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# Enhancement of Medical Image by Fusion Method using Fast Discrete Curvelet Transform

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**Abstract:** Image fusion is the combination of two (or) more different image to form a new image with better information. Image resolution enhancement based on Fast Discrete Curvelet Transform. The info pictures are gotten from various envisioning methods such as Computer Tomography (CT), Positron Emission Tomography (PET) and Magnetic Resonance Imaging (MRI). Info picture is disintegrated into various sub-groups. After decay, a non-straight capacity is connected to the produced curvelet co-efficient to improve the distinctive recurrence sub-groups. The resultant images are fused by fusion techniques such as Principle Component analysis (PCA), Minimum selection method, Maximum selection method and Simple average method. Fused image results was evaluated using metrics of Root Mean Square Error (RMSE), Peak Signal to Noise Ratio (PSNR) and Entropy (H). The outcomes demonstrated that the resultant picture has preferable data over the current strategy which respect to visual quality and information substance of consolidated picture. The results procured can be helpful for remedial finding of patient for further treatment.

**Keywords:** Image fusion, FDCT, CT, PET, MRI, PCA, PSNR, RMSE.

## I. INTRODUCTION

Medical image fusion is the process combining the two or more images to form a new image with high information. The resolution is an important aspect of image. Many techniques are proposed in order to enhance the resolution of an image and are specifically dedicated to super resolution. Wavelet change is basic, has great capacity to protect time and recurrence subtleties with better PSNR. Research demonstrates that picture combination dependent on wavelet change works effectively for satellite and medicinal applications in which pictures contain direct items however its fundamental impediment emerges for combination of bended shapes as it has low exactness for identification of bended edges. It is seen that a large portion of medicinal pictures contain curvilinear structures. So, to defeat this confinement, E. J. Candes and D. L. Donoho put forward Curvelet Transform hypothesis in 2000. A couple of endeavors for curve let based combination have been made in the field of satellite imaging, picture denosing and Differentiate improvement however, less endeavors have been made for therapeutic imaging. Curvelets and ridgelets works in Fourier area and takes the type of premise components, which show exceptionally high directional affectability along edges and are exceedingly directionally reliant which gives distinctive qualities in various directions. Thusly, curvelet change speaks to edges superior to wavelet and ridge let change and is appropriate for therapeutic applications. The Curvelet Transform had convoluted computerized acknowledgment, incorporates sub-band decay utilizing wavelet change, smooth dividing square, standardization, Ridgelet examination, etc.

Curvelet's pyramid disintegration brought enormous information excess. Subsequently in 2005 E. J. Candes set forward Fast Curvelet Transform (FCT) that was the Second Generation Curvelet Transform which was easier what's more, effectively reasonable. In this day and age numerous sensor types are sprouting up in showcase with various physical attributes and it is exceptionally hard to build up a sensor with great spatial just as recurrence qualities into a solitary picture since picture information recovered has diverse geometry, range, time and space goals. Therefore it is difficult to fulfill all these functional acquirements utilizing a solitary sensor. Consequently, the specialized strategy to take care of this issue is picture combination. In this paper Picture combination dependent on Fast Discrete Curvelet change utilizing distinctive combination guidelines, for example, Averaging, Minimum Selection, PCA based technique, Maximum Selection and Laplacian Pyramid rules are actualized, examined and contrasted with demonstrate expanded picture visual quality and wealth of data by thinking about 7 quality measurements parameters. So it is normal that combination of MR and CT pictures of the equivalent organ would result in a coordinated picture of significantly more subtleties.

The rest of the paper is organized as follows: Section II presents literature survey. Section III Presents the proposed image fusion algorithm. Section IV gives the experimental process and performance metrics. Finally, section V gives the concluding remarks.

## II. LITERATURE SURVEY

Speaks to discuss improvement differentiate on the advanced-pictures a wide zone of interests crosswise over masters and specialists around there, having managed numerous examination to upgrade differentiate research, study and assement, coming up next are some past investigation:

