

# Image Fusion of MRI and CT Images Using DTCWT

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**Abstract:-** Fusing different medical Images will increase the accuracy in diagnosis of disease and describe the complicated relationship between them for medical research. The current procedures take a lot of effort and also requires additional data points for the models to be trained. In this model, Through the use of multi-stage fusion networks, we will combine various medical Images such as Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) to recover the intricate information. In the proposed model, we will use Dual Tree Complex Wavelet Transform (DTCWT) to extract the complicated and correlated information from each Image and segmentation is done on fused Image to get the segmented Image. In the proposed method, the improved quality of final fused Image can be obtained.

**Keywords:** Image Fusion, Dual Tree Complex Wavelet, MRI, CT Scan, Medical Images, Segmentation.

## I. INTRODUCTION

Systems for medical imaging like X-rays, PET, SPECT, MRIs, and CT, provide valuable clinical data, but they often fail to reveal detailed tissue information or provide a comprehensive diagnosis. To extract complicated information from a single Image, medical Image fusion combines different types or similar types of medical Images to create a more accurate Image for diagnosis, which helps doctors extract detailed and complicated data not visible in individual Images. Medical Image fusion is used in oncology and cancer research therapy to create a perfect Image fusion process that gathers complementary information from source Images while neglecting unwanted and unexpected features.

The source picture needs to be pre-processed, registered, and aligned before Image fusion. Three layers can be used for Image fusion: pixel, characteristic, and decision. The most common technique for Image fusion is Discrete Wavelet Transform (DWT), which is flawed, having shift variation and bad directionality, leading to errors in fused Images and difficulties processing geometric features.

To overcome these limitations, the suggested technique employs Dual Tree Complex Wavelet Transform (DTCWT), which offers better directionality and shift variance, to combine various medical Images, making it easier to process edges and contours of the source Image. The increased shift variance and directionality features of the DTCWT make it a fulfilled Image fusion tool, playing a significant role in theoretical and analytical tools for Image and signal processing.

Overall, medical Image fusion helps doctors make better and more accurate treatment decisions by providing more comprehensive and accurate information for diagnosis.

## II. LITERATURE REVIEW

➤ P. Kanimozhi, N. A and N. Padmapriya, "Improved computer vision analysis for MRI and CT Images using multistage fusion networks," 2022 International Conference on Smart Technologies and Systems for Next Generation Computing (ICSTSN), 2022:

In this paper, they proposed fusing medical pictures improves illness diagnosis and medical research by describing their complex interaction. Existing methods take a long time and require a lot of data. The proposed method would use multi-stage fusion networks to extract complex information from MRI and CT Images. The proposed method first segments the fused Image using Dual Tree Complex Wavelet Transform (DTCWT) to remove complex and related information from each Image. The suggested strategy improves final fused picture quality.

➤ R. Zhu, X. Li, X. Zhang and J. Wang, "HID: The Hybrid Image Decomposition Model for MRI and CT Fusion," in *IEEE Journal of Biomedical and Health Informatics*, 2022:

The NSST inverts the picture when shearlet transform divides anatomical pictures (NSST). Low frequency is split using structural similarity and structure tensor optimization. HID uses base-layer texture details to create fused low frequency Images. 12 innovative methods are contrasted with the proposed strategy using 50 MRI and CT Images.

Fusion rules use base-layer texture details. Models extract texture better.

- *B. S. N. Rao, N. V. K. Raju, M. Dhanush, P. N. S. M. Harshith and M. J. Mehdi, "MRI and Spect Medical Image Fusion using Wavelet Transform," 2022 7th International Conference on Communication and Electronics Systems (ICCES), 2022:*

By combining pictures from different imaging devices, such as computed tomography (CT), magnetic resonance imaging (MRI), and PET, medical picture fusion aims to increase Image clarity. This paper provides a 2-Dimensional DWT-based discrete wavelet transformation Image fusion method for Image decomposition. The efficacy of the fusion is evaluated using Mutual Information (MI) and the correlation between the fused Image and the reference Image.

