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# Medical Image Fusion using Discrete Wavelet Transform for Tumor Detection

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**ABSTRACT**

A tumor is formed either by uncontrolled growth of cells in a particular human organ or due lesions caused by prolonged radiation exposure. Nowadays, most of the physicians face difficulties in diagnosing the abnormalities with a single scan image. This paper deals with the detection of tumor using image fusion, for the diagnosis of patient for better treatment. Image fusion is the process of combining two or more images or high spatial and high spectral information from different sources into a single image which has important properties of original images. The multi-resolution signal analysis in frequency domain is made by Discrete Wavelet Transform (DWT). The discrete wavelet transform has become a very useful tool for image fusion. In this work, DWT based image enhancement and fusion technique has been implemented using different fusion rules including up-down fusion and down-up fusion for the detection of tumor in lung and brain. The fusion parameter Peak Signal to Noise Ratio (PSNR) is calculated and the results show the effectiveness of fusion based on DWT.

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## INTRODUCTION

Image fusion is used to find the exact location of abnormality in soft tissues like brain, lungs, cervix, kidney and so on .Tumors and cancers are produced by uncontrolled growth of cells in Human body. Lung cancer is the major cause of Cancer related death in today's world, caused mainly due to long term exposure to tobacco smoke. Nearly 1.56 million deaths occur per year due to lung cancer. Brain tumors are the second leading cause of cancer among children and adults. Tumors are classified using Discrete variable classification system (Daumas Duport, C., 2000). In order to detect tumors and cancers or to perform difficult biopsies, surgeons must follow complex trajectories to differentiate blood vessels or functional areas. Due to high tissue contrast, MRI is the most sensitive method for diagnosing tumors. To improve the accuracy it is necessary for discarding other tissues. Measurements of the volume of anatomical structures in both normal anatomy and at various pathological conditions are necessary to fix the location of disorders. The first step to minimize the death rate due to tumors is to develop an effective diagnosing method. The main objective of this work is to develop a system to detect tumors.

For accurate diagnoses, radiologists must integrate information from multiple images of a patient. Multiple images are registered in different formats and are overlaid or combined to provide additional information. The image fusion techniques find enormous application in medical imaging. The fused image should have complete information and the advantages of medical imaging such as high reliability and high capability (Wang, H.H., 2004; Pajares, G., J. M. Ldela Cruz, 2004). Fusion techniques provide spatial resolution of 2-D surfaces.

Image fusion is to integrate different images in order to obtain more information that can be derived from each single image. The composite image is formed to improve quality and to make it easier for the surgeon to detect, recognize and identify the abnormalities. The time-frequency representation of the image can be provided by Wavelet Transform. The wavelet domain representation of an image is very useful in many applications like compression, noise reduction, image registration, etc. The multi-resolution image in frequency domain is made by Discrete Wavelet Transform (DWT). The discrete wavelet transform has become a very useful tool for fusion.

### *Preamble To Image Fusion:*

The aim of image processing is to get more information of the resulting image produced by various sources. In precise, image fusion is the process of merging images from different sources to obtain more information than any other source image. The image fusion plays an important role in diagnosing diseases. Magnetic Resonance image (MRI) and Computed Tomography (CT) image are

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fused for the diagnosis of diseases (Lifeng, 2001). Image fusion is implemented by considering Region of Interest (ROI) such as edges and curves, in feature level or decision level description (Xiao Bai, 2015). Principle Component Analysis (PCA) (Myungjin Choi, *et al*., 2005), Intensity-Hue-Saturation (IHS) method(Myungjin Choi, *et al*., 2005) and transform based fusion (Liang Xu, 2013).

