MULTIMODALITY MEDICAL IMAGE FUSION FOR CLINICAL DIAGNOSIS

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ABSTRACT

The rapid development in high-technology and modern instrumentations, medical imaging has become a vital component of a large number of applications, including diagnosis, research, and treatment. Medical image fusion is the idea to improve the image content by fusing images taken from different imaging tools like Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET) and single photon emission computed tomography (SPECT). For medical diagnosis, Computed Tomography (CT) provides the best information on denser tissue with less distortion. Magnetic Resonance Image (MRI) provides better information on soft tissue with more distortion. In this case, only one kind of image may not be sufficient to provide accurate clinical requirements for the physicians. Therefore, the fusion of the multimodal medical images is necessary. The idea is to improve the image content by fusing images like computer tomography (CT) and magnetic resonance imaging (MRI) images, so as to provide more information to the doctor and clinical treatment planning system. So enhancing the image and performing best fusion technique lead to a good and clinical result. This paper presents a hybrid technique using curvelet and wavelet transform used in medical diagnosis. In this technique the image is segmented into bands using wavelet transform, the segmented image is then fused into sub bands using curvelet transform which breaks the bands into overlapping tiles and efficiently converting the curves in images using straight lines. These tiles are integrated together using inverse wavelet transform to produce a highly informative fused image. These two fusion techniques are extracted and then fused implementing hybrid image fusion method, findings shows that fused image has minimum errors and present better quality results. The Peak signal to noise ratio value for the hybrid method is high when compared to the other two fused images. This shows that the quality of fused image is better in case of hybrid method.

Keywords: Curvelet transform, Hybrid image fusion, Image fusion, Wavelet transform

I. INTRODUCTION

Fusion of two or more images of the same scene to form a single image is known as image fusion. Image fusion process combines the relevant information from two or more images into single image therefore the resultant fused image will be more informative and having important features from each image. Image fusion is important in many different image processing fields such as satellite imaging, remote sensing and medical imaging. Several fusion algorithms have been evolved such as pyramid based, wavelet based, bravery, HIS (Intensity Hue Saturation), color model, PCA (Principal Components of Analysis) method. But all of them lacks in one criteria or the other [1]. Fusion of medical images should be taken carefully as the whole diagnosis process depends on it. Medical images should be of high resolution with maximum possible details [2]. The medical images should represent all important characteristics of the organ to be imaged so the integrated image should present

maximum possible details. Therefore our aim is to adopt the best method of image fusion so that the diagnosis should be accurate and perfect [3].

Wavelet method was supposed to be one of the most promising methods of image fusion due to its simplicity and ability to preserve the time and frequency details of the image to be fused. Wavelet Fusion transforms the images from spatial domain to wavelet domain. The wavelet domain represents the wavelet coefficient of the images [4, 5]. The wavelet decomposition is performed by passing the image into series of low pass and high pass filters.

In this method the input signal goes through two one dimensional digital filters. One of them performs high pass filtering and the other performs low pass filtering. The various filter bands are produced and each band producing images of different resolution levels and orientations. These sub bands are then combined using inverse wavelet transform. Fig. 1 shows the schematic process of fusion of two images into single fused image [6-8]. The curvelet transform is used to represent the curved shapes. This transform represents edges better than wavelets. The fused image obtained yields higher details than the original image due to edge representation thereby preventing image denoising. It is based on the segmentation of the whole image into small overlapping tiles and then the ridgelet transform is applied to each tile [9]. Segmentation approximates the curved lines by small straight lines. Overlapping of tiles avoid edge effects.

Wavelet transform does not give good details about edges of the images so we are proposing hybrid of wavelet and curvelet transform techniques