- *S. Praveen kumar and S. Sridevi, " Image Fusion Algorithm for Medical Images using DWT and SR," 2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS), 2021:*

The merged Image will incorporate precise and valuable data from numerous imaging modalities. Discrete wavelet transform (DWT) is applied to brain region MRI, CT, and PET Images. The segments from the low pass and high pass fusion are combined using inverse DWT reconstruction. The entropy of the suggested technique is 2.9299, which is significantly higher than the state of the art at this time. More accurate and significant information will be present in the combined Image than in the separate Images.

- *S. A. Begum, K. S. Reddy and M. N. G. Prasad, "CT and MR Image Fusion based on Guided filtering and Phase congruency in Non-Subsampled Shearlet Transform domain," 2021 5th Conference on Information and Communication Technology (CICT), 2021:*

Multi-modal Image fusion is essential for the early diagnosis and management of diseases. To evaluate issues with the human body, medical professionals use imaging methods like MRI, PET, CT, and SPECT. This is accomplished using a guided Image filter (GIF) and a Non-subsampled Shearlet transform (NSST) with combined phase congruency-based fusion rules. The GIF gives the fine details needed for the later fusion using the aforementioned transform technique. This method is tested using MRI and CT scans.

- *V. A. Rani and S. Lalithakumari, "A Hybrid Fusion Model for Brain Tumor Images of MRI and CT," 2020 International Conference on Communication and Signal Processing (ICCS), 2020:*

Multimodal medical picture fusion improves functional and structural information. Fusion may also solve storage issues. An optimal method for a higher-quality hybrid picture is being researched. This study suggests an empirical mode decomposition and discrete wavelet transform-based multimodal picture fusion paradigm. The recommended method creates a combined Image with all of the functional and spatial details of the original. The combined picture

lacks distortion. This suggested technique combines MRI and CT brain imaging. This method's fusion outcomes are quantified. This approach's hybrid fusion reaction shows the findings' supremacy.

- *J. Du, W. Li and H. Tan, "Three-Layer Image Representation by an Enhanced Illumination-Based Image Fusion Method," in IEEE Journal of Biomedical and Health Informatics, 2020:*

This study proposes a three-layer picture decomposition method that uses rules for CT and MRI fusion. Three phases are suggested. Each input picture is deconstructed using local extrema and low-pass filters in the spatial domain. To retain tumour illumination, increased contrast is applied to deconstructed CT and MRI Images. Second, the three-layer representation uses three fusion rules.

- *R. Zhu, X. Li, X. Zhang and M. Ma, "MRI and CT Medical Image Fusion Based on Synchronized-Anisotropic Diffusion Model," in IEEE Access, 2020:*

They proposed a newly developed multi-modal medical picture fusion technique centered on the Synchronized-Anisotropic Diffusion Equation. (S-ADE). The modified S-ADE model, which proves more suitable for MRI and CT Images, is utilized for decomposing two source Images into a single Image. The fusion decision map is computed on texture layers using the New Sum of Modified Anisotropic Laplacian (NSMAL) algorithm.

- *J. Huang, Z. Le, Y. Ma, F. Fan, H. Zhang and L. Yang, "MGMDcGAN: Medical Image Fusion Using Multi-Generator Multi-Discriminator Conditional Generative Adversarial Network," in IEEE Access, 2020:*

MGMDcGAN is an adversarial conditional generative network with numerous producers and discriminators. In the first cGAN, the generator seeks to create a fused Image that closely mimics reality by using a specially designed content loss that will fool two discriminators. The discriminators' objective is to distinguish structural variations between the fused Image and the source Images. Using this as our foundation, we employ the second cGAN with a mask to enhance the dense structure information in the final fused picture without sacrificing functional information. The three kinds of medical Image fusion that can be applied using MGMDcorgan as a unified strategy are MRI-PET, MRI-SPECT, and CT-SPECT.

### III. EXISTING SYSTEM

Discrete Wavelet Transform has been used to combine multimodal medical pictures. This includes Magnetic Resonance Imaging and Computerized Tomography. To make up for the information gaps in a single imaging, MRI and CT are combined to combine the advantages of MRI pictures with clear soft tissue information and CT Images' clear bone information. An assisted filtering-based MRI and CT fusion method was proposed by Na et al. (GF). The fused Image resolves the edge degree and clarity issue by removing the feature data though leaving the edge data of the initial Image untouched. Visual study of the fusion

products' contrary and structural similarity obviously got better.