***Related Works:***

High Resolution Multispectral (HRM) image is generated from High Resolution Panchromatic (HRP) and Low Resolution Multispectral (LRM) image by compressed sensing method (Shah, V.P., 2008). Spectral distortion is reduced in the pan sharpened image using an Adaptive Principle Component Analysis method (Rahmani, S., 2010). The Adaptive Intensity-Hue-Saturation (IHS) method achieves high spatial and spectral resolution (Demiral, 2011). A simple image fusion algorithm based on wavelet transform is proposed in (Wei-Wei Wang, 2003). Multimodal image fusion is performed using Daubechies Continuous Wavelet Transform (Kanisetty Venkata Swathi and C.H.Hima Bindu, 2013). The pixel level image fusion algorithm is evaluated (Dr. M. Sumathi and R. Barani, 2012). Image fusion using various Transforms is explained (Ramesh Babu, G. and K. Veera Swamy, 2014). Medical Image Fusion through MATLAB Based Wavelet Transform (Neetu Mittal and Rachana Gupta, 2013).

***Traditional Fusion Algorithms:***

***A. Principle Component Analysis***

In PCA transform, Correlated multispectral (MS bands) image are converted into a new set of uncorrelated components. The principle component of the MS image band contains more information which is substituted by the panchromatic (PAN) image. The new RGB bands of multi-spectral image from the principle components are obtained by taking inverse PCA transform.

***B. Intensity-Hue-Saturation (IHS) fusion:***

The intensity-hue-saturation (IHS) fusion converts color multispectral image from the RGB image into the IHS color image. The Brovey Transform multiplies each MS band and high resolution PAN band then, each product is divided by the sum of the MS band.

$$DN_{fused} = DN_{pan} \times DN_{b1}/(DN_{b1}+DN_{b2} + DN_{b3}) \; \dots\dots (1)$$

Where $DN_{fused}$ means the Digital Number ($DN$) of the resulting fused image; $DN_{b1}$, $DN_{b2}$ and $DN_{b3}$ are the pixel values of three bands of multiple spectral image. $DN_{pan}$ is the pixel value of high resolution PAN band.

***C. Multi-resolution analysis based fusion:***

In 1980s Multi-resolution or multi-scale method, pyramid transformation has been used for data fusion (Adelson, C.H. and J.R. Bergen, 1984). Laplacian Pyramid transformation and Gaussian Pyramid transformation have been used (Miao, Q.G. and B.S. Wang, 2007; Xiang, J. and X. Su, 2009). Wavelet Transform can be applied to image decomposition and reconstruction based on the construction of wavelet orthonormal by fast wavelet transform. Fusion algorithm of multiple images based on Fast integer lifting wavelet transform considers speed of fusion and sub-band characteristics.

***Discrete Wavelet Transform Image Decomposition:***

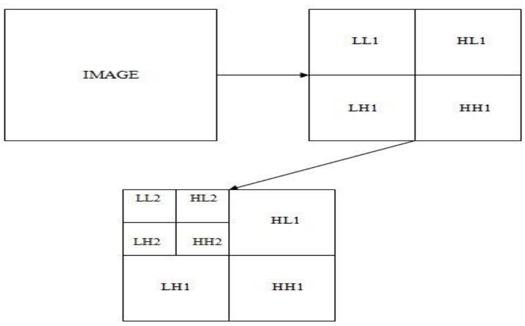


**Fig. 1:** Two level Image decomposition using 2D – DWT.

Discrete Wavelet Transform (DWT) is an efficient tool to examine the images. The image can be passed through filter bank followed by a decimation operation. At each decomposition stage, the filter bank consists of a low pass and a high pass filter. When the image passes through the filters, the low pass filter extracts the coarse information of the image by averaging operation and the high pass filter extracts the detailed information from the image by differencing operation. The output of the filter is decimated by two. Wavelet transform afford a frame work in which the image is decomposed with each level the corresponding coarser resolution band. The wavelet is given by

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$$\psi_{a,b}(x) = \frac{1}{\sqrt{a}}\psi\left(\frac{x-b}{a}\right) \ldots\ldots (2)$$

Where, $a$ is scale coefficient and $b$ is shift coefficient.

