

Enhancing Segmentation Accuracy in Brain Tumour Analysis By Implementing Image Fusion Using DTCWT

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Combining data in a way that maximises the pertinent information and minimises the redundant data is known as "image fusion." Since the idea of information fusion was initially applied, numerous methods have been developed to specify a processing model for combining information. Information fusion utilises three fundamental methods. the Maximum level-based image fusion approach, which is the second method used, Principal Component Analysis, which is the third way used, is the one that is utilised first: the Average image fusion method. The processing paradigm differs depending on the application area and the nature of the information being altered. Image fusion is carried out in image processing using a variety of strategies and processes. The Dual Tree Complex Wavelet Transform (DTCWT) approach is suggested. The main benefit of using this method is that it is highly directional, overcomes spectral efficiency, and targets the precise region of the brain where the tumour is present, as opposed to areas where morphological operations like erosion and dilation are used, as well as threshold segmentation and bounding box methods. The outcomes are attained in a way that results in the image's increased qualities.

Keywords: Image fusion, Principal Component Analysis, Dual Tree Complex Wavelet Transform, Threshold Segmentation, image quality.

1. Introduction

A two-dimensional function $F(x,y)$ can be used to represent an image, where x and y are coordinates and F is the intensity of the image at that location. We refer to it as a digital image when F 's x , y , and amplitude values are all finite [1][15]. An array of real or complex integers specified by a finite number of bits makes up a digital image. Digital image processing is the application of computer algorithms to the image processing of digital images in computer science. It can prevent issues like the accumulation of noise and signal distortions during processing and offers a greater selection of algorithms available for use on the input data [2][25]. As seen in figure 1, picture fusion is the process of integrating two photographs into one that has the most information possible without adding any details that aren't there in the original images [3][21]. The quality of information from a series of photographs can now be

improved because to the quick development of technology by fusing data from multiple sources to create high-quality images with spectral and spatial information [4-6].

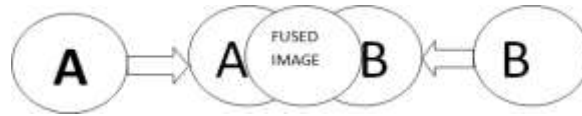


Figure 1 Graphical representation of the image information fusion process

A. SPATIAL DOMAIN FUSION:

Local spatial features including gradient, spatial frequency, and local standard deviation are used in the spatial domain fusion technique [6][12]. The spatial domain fusion approach combines and modifies the pixel values from two or more images to produce the desired results.

B. TEMPORAL DOMAIN FUSION:

When using the transform domain method, the image is first converted to frequency. This involves the projection of source pictures onto localized bases, which are often created to represent the edges and sharpness of an image [7-9]. As a result, the converted coefficients of an image—each of which corresponds to a transform basis—have significance for identifying important features. The spectral content produced by the transform domain approaches is of good quality [10].

Medical imaging has seen several applications of fusion, such as the simultaneous examination of CT, MRI, and PET images [11][16]. Many military, security, and surveillance applications that combine visible and infrared pictures from many sensors have been developed.

2. Literature Survey

In general, the phrase "fusion" refers to a method of extracting data from various sources. Image fusion (IF) aims to combine complementary multisensory, multitemporal, and Multiview data into a single new image that contains data of an unachievable quality. The definition of quality, how it is measured, and how it is used vary depending on the application [3][12]. There are various applications for image fusion. Multi-sensor fusion, which combines pictures from two sensors with high spatial and spectral resolutions, is used in astronomy and remote sensing to attain high spatial and spectral resolutions. With multi-view fusion, a collection of images of the same scene captured by the same sensor but from various angles are combined to produce an image with a greater resolution than the sensor would typically provide or to recreate the scene's three-dimensional (3D) appearance [4][13]. Two distinct goals are acknowledged by the multi-temporal approach. Images of the same scene are taken at various times to either detect and assess scene changes or to obtain a less distorted view of the scene. The first objective is frequently pursued in remote sensing for tracking land or forest utilisation as well as in medical imaging, particularly in the change detection of organs and cancers [14].