Discrete wavelet transform has optimal positioning in the time and frequency domains, which aids in maintaining the Image's particular information, and it can generate various input frequency signals while preserving stable output. The principal component analysis's drawbacks are overcome by the discrete wavelet transform, which also has an effect that is both visual and quantitative. The source Image is enhanced and preprocessed, and the IHS transform, which retains more anatomical details and lessens color distortion, is used to extract the intensity component from the CT Image. The DWT transform is used to create high- and low-frequency subbands made up of the amplitude components of CT and MRI. The inverse DWT transform is used to create the combined Image after the high- and low-frequency sub bands are fused using separate fusion rules.

to combine these two multimodal pictures (as shown in Image 3). Following the wavelet coefficient extraction, a second fusion algorithm is used to fuse the coefficients.

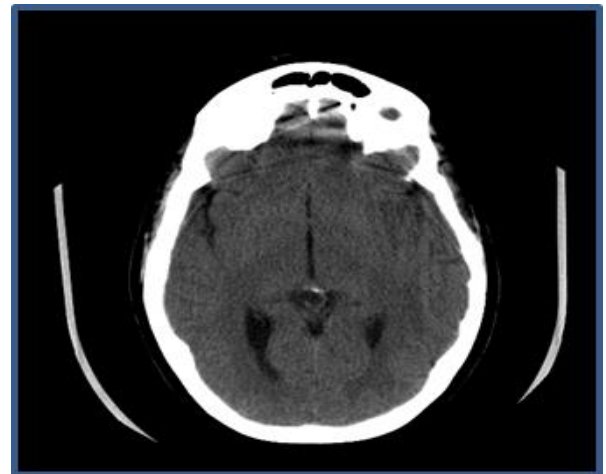
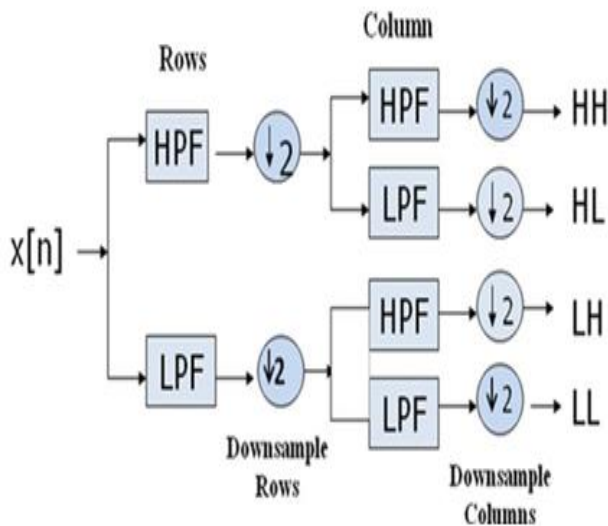


Fig 1 CT Scan for Sarcoma

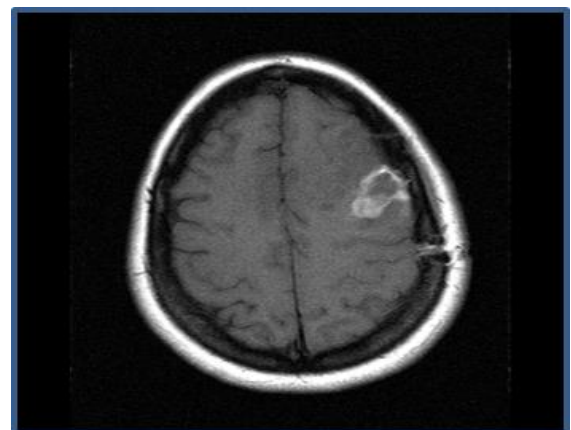


Fig 2 MRI Scan for Sarcoma

The decomposed The decomposed low-frequency coefficients are merged using the weighted average method, the high-frequency coefficients are fused using the absolute high-value method, and the weights are approximated and optimised using the predator-optimizer, and then the fused Images are by applying the inverse transform, acquired. Due to the factors of low and high frequencies have different meanings, separate fusing rules were used. Therefore, the idea of fusing is accomplished by using two fusion rules. First, the most common method of combining features is to select a larger wavelet coefficient because higher values indicate stronger edges, which are preferred as an important component of information content. Two of these important components of pictures are the corners and borders. Averaging is used to uncover more information about both of the initial Images, which are approximate based on their low wavelet coefficient values. After approximating the extracted wavelet coefficients, the merged Image is produced using the Inverse Discrete Wavelet Transform.

