iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** X **Month of publication:** October 2021

DOI: https://doi.org/10.22214/ijraset.2021.38516

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

Development & Analysis of 2D Medical Image Fusion Using Wavelets

Shraddha P. Diwalkar[1], Prof. Dr. S.M. Hanbarde[2]
[1]*Student, Dept. Of Electronics & Communication, Jayavantrao Sawant College Of Engg., Pune, Maharashtra, India.*
[2]*Dept. Of Electronics & Communication, Jayavantrao Sawant College Of Engg, Pune, Maharshtra, India.*

Abstract: Medical image fusion is the technique of integrating two or more images from various imaging modalities/scans to get a fused image with information having the details of anatomical information combined from all the modalities for accurate diagnosis and further treatment. This paper performs the analysis of various wavelet functions for decomposition and synthesis. PET (Positron Emission Tomography) and MRI (Magnetic Resonance Imaging) scans of Brain and chest are used and compared using Stationary Wavelet Transform (SWT) and Discrete wavelet Transform (DWT). Entropy is calculated which is a measure of information acquired after the fusion process.
Keywords: Wavelet transform, Fusion, Stationary Wavelet Transform, Discrete, Medical image

I. INTRODUCTION

In this highly developed digital images era, Medical image fusion is became very popular for medical professionals to be relay on. Diagnosis and treatment of disease require accurate information obtained from various modalities or medical scans, such as PET (Positron Emission Tomography helps to reveal the metabolic or biochemical function of tissues and organs and MRI (Magnetic Resonance Imaging) that displays soft tissues, CT (Computerized Tomography) which gives the hard tissue details etc. Ideally, all the important information and features form each of the modalities should be included in the fused image without information loss. So researchers try to find methods that give best results in terms of resolution, texture, edges & most importantly the information obtained. Medical image fusion is favorable to the healthcare professionals for correct diagnosis & treatment of disease. Multimodal and multi-resolution image fusion is very powerful method to attain the desired output image from various medical scans using wavelet transform is a powerful mathematical tool which is a localized transform in both time(or space) and frequency and this property is advantageously used to extract information form a signal that is not possible with Fourier transform. Wavelet Transform is also very much useful for multimodal and multi-resolution analysis of signal or images.

II. WAVELET TRANSFORMS

A. *Discrete Wavelet Transform*

Discrete Wavelet Transform (DWT) is used, as it decomposes the signal into "sub-bands". Therefore, at each level, the signal splits into high and low frequency components. This is a specialized approach for image fusion and denoising. The Discrete wavelet Transform of a signal x is calculated by passing it through a low pass filter resulting in convolution of the two,

$$y(n) = (x * g)[n] = \sum_{k=-\infty}^{\infty} x[k]g[n-k] \quad (1)$$

The signal is decomposed using high pass filter h. The output of DWT decomposition give the detailed coefficients (from high pass filter) & approximation coefficients (from low pass filter).

By the decomposition process, the time resolution get halved as only half of each filter output characterizes the image. However, each output image has half the frequency spectrum of input image, so frequency resolution has been doubled.

At each level of DWT, the signal is decomposed into low and high frequencies for rows and columns. Due to decomposition process, the input image must be a multiple of 2^n where n is the no. of levels.

Scaled and translated basis function,

$$\emptyset_{j,m,n}(x,y) = 2^{j/2}\emptyset(2^j x-m, 2^j y-n) \quad (2)$$

$$\varphi^i(x,y) = 2^{j/2}\varphi^i(2^j x-m, 2^j y-n) \quad (3)$$

Where, i= {H, V, D}

©IJRASET: All Rights are Reserved

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

The discrete Wavelet Transform function (x,y) of size M * N is then,

$$W_{\emptyset}\left(j_0, m, n\right)=1/\sqrt{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\, \emptyset_{j_0,m,n}(x,y) \quad \ldots() \tag{5}$$

$$W_{\varphi}^{i}\left(j_0, m, n\right)=1/\sqrt{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\, \varphi^{i}_{j_0,m,n}(x,y) \tag{6}$$

Where, i= {H, V, D}

Discrete Wavelet Transform (DWT) decomposes a signal into a set of mutually orthogonal wavelet basis functions. These functions differ from sinusoidal basis functions in that they are spatially localized – that is, nonzero over only part of the total signal length. As is the case in Fourier analysis, the DWT is invertible, so that the original signal can be completely recovered from its DWT representation.[7]

