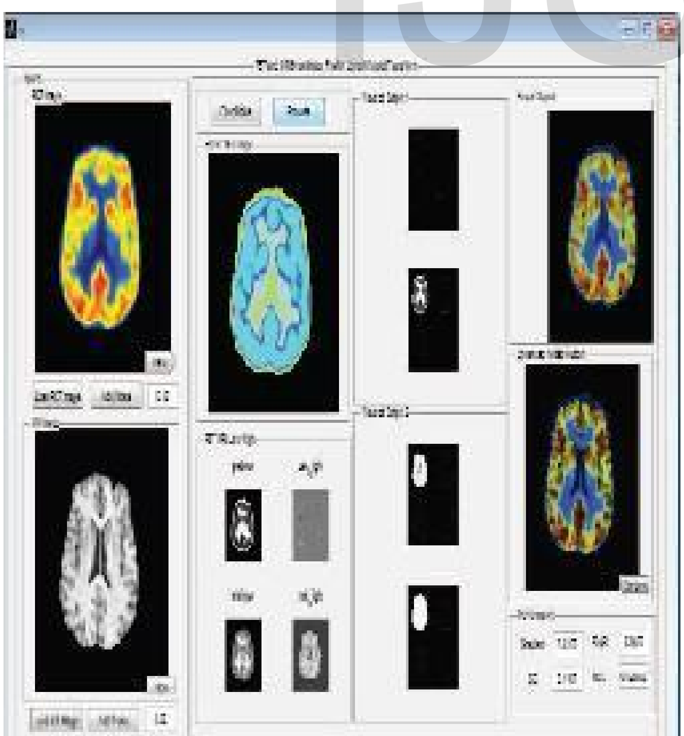

Fig. 4. GUI performing various processes to analyze the high contrast fused output for Normal Axial Brain Disease

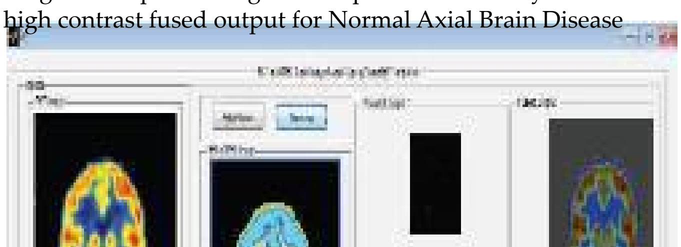

Fig. 5. GUI performing various processes to analyze the high contrast fused output for Normal Coronal Brain Disease

Fig. 6 and Fig. 7 shows the comparison of input PET and MRI images with the fused output for Normal Axial and Normal Coronal Brain Disease.