During decomposition, the low pass filter coefficients are stored in left part and high pass filter coefficients in right part of the matrix. Due to decimation the total size of the transformed image is same as that of original image. Two level Image decomposition using 2D – DWT is shown in Fig. 1. First DWT is performed in the vertical direction then in the horizontal direction. After first level of decomposition the original image is split into four bands represented by LL, HL, LH and HH. During the second level of decomposition the LL band is split into four bands. This procedure continues for further decomposition levels.

***Discrete Wavelet Transform Image Fusion:***

Discrete Wavelet transform image fusion method decomposes gray scale image from respective R,G,B block and each block is resized into sub images based on local frequency content and by choosing the proper wavelet coefficients; a composite multi-scale representation is built. If the color map is smooth, the wavelet transform can be directly applied to the indexed image. Otherwise indexed image should be converted into gray scale image. Since larger absolute wavelet transform coefficients correspond to sharper brightness changes, a common integration rule is applied, at every point in the transform domain, the coefficients whose absolute values are higher. In this way the fusion takes place in all the resolution levels and the more dominant features at each scale are preserved in the new multi-resolution representation.

Generic flowchart of Image Fusion using DWT is shown in Fig. 2. MS image is fused with high resolution PAN image with wavelet fusion, the PAN image is first decomposed into a set of low resolution images with the wavelet coefficients for spatial details in each level. Individual bands of MS image are replaced by low resolution Pan at the resolution level of the original MS image. The high resolution spatial detail is then injected into each MS band by performing inverse wavelet transform on each MS band together with the corresponding wavelet coefficients.

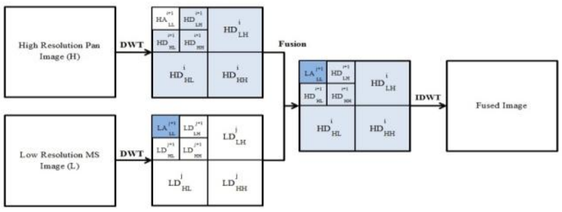



**Fig. 2:** Generic flowchart of Image Fusion using DWT.

The detail information from the PAN image using wavelet transform is injected into the MS image. In wavelet transformation, at each level of decomposition the image size is halved in both the spatial directions which lead to a multi-resolution image representation, due to sampling. A new image is constructed by performing an inverse wavelet transformation.

The input images $I_1(i,j)$ and $I_2(i,j)$are decomposed and the coefficients at required level using DWT. The fused image is obtained by Inverse Discrete wavelet transform (IDWT) as

$$I(i,j) = \frac{DWT[I_1(i,j)] + DWT[I_2(i,j)]}{2} \ldots\ldots (3)$$

***Proposed Methods Of Image Fusion:***

The proposed image fusion using Discrete Wavelet transform has two processes such as image enhancement and image fusion. CT images have low spatial resolution as compared to MRI image. The interpolation is used to resize the CT image, so that the size of MRI and CT image is equal. The wavelet based interpolation is given by eqn.(4)

$$DN_{CT}^{h} = DN_{CT}^{l} + (DN_{MRI}^{h} - DN_{MRI}^{l}) \ldots\ldots \quad (4)$$

The MRI image at various decomposition levels 'r' can be calculated

$$DN_{MRI}^{l} = P_r \ldots\ldots\ldots\ldots\ldots (5)$$

Interpolation gives smoothness to the image and the smoothness depends on the interpolation techniques used. Bi-cubic interpolation fails to preserve the edges (Zhou, J., 1998). To preserve the edges Lagrange interpolation technique is proposed as shown in Fig. 3. The input low resolution CT is divided into sub-bands HL, LH, LL and HH by discrete wavelet transform. The high frequency component is present in sub-band HH. The Lagrange interpolation is applied to all four bands. The Lagrange interpolation of $NxN$ image region can be derived from (6).

$$Lag_{hN(I)} = \begin{cases} \prod_{j=0, n\neq j-\frac{N}{2}+1}^{N-1} \frac{n-k-I}{n-k}, & n-1 \leq I < n \\ 0, & elsewhere \end{cases} \ldots\ldots (6)$$

Lagrange interpolation is applied on the difference between the sub-band LL image and the low resolution CT image to enhance the low resolution CT image. The estimated difference image is added with the images from sub-bands HL, LH and HH. The enhanced CT image is obtained by taking inverse DWT of input CT image, HL image, LH image and HH image. Fig.4. shows the Proposed Medical Image Fusion. DWT will decompose the input CT and MRI image and the fusion rule is applied after inverse DWT is taken to get the fused image.