The built-in automatic focus feature or a single point of focus are the only two options available to users of standard digital cameras due to the Depth of field (DOF) limit issue. In

this DOF limit problem, the depth of field appears to be clear, yet the surroundings in front of and beyond it are hazy. It offered two methods of picture merging to increase depth of field [8][16]. The concepts in this work include fusing image by DCT-STD and DWT-STD auto focus measurements, with comparison and experimentation used to demonstrate the superiority of the DWT-STD approach. For the objective of improving the complementary and redundant information for diagnosis, Magnetic Resonance Imaging and Computed Tomography pictures are combined to create a modern image [17-18]. Techniques such as curvelet transform, discrete wavelet transform (DWT), stationary wavelet transform (SWT), and principle component analysis (PCA) are used for this. Comparison results show that utilising the curvelet transform improves fusion performance [1][20].

With the demand for clinic applications growing, multimodality medical image fusion has gained a lot of attention. The complementing information in images from other modalities, for example, is frequently advantageous to radiotherapy plans. While tumour delineation is frequently more effectively done in the matching magnetic resonance (MR) scan, dose estimation is dependent on computed tomography (CT) data [3][22]. For medical diagnosis, a CT scan gives the best information on denser tissue with the least amount of distortion, an MRI scan gives the best information on soft tissue with more distortion, and a PET scan gives the best information on blood flow and flood activity with the least amount of spatial resolution overall. The idea of integrating images from several modalities becomes extremely significant as more multimodality medical images are made available for clinical purposes, and medical image fusion has emerged as a fresh and promising research area [5][23]. A medical fusion image combines anatomical and functional information into one image.

The existing models for image fusion are JDL Approach, The Intelligence cycle model, Data-Feature- Decision model. The problems [24] arise during the use of existing methods are Wavelet Co-efficient tend to oscillate positive and negative, Small Shift Variance greatly perturbs the wavelet co-efficient pattern, substantial aliasing, Phase gives local behaviour of a function and increases robustness, Lack of Directionality.

3. Proposed Work

To make a diagnosis, medical imaging seeks to provide a high-quality image containing as much detail as possible. Prior to the fusion process, the intended medical photos must be correctly aligned and of comparable size. The complementary information provided by multimodal medical pictures includes the structural image's higher spatial resolution, which in turn yields more analytical information, and the functional image's inclusion of tissue function-related information. Therefore, better images with more precision are produced when multimodal images are combined. Medical picture fusion frequently results in new clinical information that is not visible in the individual images. The transform's primary goal was to reduce oscillation, aliasing, directionality, and shift variance. Tumour detection in this method is based on the picture fusion, which is based on the Dual Tree Complex Wavelet Transform (DTCWT). The two input images, such as those from PET and MRI (magnetic resonance imaging), are merged. An MRI creates precise images of the body using magnetic fields rather than x-rays. The tumour's size can be determined via MRI. The best method for identifying a

brain tumour is an MRI, which produces more precise images than CT scans. While a patient is undergoing therapy, a PET scan is initially utilised to learn more about a tumour. It might also be applied if the tumour returns following treatment. The examination precisely identifies the dimensions, structure, and capabilities of the brain.

The two input pictures (MRI and PET) are shrunk to 256x256 before being improved with power law transformation. The improved images are then divided using a dual tree complex wavelet transform into lower frequency coefficients and high frequency coefficients. Dual tree filter is used to separate the high frequency coefficient from the low frequency coefficients, and FSfarras filter is used to separate the two. With the help of the weighted average fusion rule, the low frequency coefficients of the two input images are combined. With the help of a maximum level-based fusion rule, the high frequency coefficients of the two input images are combined. Principal component analysis (PCA) is used to fuse the resultant coefficients that are acquired using both fusion rules once more to produce the final fused image, as illustrated in the figure 1.