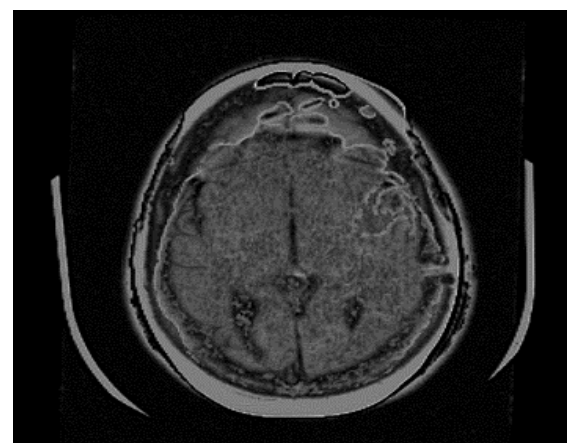


Fig 3 Fused Image

Image 1 below displays the CT scan of a patient with sarcoma-related brain illness, and Image 2 displays the MRI of the same patient. Discrete Wavelet Transform was used

The fused Image's mean average accuracy is both the lowest and highest when using the discrete wavelet transform. This is as a result of a geographic resolution issue. With DWT, an Image is divided into rough and fine sections, which correlate to lower frequency and higher frequency sub bands.

➤ *Drawbacks of Existing System:*

- Only the spatial connection of the pixels within a single 2-D block is taken into account; the neighbouring blocks' pixels are not taken into consideration.
- The peak signal to noise ratio is high. Blurring is produced when bigger DWT basis functions or wavelet filters are used. This is time consuming process.
- More data set is required for the training purpose, and also gives less accuracy because it was not done in real time with 2 input Images
- Therefore has low accuracy and low efficiency in terms of loading time and implementation time.

➤ *Proposed System:*

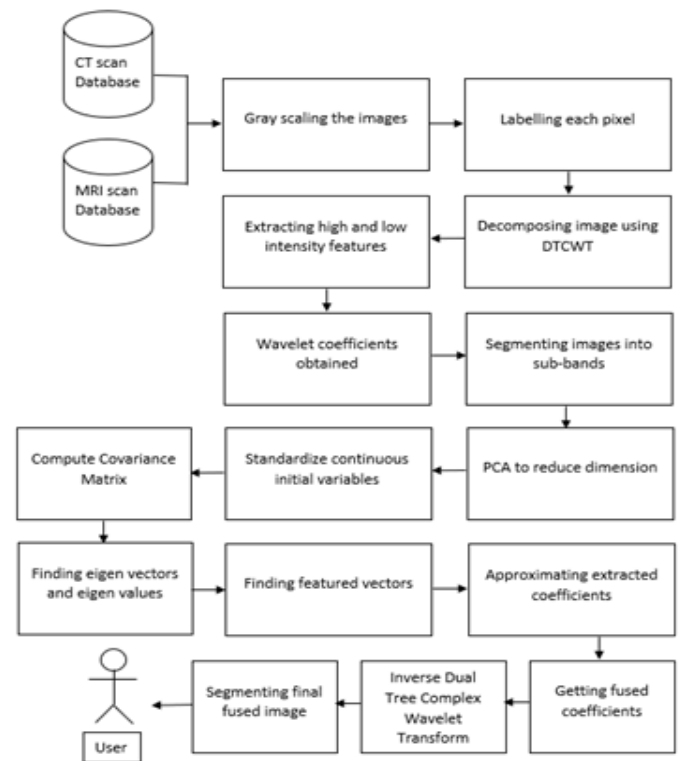
While ignoring the unwanted and unexpected features, the complementary information from the source Images should be incorporated into the final fused Image in an ideal Image fusion process. The basic idea behind wavelet-based Image fusion is to combine the two source pictures' wavelet decompositions using fusion methods on the details and approximations coefficients.