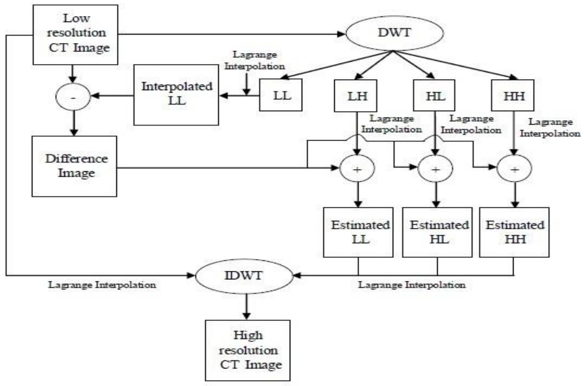



**Fig. 3:** Proposed Medical Enhancement Technique.

The fused data of medical imaging has a vital role in many medical fields such as radiotherapy. During surgery it is not possible to take MRI for a patient. Fused X-ray computed tomography (CT) and magnetic resonance (MR) images assist the physician during Computer assisted surgery.

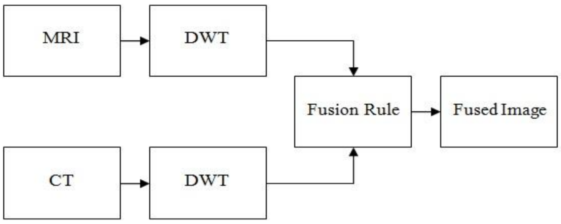



**Fig. 4:** Proposed Medical Image Fusion.

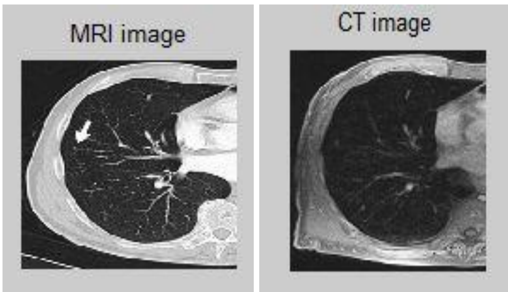
The fusion techniques such as Up-Down Fusion, Down-Up fusion, Left-Right Fusion and Right-Left fusion are proposed because of the option to remove artifacts. By fusion the artifacts are removed and the fused image has less distortion so that body information and border information can be separated. The defects in the lower part of the image are removed and the upper part is kept by Up-Down Fusion. Likewise, the defects in the upper part of the image are removed and the lower part is kept by Down-Up Fusion. Similarly left-right fusion is used to remove the defects in right and right-left fusion for left side artifacts.

***Result:***

Two experiments are carried out to find the brain tumor and Lung cancer. Image enhancement technique is applied to low resolution CT image to improve the resolution. Discrete Wavelet Transform (DWT) is applied to both the input images CT and MRI tumor images and the fusion coefficients such as Up-Down (UD), Down-Up (DU), Left-Right (LR), and Right-Left (RL) are applied. 2-levels of decomposition is carried out. Both CT and MRI images are fused, after fusing Inverse Discrete Wavelet Transform (IDWT) has been applied. Fused image is displayed as output in MATLAB window. The PSNR value for Fusion is found separately for lung cancer and brain tumor as listed in table 1 which provides the effectiveness of image fusion and it has the facility to preserve the test images for future information.