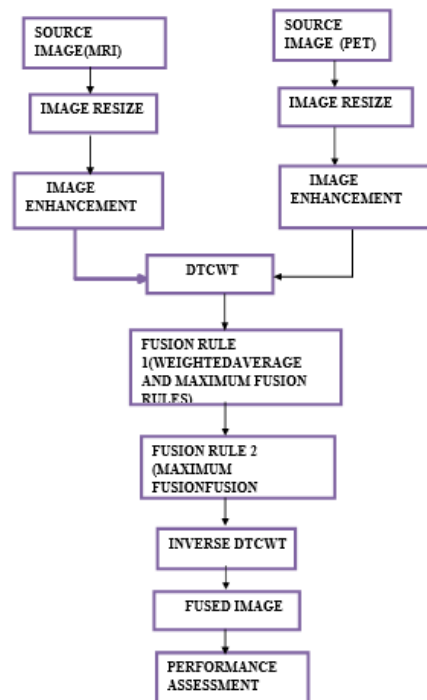


Figure 1 Block Diagram of DTCWT

The result that is obtained after tumour detection shows a better clarity of where the tumour is been exactly present.

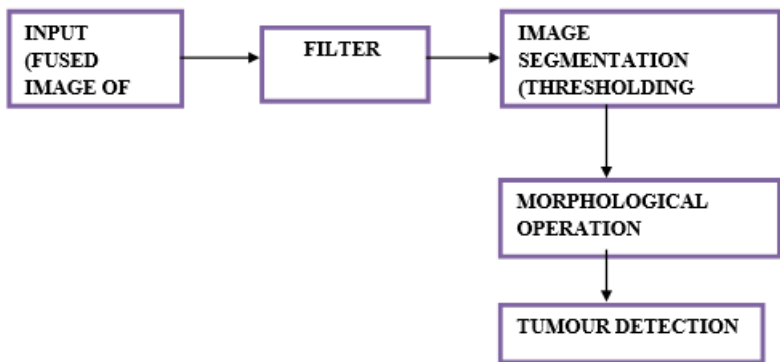


Figure 2 Block Diagram of Tumour Detection

Digital images are modified during the process of image enhancement to provide outcomes that are better suited for display or additional image analysis. To make it simpler to spot important details, you can, for instance, eliminate noise, sharpen, or brighten an image. The spatial domain, which is based on the direct manipulation of pixels in a picture, refers to the image plane itself. Techniques for frequency domain processing are built around changing an image's Fourier transform. Gray level transformation functions are the foundation of image enhancing techniques. The suggested method uses power log transformation to improve images. When doing a piecewise linear transformation or a power law transformation, the exponent that appears in the transformation function must be chosen; in the latter case, the slopes and ranges of the straight lines that make up the transformation function must be chosen. Because every display monitor has an integrated gamma correcting feature with certain gamma ranges, they all display images at varying intensities and clarity. For the optimum contrast, all of the photographs were displayed on it.

The Power Law Transformations can be given by the expression,

$$s = cr^\gamma$$

where, s is the output pixels value, r is the input pixel value, c and γ are the real numbers.

The Dual Tree Complex Wavelet Transform (DTCWT) is a complex-valued addition to the fundamental wavelet. Complex valued filtering, an unique kind of filtering method used by this system, divides the input image into actual and fictitious components. the DTCWT filter bank structure that divides the input image into a real tree and an imaginary tree. By doubling the sample rate, it is possible to create in DWT the shift invariance property that is produced in DTCWT. The following filters require one tree with a half-sample difference delay in order to provide consistent intervals between the two tree samples. Using separable complicated filtering in two dimensions, application to a picture can be accomplished. Two critically-sampled, separable 2-DDWTs are used in parallel to create the actual 2-D Dual Tree DWT of an image x . Next, the sum and difference are calculated for every pair of sub bands. Four critically sampled separable 2-D DWTs working in parallel are used to create the complex

2-D dual-tree.