Without providing functional information, magnetic resonance imaging (MRI) reveals the soft tissue anatomy of the brain. A significant role in clinical diagnosis is played by its great spatial resolution, lack of radiation benefits to the human body and extensive knowledge. Due to bone's incredibly low proton density, an accurate MRI bone Image cannot be created. The bone tissue in the computed tomography imaging (CT) Image is especially clear because bone tissue absorbs density at a greater rate than soft tissue. Less cartilage information is visible on CT Images, which is consistent with the anatomical information. Single-photon emission computed tomography, or SPECT, is a functional imaging technique that shows the flow of blood in vessels and veins as well as the metabolism of human tissues and organs. It is commonly used in the diagnosis of various tumour diseases and provides both beneficial and detrimental knowledge about tumours.

Although each will offer particular details, none of these methods could deliver all the necessary data in a single Image. Fusion of medical Images is the answer to this issue. All the necessary details from different sources could be condensed into one Image.

In order to get around the limitations of the current system, the suggested method employs Dual Tree Complex Wavelet Transform (DTCWT) to combine various medical Images. The Discrete Wavelet Transform's shortcomings will be fixed by the dual tree complex wavelet transform. Better directionality and shift variance makes it simple to handle the edges and contours of the source picture. The DTCWT's enhanced shift variance and enhanced directionality characteristics make it a successful Image fusion tool.

➤ *Architecture Diagram:*



➤ *Modules Used:*

• *Image Decomposition:*

In this module, we developed a website, which will prompt the user to upload the patient's CT and MRI Images. The CT and MRI Image will be in the size of 512\*512. and also, we need to give the input as the maximum coordinate, to fix the coordinate in the uploaded source Image for the purpose of fusion. The uploaded Image is in the form of RGB. This RGB visual is transformed to a gray scale rendition, which has the intensity information. After that these source gray scale CT and MRI Image is decomposed using DTCWT.

• *Extracting Features using DTCWT:*

After decomposition we will extract the high intensity and low intensity features as wavelet coefficients. It produces the various levels of decomposed Images. Each level the Images are segmented into sub-bands at six directions like -15°, -45°, -75°, 75°, 45°, 15° to extract the features from the Image.

Principal component analysis is used if the data is bigger to reduce the dimension of the data, also extract the silent and complementary features. As the medical Images are larger, to reduce the data here, PCA is used therefore removes the unwanted and repeated information present in DTCWT. The PCA analysis has several steps. The first is standardization, the objective of this step is the continuous initial variables' range needs to be standardised. Therefore, each will have an equal impact on the research. Mathematically, standardization is done by finding the difference between each value and mean and finally



dividing by standard deviation. The next step is to compute covariance matrix, some variables are highly correlated with other variables such a way that they contain redundant information. Hence, compute the covariance matrix to find the correlation. To identify the principal components, you should also compute the eigenvectors and eigenvalues of the covariance matrix. Next is to find the featured vector from all the computed principal vectors. Finally, reconstruct the data with the principal axes.

• *Image Fusion:*

The extracted coefficients are approximated. Finally, we get the approximated wavelet coefficients. Now the Image fusion, that is approximated coefficients are fused to get the fused coefficients. To restore the fused picture, we use the Inverse dual tree complex wavelet transform.

• *Image Segmentation:*

The segmentation is used to differentiate the details of lines, curves and boundaries. So the segmentation is performed on the final fused Image.

**IV. METHODOLOGIES**

The suggested framework enables the use of Dual Tree Complex Wavelet Transform in the fusion of Images. The dual tree complex wavelet transform will be the solution for the shortcomings of Discrete Wavelet Transform (DWT). The DTCWT will offer improved directionality and shift variance, making it simple to process the source Image's edges and contours. Increased shift variance and increased directionality features of the DTCWT make fulfilled Image fusion tool. Medical imaging systems are helpful to detect various defects and issues in our body. X-rays, Positron Emission Tomography (PET), Single Photon Emission Computed Tomography, Computed Tomography, Magnetic Resonance Imaging (MRI), and Computed Tomography (SPECT) are some types of medical imaging system. Each will provide unique details, but none of those applications could give all the information required in a single Image. Fusion of medical Images is the answer to this issue. One picture could contain all the pertinent data from various source Images.