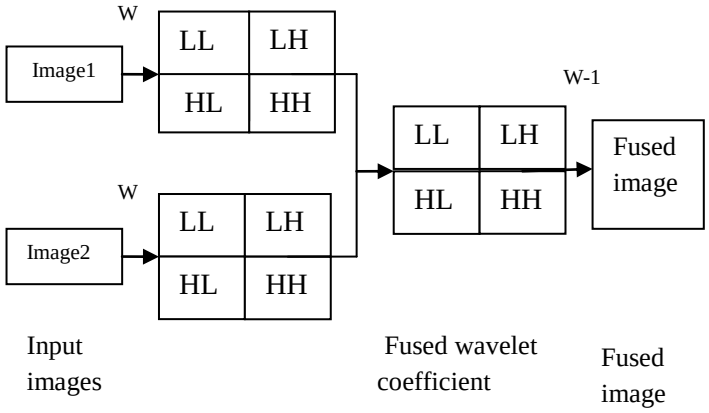


Figure1 Systematic Process of Wavelet Transforms

II. PROPOSED WORK (HYBRID IMAGE FUSION TECHNIQUE

A single method of fusion may not be as efficient as it always lacks in one point or the other. Therefore the need of developing a method which takes into consideration the advantages of various different fusion rules. Thus the Hybrid Image fusion is used. It performs processing of the image based upon the different fusion rules and then integrates these results together to obtain a single image. The results of various fusion techniques are extracted and then they are again fused by implementing a hybrid method presenting better quality results. A single method may not effectively result in removing the ringing artifacts and the noise in the source images. These inadequacies result in development of fusion rules which follow a hybrid algorithm and improve to great extent the visual quality of the image [13].

2.1 Proposed Work (Hybrid of Wavelet And Curvelet Fusion Rules

Curvelet based image fusion efficiently deals with the curved shapes, therefore its application in medical fields would result in better fusion results than obtained using wavelet transform alone. On the other hand wavelet transform works efficiently with multifocus, multispectral images as compared to any other fusion rule. It increases the frequency resolution of the image by decomposing it to various bands again and again till different frequencies and resolutions are obtained. Thus a Hybrid of wavelet and curvelet would lead to one of the best method that could be used for fusion of medical images.

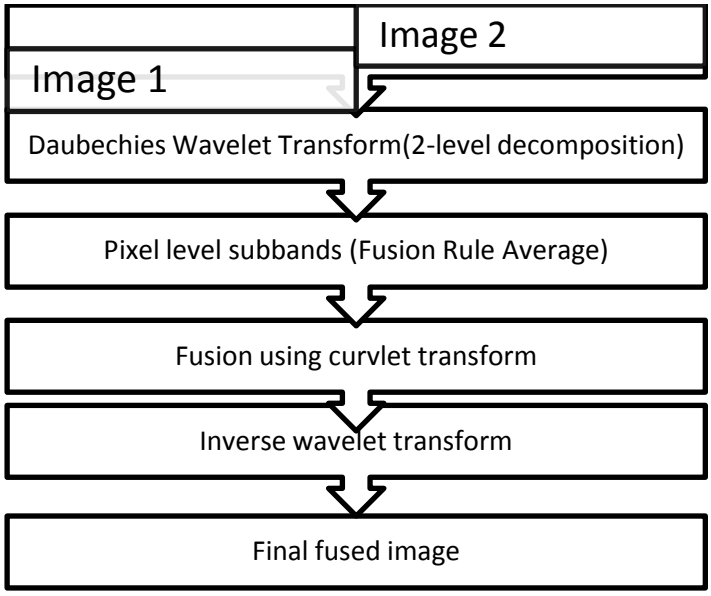


Figure 2 Proposed Work For Fusing Medical Images Using Hybrid Transform

A hybrid of wavelet and curvelet integrates various pixel level rules in a single fused image. Pixel based rules operates on individual pixels in the image but ignores some important details such as edges, boundaries of the image. Wavelet based rule alone may reduce the contrast in some images and cannot effectively remove the ringing effects and noise appearing in the source images .Curvelet method can work well with edges and boundaries and curve portions of the images using ridgelet transforms. In the hybrid method first the decomposition of the input images is done up to level N by passing the image through series of low and high pass filters. The low and high pass bands are then subjected to curvelet transform by decomposing it further into small tiles and then fused using wavelet transform and inverse wavelet transform to get full size images. This will take into account the drawbacks of wavelet and effectively remove it using curvelet transform and visual quality of the image is improved. Wavelet transform of an image up to level N till different resolution is obtained. This gives various frequency bands the procedure of combining image 1 and image 2 into single fused wavelet coefficientsThese bands obtained are then passed through curvelet transform which segments it into various additive components each of which is subband of the image. These bands are then passed through tilting operation which divides the band to overlapping tiles. The tiles are small in dimension to transform curved lines into small straight line and overlapping is done so as to avoid the edge effects. Tilting operation is performed after subband filtering of the filter bands. Finally these overlapped tiles are passes through ridgelet transform which is a kind of 1-D wavelet transform helps in wavelet transform in Random Domain which helps in shape and edge detection (figure 3) band obtained by wavelet transform. Now these fused bands after curvelet

transform are fused again using Inverse wavelet Transform. The Inverse Wavelet Transform fuses together all the bands and result in a full size integrated image.