The fused image is been subjected to tumour detection which includes the process such as:

- Filter
- Image segmentation
- Morphological operation
- Tumour detection

A. Anisotropic Diffusion Filtering

Magnetic resonance images contain high-frequency noise, which is often reduced using a filtering procedure. Regularization techniques for space are frequently used by the anisotropic diffusion filter (ADF). an all-encompassing theoretical foundation for spatial regularisation. Many of the earlier findings can be extrapolated to greater dimensions. When using diffusion filters to the subsequent processing of oscillating higher-dimensional numerical data, or when considering medical image sequences from methods like positron emission tomography (PET) or magnetic resonance imaging (MRI), for example, this may be helpful.

B. Image Segmentation

The fused image, which is the final output image, should be distinct and easier to understand visually. Segmenting images is a crucial part of the pre-processing process. It has several uses, including biometrics and medical image analysis. The process of automatically or partially automatically identifying boundaries within a 2D or 3D image is known as medical image segmentation. The considerable diversity of medical images makes segmenting them a significant challenge. Segmentation aims to streamline and transform an image's representation into something more relevant and understandable. Image segmentation is frequently used to identify objects and boundaries in images (such as lines, curves, etc.). This segmentation technique is called "Threshold Segmentation." In order to divide a digital image into several segments, including sets of pixels and sets of super pixels, segmentation is a technique that has been developed. By simplifying and altering the format of an image's representation, segmentation can achieve the goals of making the image more detailed, meaningful, and straightforward for analysis. Image segmentation can be used to position objects and boundaries, such as lines and curves, in photographs. During the image segmentation process, each pixel in an image is given a name, and the pixels with the same label have certain visual characteristics. In terms of some attributes or computed properties, like colour, intensity, or texture, every pixel in the region is comparable. Regarding the same features, adjacent regions differ significantly. The simplest approach of segmenting images is the thresholding methodology. This method uses a threshold value to transform a featured grayscale image into a binary image. The main benefit of this approach is the ability to choose the threshold value and the gradient magnitude to identify probable edge pixels.

C.Morphological Operation

Bounding box operation is one of the morphological operations, along with dilatation, erosion, and reconstruction. Morphology is a large category of image processing techniques that manipulate images according to their shapes. A morphological operation modifies each pixel in the image dependent on the values of the pixels nearby. The BBM (Bounding box morphological) operations are based on a geometry-based merging technique for bounding boxes. The intersection at the edge geometry kinds of the BB (Bounding box) includes ET, EB, EL, and ER, which stand for the situations where two BBs (Bounding boxes) cross at the top edge, bottom edge, left edge, and right edge, respectively. The circumstances when one BB contacts another at the left-top, right-top, left bottom, and right bottom are represented by the letters CLT, CRT, CLB, and CRB, respectively as shown in figure 3.

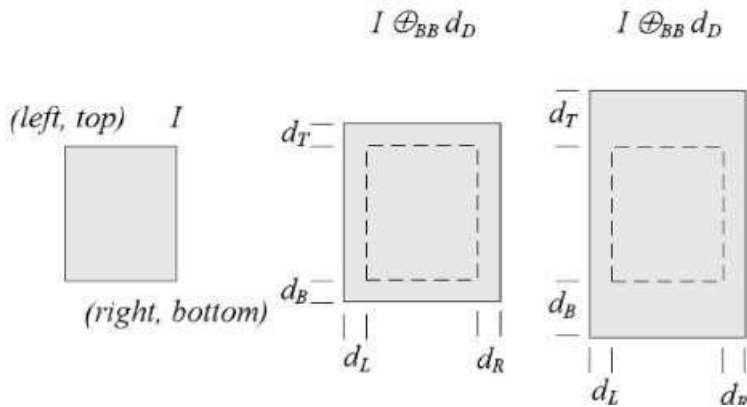


Figure 3 Bounding box morphological operation

D.Tumour Detection

By turning the grayscale image into a black-and-white image and taking the largest region in the resulting fused image as the tumour affected area of that image, the tumour can be detected from the combined image. It is used to compute the area and identify the eroded image. By removing the original image from the eroded image, the contour of the tumour is created. So, in the combined image in the end, the tumour is highlighted.