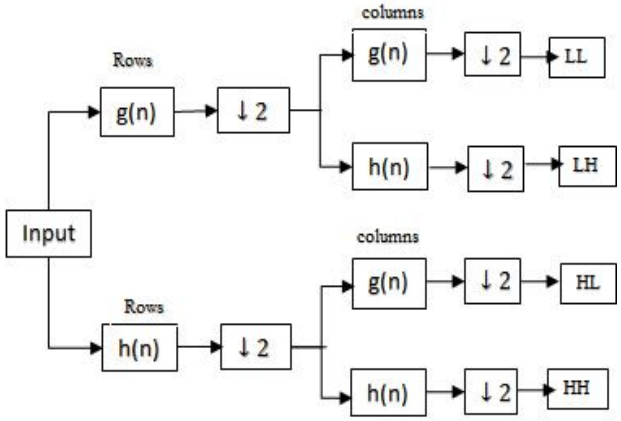


Fig 1. DWT Decomposition

B. Stationary Wavelet Transform

Stationary Wavelet Transform (SWT) is an algorithm designed to get over the drawbacks of DWT. The down sampling & up sampling in DWT results in translation invariance. SWT is the non-sampled DWT also known as un-decimated DWT, as it does the decomposition by up sampling the signal, by adding zeros in between the filter coefficients, that are called 'trous' which is a French word means 'holes'.

Beside the DWT, the resolution /quality of decomposed image is degraded because of down sampling whereas in case of SWT, the spatial resolution of the original image remains the same because of un-decimated algorithm. In other words, SWT is DWT without down sampling.