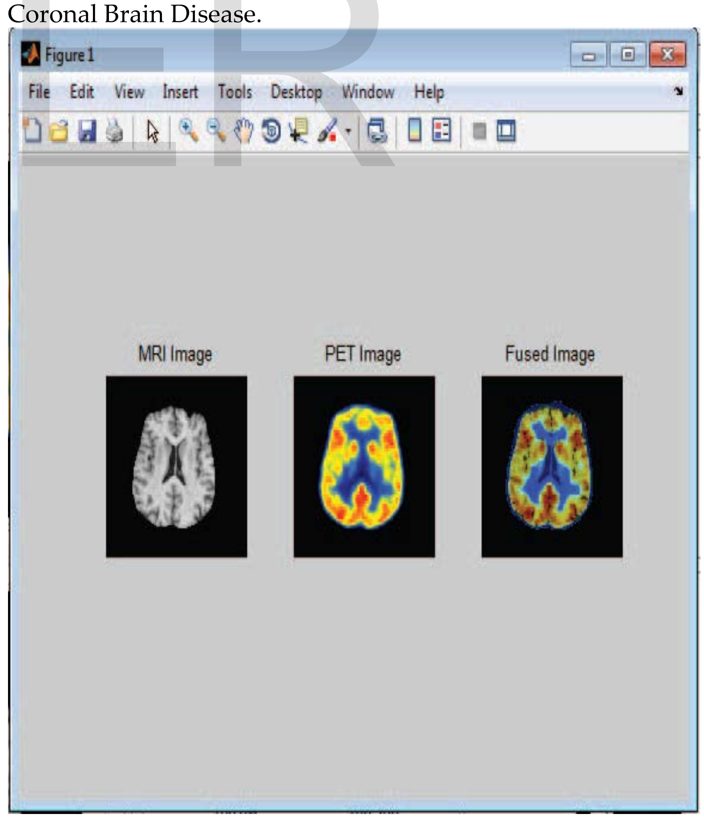

Fig. 6.PET and MRI images with the fused output for Normal Axial Brain Disease

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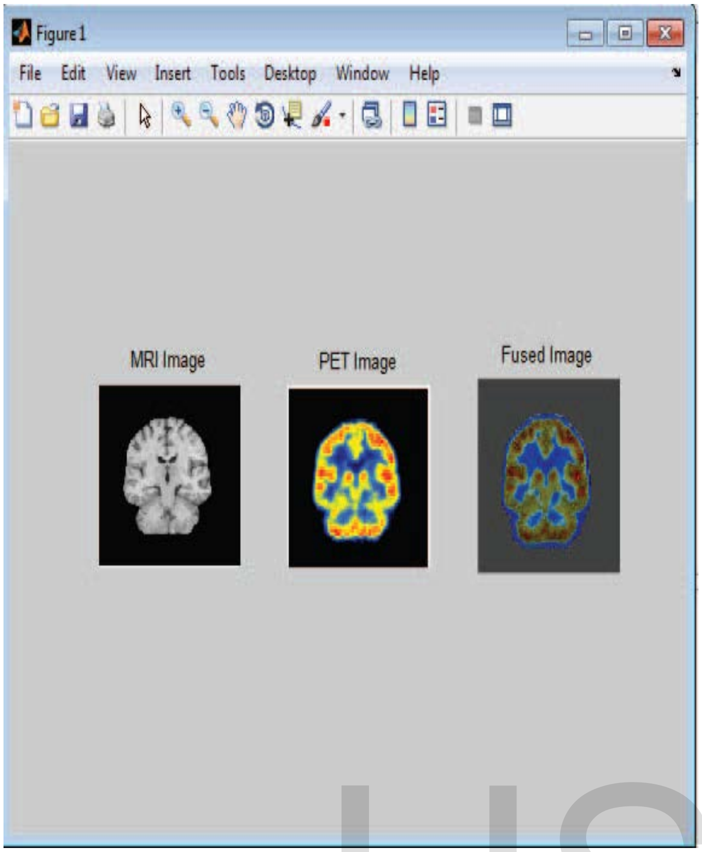

Fig. 7. GUI comparing input PET and MRI images with the fused output for Normal Coronal Brain Disease

TABLE I

PERFORMANCE INDICES EVALUATION FOR NORMAL AXIAL BRAIN DISEASE

Fusion Method	MSE	PSNR	AG	SD
IHS+RIM Method	0.046	56.37	5.3603	8.7061
Our Method	0.028	63.65	5.6265	8.1187

TABLE II

PERFORMANCE INDICES EVALUATION FOR NORMAL CORONAL BRAIN DISEASE

Fusion Method	MSE	PSNR	AG	SD
IHS+RIM Method	0.236	52.43	5.2927	7.9031
Our Method	0.1153	57.51	5.4657	4.9117

TABLE I and II represents the performance metrics comparison of the proposed method with the existing IHS+RIM Model for normal axial and normal coronal brain diseases.

If the spectral discrepancy is less, then the fusion results will be more good and if the average gradient is high, then the spatial resolution of fused output will be more. Experimental results demonstrated that our fused results for PET and MRI normal axial & PET and MRI normal coronal brain images have less color distortion and richer anatomical structural information than those obtained from the existing method visually and quantitatively and by using adaptive histogram equalization in the fused image, high contrast output image is also achieved[7]. Also, from the inference of results we can conclude that high contrast fused output image has low average gradient and high spectral discrepancy which provides promising results.

5 Conclusion

In this paper, a new fusion method based on wavelet transform with MRI and PET brain images is proposed with less color distortion and with high contrast output using adaptive histogram equalization. Experimental results reveal that the fused image for normal axial and normal coronal disease brain images have very good structural information and less color distortion. The research can be further extended by using other multi-modality medical images with color and gray scale information and using an integration of complex wavelets for fusion to preserve the edge information.

References

[1] P. A. Van den Elsen , Evert-Jan D.Pol et al, "Medical image matching –a review with classification",*IEEE Engineering in Medicine and Biology*, March 1993, pp. 26-38.

ISSN 2229-5518

[2] Bhavana.V, Krishnappa H.K, “Multi – Modality Medical Image Fusion–
A Survey”, International Journal of Engineering Research &Technology
(IJERT), Vol.4, Issue 02 , 2015, pp. 778-781.

[3] TanishZaveri, MukeshZaveri, “A Novel Region Based Multifocus Image Fusion Method”, *IEEE International Conference on DigitalImage Processing*, 2009

[4] S.Daneshvar and H.Ghassemian, “MRI and PET image fusion by combining IHS and retina-inspired models*”,IEEE International Conference on Information Fusion*,vol.11,2010, pp.114-123.

[5] Maruturi Haribabu, CH Hima Bindu, Dr. K. Satya Prasad, “Multimodal Image Fusion of MRI-PET Using Wavelet Transform”,*IEEE International Conference on Advances in Mobile Network,Communications and its Applications*, 2012

[6] Po-Whei Huang, Cheng- I Chen, Phen- Lan Lin, Ping Chen, Li-PinHsu,
“ PET and MRI Brain Image Fusion Using Wavelet Transform with Information Adjustment and Spectral Information Patching*”, IEEE International Symposium on Bioelectronics and Bioinformatics*, 2014.

[7] C. Di Ruberto, A. Dempster, S. Khan and B. Jarra, “Segmentation of blood images using morphological operatorsî”, Proceedings of 15th International Conference on Pattern Recognition Barcelona, Spain, vol. 3,pp. 3401, 2000.

[8] Rafael C. Gonzalez, Richard E. Woods,”Digital Image Processing” Third Edition (2009).

[9] Y. Zhong, K. Karu et.al, "Locating Text in Complex Color Images,"Pattern Recognition, vol. 28, no. 10, pp.1523-1535, October 1995.

[10] Fusion of MRI and PET images using DWT and Adaptive Histogram Equalization, Bhavana.V,Krishnappa. H. K.

[11] Digital image processing using MATLAB by Rafael C.Gonzalez,RichardE.Woods.

[12] Fundamentals of digital image processing using MATLAB by Anil K.Jain.

[13] www.med.harvard.edu.