2.2 Performance Parameters for Determining the Quality of Fused Image

In the present work, we have used two performance measures to evaluate the performance of the wavelet, curvelet and hybrid fusion algorithms. MR image is taken as the reference image in the calculation of performance metric values.

2.3 Root Mean Square Error (Rmse)

A commonly used reference based assessment metric is the Root Mean Square Error (RMSE). The RMSE between a reference image, R, and a fused image, F, is given by the following equation

$$\mathbf{RMSE}= \sqrt{\frac{1}{\mathbf{MN}}\sum_{\mathbf{n=1}}^{\mathbf{M}}\sum_{\mathbf{n=1}}^{\mathbf{N}}(\boldsymbol{R(m,n)}-\boldsymbol{Fm,n}))^{\mathbf{2}}} \quad \mathbf{(1)}$$

where R(m, n) and F(m, n) are the reference (CT or MR) and fused images, respectively, and M and N are image dimensions. Smaller the value of the RMSE, better the performance of the fusion algorithm.

B. Peak Signal To Noise Ratio (Psnr)

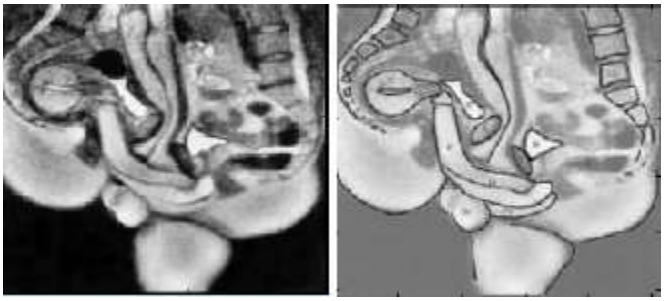
PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. The PSNR of the fusion result is defined as follows

$$\mathbf{PSNR = 10\ X\ log}\frac{(\boldsymbol{f_{max}})\mathbf{2}}{(\boldsymbol{RMSE}\,)\mathbf{2}} \quad \mathbf{(2)}$$

Where f_{max} is the maximum gray scale value of the pixels in the fused image. Higher the value of the PSNR, better the performance of the fusion algorithm.

III. EXPERIMENTS AND DISCUSSION

The proposed technique is compared with the existing Image Fusion Methods: wavelet transform and Curvelet transform. To check the performance of the proposed fusion method as well as the existing fusion method, the performance-measures: MSE and PSNR are evaluated for all cases. Only these metrices are not sufficient for evaluation hence we considered visual representation of fused images also. Here, three MRI and CT images are taken as test images. Table clearly shows that our proposed fusion method gives improved MSE and PSNR.

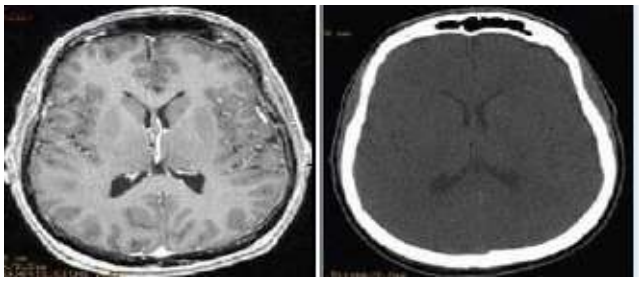


(a) **(b)**

Figure 3 MRI Scan and CT Scan (Image Set1)

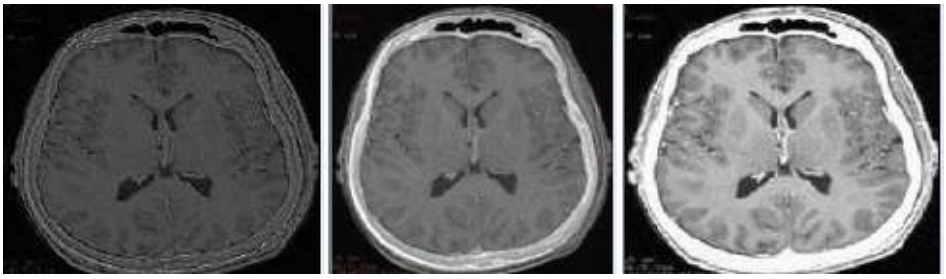
(a) (b) (c)