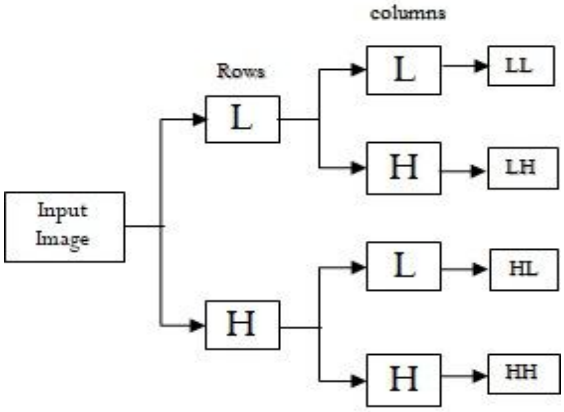


Fig. 2. SWT decomposition

©IJRASET: All Rights are Reserved

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

III. BLOCK DIAGRAM

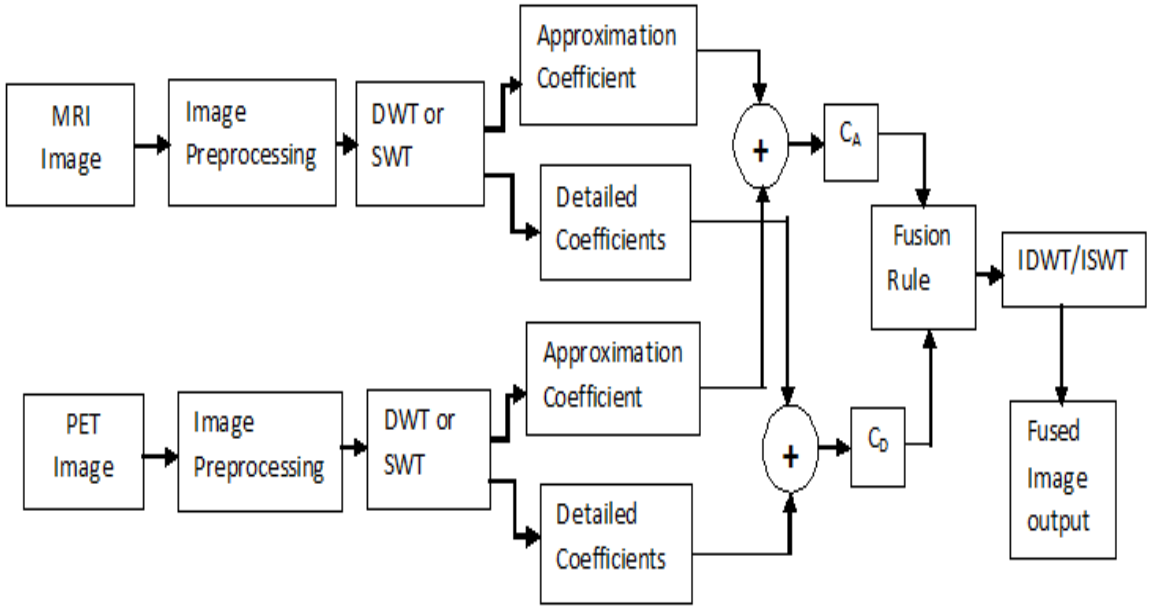


Fig 3. Block Diagram of Medical Image Fusion

As shown in block diagram, we took two input images from different modalities like MRI, PET or CT scans.
The images are fused using pixel level image fusion technique, in which preprocessing done is resizing of the image. Both the image are compared for same resolution, if not, one of the image is resized to another image to get better output.
The decomposition of image is done by either DWT or SWT.
After decomposition, we get 4 coefficients HH, LH, HL, HH obtained from passing the image from LPF & HPF for rows & downs sample them. We get half resolution of resultant/ output image. Again the output be passed from LPF & HPF for columns & then again down sample them. We get four coefficients of both images, that means total 8 coefficients & those are Approximation Coefficients (low frequency components of an image) & detailed coefficients (horizontal, vertical and diagonal coefficients).As per the no. of levels, we can decompose the image in the same way as described above. After getting the coefficients at level n (no. of decomposition level), all the resultant coefficients are added/ fused by fusion rule. The approximation coefficients are fused and detailed coefficients are fused separately and inverse DWT or SWT is applied on the outputs. The result is a fused image which is having feature /details of both the original medical images. Calculate the Entropy of all the images and compare which wavelet function is better or comparison of DWT & SWT.

A. Algorithm

1) *Input:* Acquisition of images from two different sensors or equipment
2) *Output:* Final Fused Image with more information than a single image
a) Read input image 1
b) Read Input Image 2
c) Convert both the images in gray scale image (For Colour images)
d) Check for Resolution of both images
e) If not, resize image high resolution image to size of lower resolution image
f) If yes, decompose the images up to level 2 using DWT or SWT
g) Apply Fusion Rule
h) Perform Inverse DWT or inverse SWT operation
i) With the parameter- Entropy, compare the fused images

©IJRASET: All Rights are Reserved

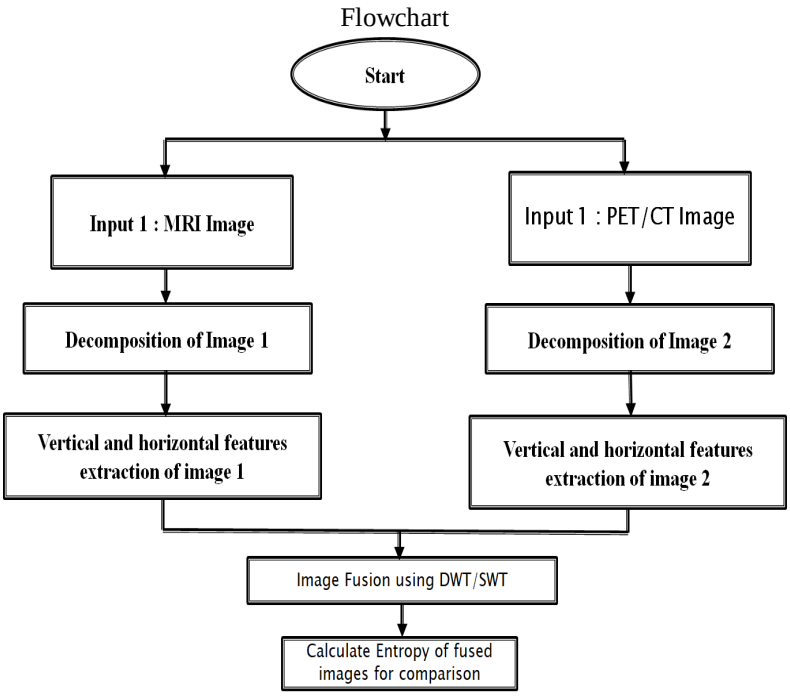
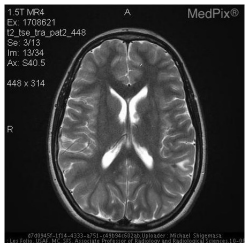