4. Result and Analysis

The detection of tumor is estimated by analyzing the area of the tumour of the individual images of the scan report as shown in the figure 4

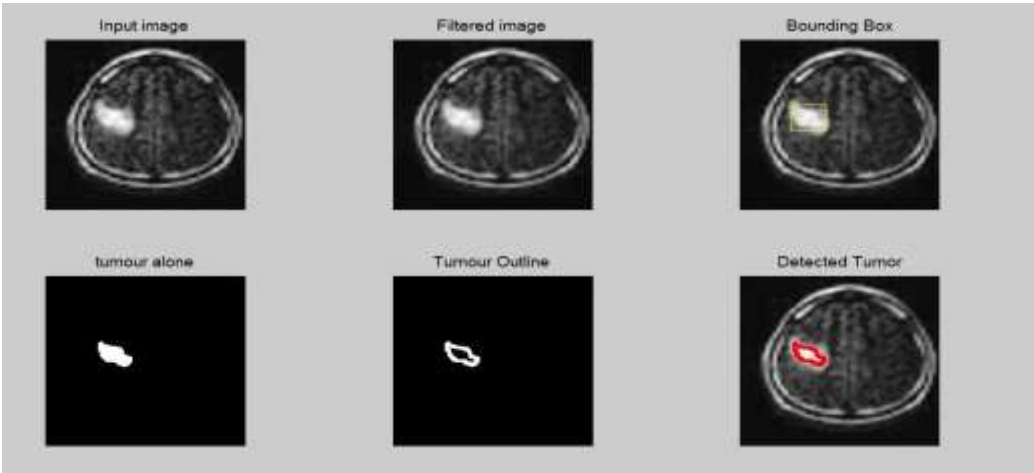


Figure 4 Tumour Detection Steps

Quantitative Evaluation results for Image Fusion:

To check quality of image from PSNR a indication box is display as shown in the figure 5.



Figure 5 Image quality PSNR analysis for MRI image with fused image

METRICS	MRI IMAGE	PET IMAGE	FUSED IMAGE	MRI IMAGE WITH FUSED IMAGE	PET IMAGE WITH FUSED IMAGE
PSNR	-	-	-	77.480	65.5932
ENTROPY	5.71	6.325	6.659	-	-
SNR	0.7396	1.088		-	-
CORRELATION	-	-	-	0.9920	0.6687

Table 1 Evaluation results of Image Fusion

AREA OF TUMOUR	MRI IMAGE (micrometer)	PET IMAGE (micrometer)	FUSED IMAGE (micrometer)
Maximum area of tumor enhanced	8.337e+14	1.02466e+15	1.42e+24(in Real number-> 14,8699999)

Table 2 Evaluation results of Tumour Detection

5. Conclusion

The suggested approach of image fusion employing dual tree complex wavelet transform (DTCWT) displays an augmented and fused image (MRI and PET) that aids in pinpointing the location of the tumour and the tissues that are impacted as a result, allowing the physician to perform a more thorough analysis. Determining the stage of cancer—whether it is in the early or late stages—also helps. The transform used for image fusion is Discrete Wavelet Transform (DWT), which has some drawbacks like less directionality, shift invariance, and oscillation to overcome the drawbacks in the proposed system Dual Tree Complex Wavelet Transform (DTCWT), which produces better diffraction images. In the existing system, the fused image (MRI and CT) shows where the tumour is exactly present in our brain, and it does not provide any detailed description of the affected tissues. When compared to the image obtained in existing system, the fused image produced by the suggested system provides better results and information in the application where it can be utilised to determine if the cancer has been cured or not after the patient has received therapy. The fused image is used to detect tumours. To do this, the image is first segmented using threshold segmentation, and then it is eroded using morphological operation. The tumour outline alone is isolated from the eroded image and then shaded using the bounding box operation. Only the tumor's detected region is constrained. Then it was calculated for both the images, which were the fused images (MRI and CT) from the present system and the fused images (MRI and PET) from the proposed system, to determine the image attributes such as entropy, peak signal to noise ratio, correlation, And Signal To Noise Ratio.

6. References

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