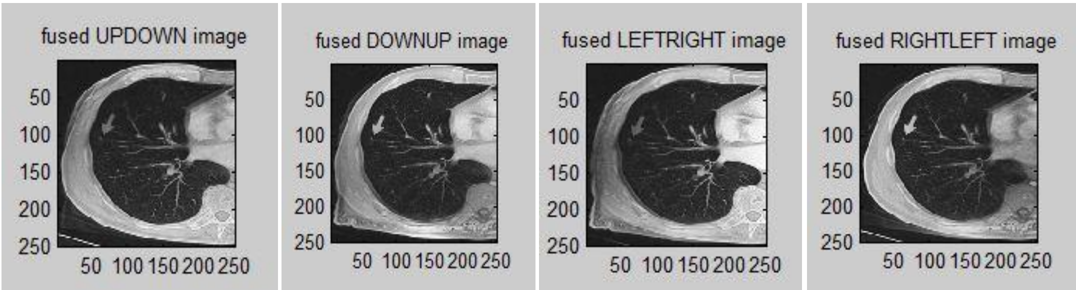
***Conclusion:***

This paper deals with the detection of tumor using image fusion, for the diagnosis of patient for better treatment. This method of fusion is used to find out the exact location of abnormality in soft tissues like lung and brain. In this work, DWT based image enhancement and fusion technique has been implemented using different fusion rules including up-down fusion, down-up fusion, left-right fusion and right-left fusion for the detection of brain tumor. The experimental result shows that DWT based image enhancement and fusion technique is the power tool for image fusion. The fusion parameter PSNR is calculated and the result shows the effectiveness of fusion based on DWT. The proposed fusion techniques provide a valuable diagnosing technique for the physician to detect the tumors.



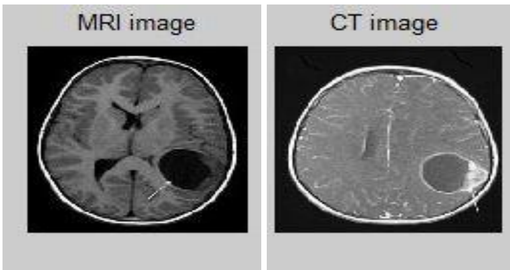

(a) (b)

**Fig. 4:** Input Images. (a) MRI Lung cancer Image. (b) CT Lung cancer Image.



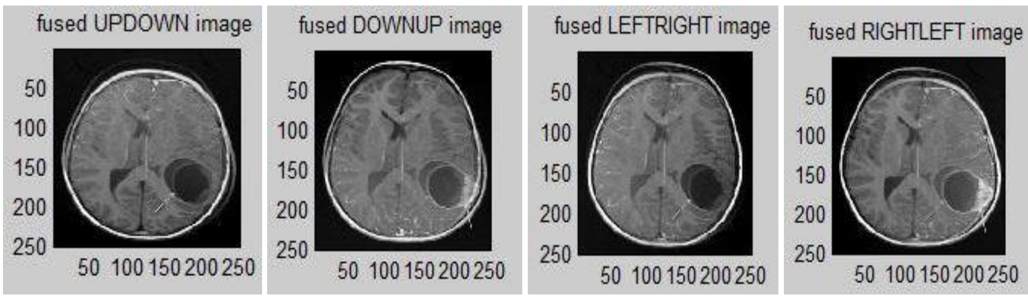

(a) (b) (c) (d)

**Fig. 5:** Output Images. (a) Fused Up-Down Image. (b) Fused Down-Up Image. (c) Fused Left-Right Image. (d) Fused Right-Left Image.




(a) (b)

**Fig. 6:** Input Images. (a) MRI Brain Image. (b) CT Brain Image.




(a) (b) (c) (d)

**Fig. 7:** Output Images. (a) Fused Up-Down Image. (b) Fused Down-Up Image. (c) Fused Left-Right Image. (d) Fused Right-Left Image.

Table I: Performance Of The Fused Image.

| Fusion method | PSNR(dB) (Lung Cancer) | PSNR(dB) (Brain Tumor) |
|---|---|---|
| UD Fusion | 15.4051 | 16.5482 |
| DU Fusion | 16.6425 | 16.9982 |
| LR Fusion | 14.9611 | 15.5993 |
| RL Fusion | 16.0405 | 17.4169 |

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