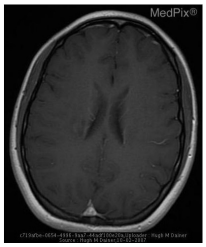
Fig 4. Flowchart of Image fusion using DWT/SWT

IV. RESULTS

A. *Brain Images Analysis using DWT & SWT*

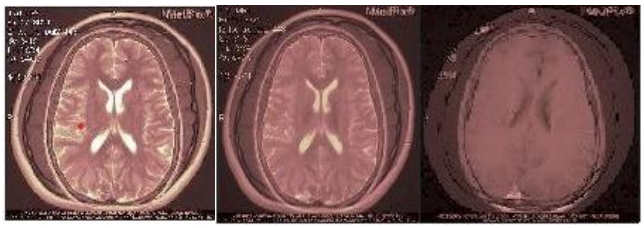


Brain MRI original



Brain PET original

SET 1



(a) (b) (c)

SET 2

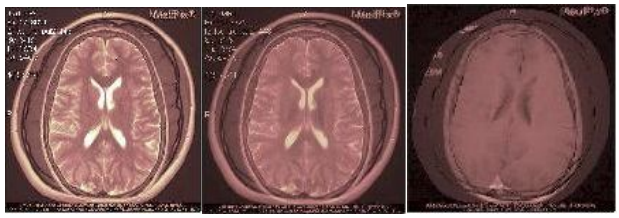


(a) (b) (c)

©IJRASET: All Rights are Reserved

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

SET 3



(a) (b) (c)

SET 4



(a) (b) (c)

SET 5



(a) (b) (c)

Fig 5.DWT Fused Brain images using various WT functions like Bior1.3, Coif4, db2, haar, sym4 by given fusion rules (a) Max, (b) Mean, (c) Min

Entropy: Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. Entropy is defined as -sum(p. *log2(p)) , where p contains the normalized histogram counts returned from imhist .

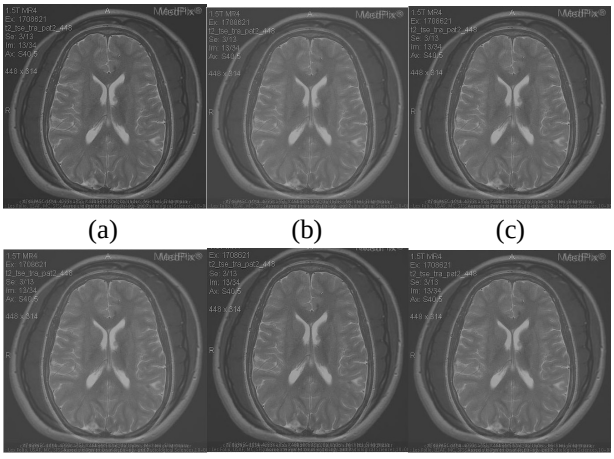
Entropy is **a measure** of disorder or randomness, and hence a measure of uncertainty. Thus, entropy can be considered as an assessment criterion for the significance of ciphering technique. The higher the entropy the better the encryption algorithm.

$$H = \sum_{i=0}^{n} P_i \log_2 P_i \quad (7)$$

Wavelet/ Fusion Method	Bior1.3	Bior3.5	Coif4	DB2	DB4	DB8	Haar	Sym4
MaxMax	7.7478	7.7459	7.7336	7.7478	7.7425	7.7476	7.7559	7.7466
MeanMean	7.4540	7.4587	7.4322	7.4244	7.4474	7.4376	7.4550	7.4553
MinMin	7.0912	7.0748	7.0764	7.0813	7.0515	7.1124	7.0263	7.0984

Table 1. Entropy values of Brain MRI & PET images fusion using DWT

©IJRASET: All Rights are Reserved



(a) (b) (c)

(d) (e) (f)

Fig 6. SWT Fused Brain images using sym4 by given Wavelet transform functions (a) Bior1.3, (b) Coif4, (c) db2, (d) db8, (e) haar, (f) sym4

Stationary Wavelet Transform	Bior1.3	Bior3.5	Coif4	DB2	DB4	DB8	Haar	Sym4
Entropy	6.3904	6.3399	6.3467	6.3769	6.3185	6.2946	6.3947	6.3332

Table 2. Entropy values of Brain MRI & PET images fusion using SWT

B. Chest Images Analysis using DWT & SWT



Chest MRI original



Chest PET original

SET 1



(a) (b) (c)

SET 2



(a) (b) (c)