Dual Tree Complex Wavelets could provide reasonable shift invariance and good directionality, but using a single tree it was impossible to achieve perfect reconstruction and acceptable frequency characteristics. However, approximate shift invariance could be obtained by tripling the sampling rate at each tree level. Samples must be equally spaced for it. This could be acquired by eliminating down sampling of 2 after level 1 filters, H0a and H1a. Another way to accomplish this, two parallel completely decimated trees, a and b, will be used. Under level 1, filters from one tree should have a half-sample delay distinct from filters from another tree in order to achieve uniform intervals between samples of the two trees. This requires odd-length filters in one tree and even-length filters in another tree in order to achieve linear phase. Greater symmetry exists between trees if even and odd filters are used in levels of tree, alternately. PR filters are used as usual to invert each tree independently

in order to invert the transform, and the final step involves averaging the two results.

This process does not seem to yield a complex transform at all. The transform becomes complex if the real and imaginary components of a complex wavelet are specified as the outputs of two trees. Odd-length filters have even symmetry around their midpoints while even-length filters have odd symmetry for filters of linear phase PR biorthogonal sets. These filters' impulse responses resemble the actual and hypothetical components of complicated wavelets. By separable filtration along columns and then rows, 2-D extension is made possible. The 2-D signal spectrum is only maintained in the first quadrant if column and row filters reject negative frequencies. Filtering is done using complex conjugates of the row filters as well because two adjacent spectral quadrants should reflect a true 2-D signal. As a result, the converted 2-D signal has 4:1 redundancy.

➤ *Comparitive Analysis:*

For regular medical Images, such as CT and MRI Images, fusion measures are shown in Table 1; for blurred Image data sets, fusion measures are shown in Table 2. This comparison demonstrates that the proposed approach outperforms DWT-based Image fusion for both the normal and blurry medical Image data sets.

Table 1 Performance Measure for Normal Image Data Set

Fusion Method	MI	$Q_{AB}^F$
DTCWT Max	2.3136	0.6278
DTCWT Avg-Max	1.6582	0.5803
DWT Max	2.2713	0.5764
DWT Avg-Max	1.6390	0.5322

Table 2 Performance Measure for Blurred Image Data Set

Fusion Method	MI	$Q_{AB}^F$
DTCWT Max	5.1705	0.7547
DTCWT Avg-Max	5.0185	0.7511
DWT Max	4.7277	0.7133
DWT Avg-Max	4.6134	0.7126

## V. RESULTS

In addition to research showing that the Dual Tree Complex Wavelet Transform (DTCWT) gives the fused Image a more accurate representation of the spectral, spatial, and soft tissue details of the tumor, it is the basis for our proposed approach of medical Image fusion. Our suggested approach has high entropy, fusion factor, and peak signal to noise ratio values with regard to performance level. Because of this, our suggested approach outperforms other fusion techniques.

## VI. CONCLUSION

Disease diagnosis and therapy can both benefit from medical Images. The combined medical Image will be used to make more precise diagnoses and collect detailed data for improved treatment. However, we are not getting more precise pictures from the fused. to produce a fused picture that is visually intensified. In this endeavor, we demonstrated dual-tree complex wavelet transform-based medical fusion.

The fused multi-model picture will be calculated using a dual-tree complex wavelet transform and will exhibit improved shift variance and directionality selectivity. The source Images used in this project, such as CT and MRI scans, are accepted, and our suggested technique decomposes them using DTCWT. Additionally, coefficient extraction and estimate of extracted coefficients are carried out. The merged Image is then obtained by applying the inverse dual tree complex wavelet transform, and the segmented fused Image is then obtained by segmentation. As a result, the fused picture of our suggested scheme shows the tumour's more precise edges, tissues, spectral, contour, and spatial features.

### ➤ Scope for Future Development:

The technique we suggest of medical Image fusion is based on Dual Tree Complex Wavelet Transform because study indicates that it provides the fused Image a more accurate representation of the spectral, spatial, and soft tissue details of the tumour. (DTCWT). Our proposed method performs well in terms of peak signal to noise ratio, fusing factor, and entropy. As a result, when compared to other fusion techniques, our suggested algorithm works well. Block level fusion can be used in future work, and the outcomes, including performance assessment and the end fused Image regarding enhanced visual representation, can be further enhanced.

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