Figure4 Fused Images By Wavelet Transform (A), Curvelet Transform (B) and Hybrid Transform(C)



(a) (b)

Figure5 MRI Scan and CT Scan (Image Set 2)



(a) (b) (c)

Figure 6 Fused Images By Wavelet Transform (A), Curvelet Transform (B) and Hybrid Transform (C)

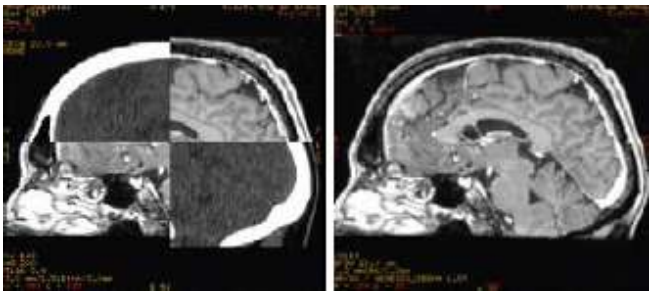
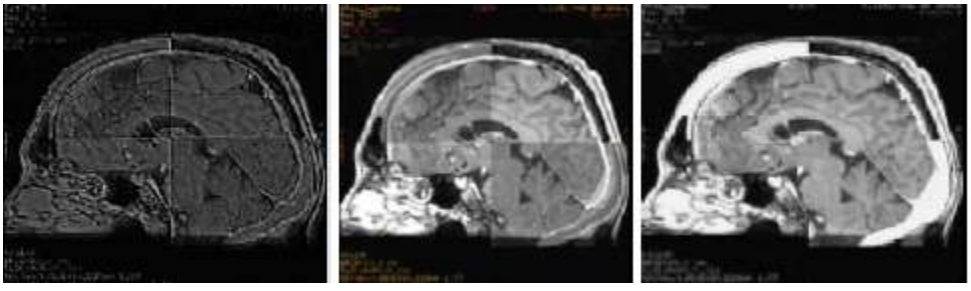


Figure7 MRI Scan and CT Scan (Image Set 3)



(a) (b) (c)

Figure 8 Fused images by wavelet transform (a) curvelet transform (b) and hybrid transform (c)

Table 1 Comparison of various image fusion techniques

Image set	Technique applied	MSE	PSNR
Image set1	Wavelet based image fusion	8974.8379	24.1089
	Curvelet based image fusion	4250.2393	25.9604
	Hybrid based image fusion	18243.982	42.5645
Image set 2	Wavelet based image fusion	3843.0595	27.3111
	Curvelet based image fusion	5222.7581	24.2175
	Hybrid technique image fusion	2945.5952	41.9446
Image set 3	Wavelet based image fusion	3718.5551	26.2327
	Curvelet based image fusion	2393.5864	35.0198
	Hybrid technique image fusion	2747.0307	46.1685

IV. CONCLUSIONS

In this research work, attention was drawn towards the current trend of the use of multi resolution image fusion techniques such as wavelet transform and curvelet transform. An efficient image fusion technique has been proposed here which is formed by combining the features of both wavelet and curvelet image fusion algorithms. In our proposed technique of image fusion we get more enhanced image and work well for edges, corners and helps in minimization of the localized errors. Thus the two different modality images are fused using the various fusion rules based on the Wavelet, Curvelet and hybrid transforms. Moreover the difference in performance for these transforms is clearly exhibited using two performance measures. It is observed that, fusion methodology based on the Curvelet transform has given curved visual details better than those given by the Wavelet fusion algorithm. The fused image obtained using hybrid transform contains more useful information than the fused image using wavelet or curvelet transform. The proposed technique compensates all the shortcomings of either wavelet or curvelet transform method of fusion. Thus enabling the radiologists to locate the imperfections accurately, making the treatment easier and perfect. From the various image quality assessment table and graphs, it has been clear that the proposed fusion technique outperforms other methods in terms of peak signal to noise ratio and root mean square error.

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