©IJRASET: All Rights are Reserved

SET 3



(a) (b) (c)

SET 4



(a) (b) (c)

SET 5

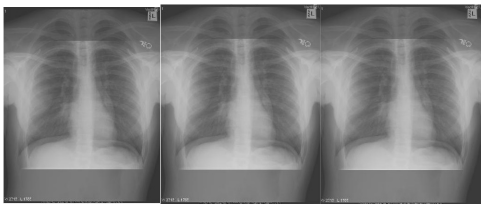


(a) (b) (c)

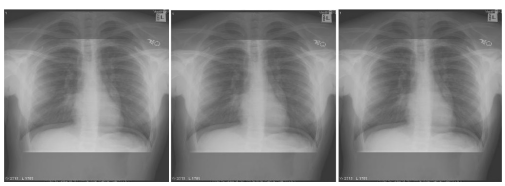
Fig 7.DWT Fused Chest images using various WT functions Bior1.3, Coif4, db2, haar, sym4 by given fusion rules (a) Max, (b) Mean, (c) Min

Wavelet/ Fusion Method	Bior1.3	Bior3.5	Coif4	DB2	DB4	DB8	Haar	Sym4
MaxMax	7.4169	7.4165	7.4403	7.4305	7.4285	7.4402	7.3909	7.4401
MeanMean	7.5969	7.5982	7.5993	7.5969	7.5840	7.6003	7.5545	7.6005
MinMin	6.9424	6.8775	6.8583	7.9477	6.8641	6.9511	6.8948	6.8871

Table 3. Entropy values of Chest MRI & PET images fusion using DWT



(a) (b) (c)



(a) (b) (c)

Fig 8. SWT Fused Brain images using sym4 by given

©IJRASET: All Rights are Reserved

Wavelet transform functions (a) Bior1.3, (b) Coif4, (c) db2, (d)db8,(e)haar,(f)sym4

Stationary Wavelet Transform	Bior1.3	Bior3.5	Coif4	DB2	DB4	DB8	Haar	Sym4
Entropy	6.9775	7.0167	7.0041	6.9759	7.0429	7.0362	6.9786	7.0185

Table 4. Entropy values of Brain MRI & PET images fusion using SWT

V. CONCLUSION

Performed Image Fusion using DWT and SWT approaches for decomposition of multimodal and multi resolution images using and applied the fusion rules-max, avg and min for DWT synthesis process.

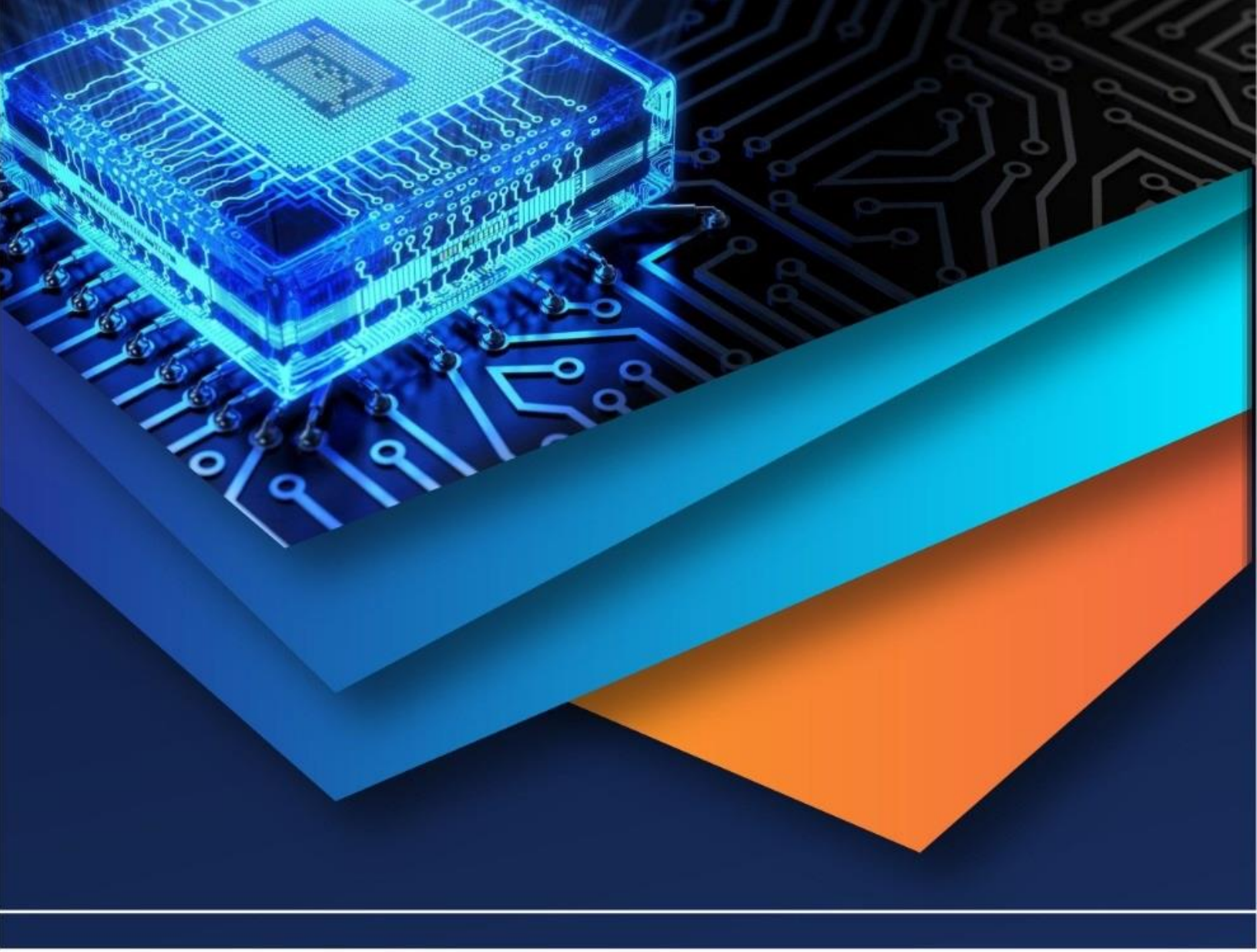
1) In case of Brain DWT, the best results get from Haar max fusion approach.
2) In case of Brain SWT, the best results get from Haar fusion approach.
3) In case of Chest DWT, the best results get from DB8 average fusion approach.
4) In case of Chest SWT, the best results get from DB4 fusion approach.

So we can conclude that the Haar Wavelet Function gave better result in case of Brain images fusion and daubechies wavelet transform function gives better result compared to all other functions.

REFERENCES

[1] Multimodal Medical Image Sensor Fusion Framework Using Cascade Of Wavelet And Contourlet Transform Domains - Vikrant Bhateja, Member, IEEE, Himanshi Patel, Abhinav Krishn, Akanksha Sahu and Aimé Lay-Ekuakille, Senior Member, IEEE
[2] Multi-scale fidelity measure for image fusion quality assessment- Jorge Martinez a , Silvina P197–211
[3] Medical Image Fusion using Transform Techniques-B. Ashwanth, K.Veera Swamy-2020 5th International Conference on Devices, Circuits and Systems (ICDCS)
[4] Image fusion using hybrid methods in multimodality medical images-Satya Prakash Yadav & Sachin Yadav -Medical & Biological Engineering & Computing-https://doi.org/10.1007/s11517-020-02136-6
[5] Medical Image Fusion Based on the Structure Similarity Match Measure - Zhang-Shu Xiao, Chong-Xun Zheng - 2009 International Conference on Measuring Technology and Mechatronics Automation
[6] https://www.mathworks.com/matlabcentral/fileexchange/65680-wavelet-based-image-fusion
[7] https://mil.ufl.edu/nechyba/www/eel6562/course_materials/t5.wavelets/intro_dwt.pdf
[8] https://www.cs.auckland.ac.nz/courses/compsci773s1c/lectures/ImageProcessing-html/topic1.htm
[9] https://link.springer.com/article/10.1007/s11517-020-02136-6
[10] https://www.alliedacademies.org/articles/hybrid-medical-image-fusion-using-wavelet-and-curvelet-transform-with-multiresolution-processing.html
[11] https://www.matlabclass.com/2014/05/matlab-implementation-of-image-fusion.html
[12] https://www.continuummechanics.org/wavelets.html
[13] https://www.hindawi.com/journals/cmmm/2020/8279342/
[14] istonesia , María Cristina Maciela , Ana Georgina Flesia -Information Fusion 50 (2019)
[15] https://en.wikipedia.org/wiki/Image_fusion#:~:text=The%20image%20fusion%20process%20is,of%20all%20the%20necessary%20information

©IJRASET: All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)