- In [1] H. Li, et, al: Proposes a novel X-ray image contrast enhancement method using the second generation curve let transform in order to better enhance contrast and edges while remove noise. Decompose images source in the curvelet transform domain. Combining with the threshold a noise reduction, the nonlinear enhancement operator is also applied to high-frequency sub-bands to enhance edges and reduce noise. Then, the processed coefficients are constructed to obtain enhanced images.
- In [2] M. Kalyan, et, al: Proposes a new method to enhance the satellite image which using the concept of curve lets and multi structure decomposition. Fast Discrete Curvelet Transform technology is used to enhancement the image of decomposing input in different sub-bands. Multiple decomposition structures is a powerful theoretical tool, which is used in the analysis of non-linear images. Revealing of the positions edges through decomposition threshold and sharpening these edges by using morphological filters.
- In [3] H. Ahmed, et, al: Proposes a new algorithm fingerprint image enhancement by performing threshold on fast discrete curvelet transform domain and applying Gabor Filters. The algorithm reduces noise image of fingerprints by using threshold Fast Discrete Curvelet Transform, then apply Gabor filters to enhancement the clarity of the image.
- In [4] S. Palanikumar, et, al: Proposes a novel approach for enhancing palm print image based on curve let transform. The enhancement uses to modify contrast of an image and reduce noise. Histogram equalization enhances the contrast of an image.
- In [5] C. Tao, et, al: Proposes an enhancement algorithm based on fast discrete curve let transform, uses positive transform on input image, means decompose the image into coarse scales and minute scales coefficients, and then make use of a directional filter and a soft threshold function to enhance image and reduce noise respectively, and implement inverse transform, and reconstruct the enhanced image.
- In [6] X. Wang, et, al : Proposes a novel method for enhancing the low contrast of fingerprint images based on fast discrete curve let transforms, uses nonlinear function based on a row means quantization transform to adjust the coefficient of low-frequency sub band in low-frequency component, and uses noise reduction threshold to enhancement the details of the image in high-frequency component.
- In [7] A. Ein-shoka, et, al: Proposes a method is employing homomorphic filtering in the fast discrete curvelet transform. It was based on the mix the advantages of fast discrete curve let transform for representing curves and clarifying features on it with Homomorphic filtering which is an efficient way for enhancing of IR images.
- In [8] Y. Juyi: Proposed an enter principle of the second generation Curvelet transform. The tests of color images show that the algorithm can provide good enhance the effect, increase the contrast, reduce noise. It is superior to wavelet and Ridge let algorithms in both visual effect and performance indicators.
- In [9] C. Ying, et, al: Proposes a technique new image enhancement based on the traditional technology, of between it Curvelet transform which are based on the ridge of the development of the theory of wave, is a kind of new way of the image enhancement technology, Some revisions and attempts were made on the basis of discrete Curvelet transform algorithm, and also, coefficient of curvelet transform was revised.

### III. PROPOSED SYSTEM

The multi modular medicinal picture are reciprocal in nature as CT picture contains subtleties of hard surface while subtleties of delicate tissues are not unmistakable and MR picture contains subtleties of delicate tissues while bone subtleties are most certainly not unmistakable. It is troublesome for doctors for right finding of patients. Subsequently our goal is to combine the two pictures to get a solitary picture with however much data as could be expected. So a Curvelet based calculation is presented for this reason. The block diagram of Proposed Method for Image Fusion is shown in Fig.1 which describes the step by step implementation.

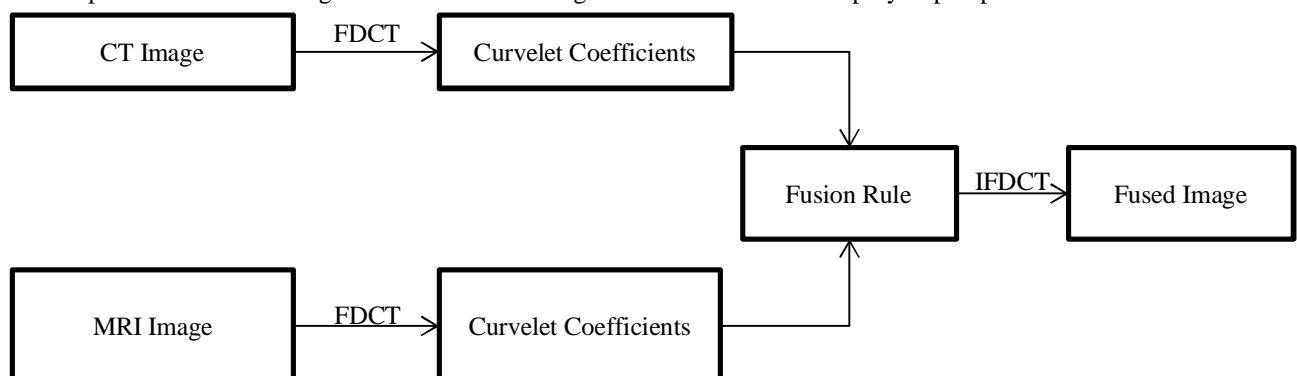


Fig 1. Block diagram of proposed system

The two source pictures CT and MR are enlisted which ought to be of same size and legitimately adjusted. At that point 2D Discrete Fast Curvelet Transform by means of wrapping is connected to both of these pictures. Pictures can be melded utilizing unique combination rules, to be specific Averaging, Minimum Selection, PCA based strategy, Maximum Selection and Laplacian Pyramid rules. The backwards change, IDFCCT is connected to get the combined picture. The steps involved in proposed system can be summarized as follows:

The two input images are registered.

Each input image is then analyzed and a set of Curvelet coefficients are generated.

One of the Fusion rules such as Maximum Selection, Minimum Selection and Simple Average are applied.

Finally the Inverse Fast Discrete Curvelet transform (IDFCCT) step is performed (The fused coefficients are subjected to the inverse Curvelet Transform) to obtain the fused image.

The steps involved in proposed algorithm can be summarized as follows:

- A. The two input images CT, image I and MR, image II to be fused are applied as input.
- B. The FDCT via wrapping method is applied to both input images.
- C. The outputs obtained after applying DFCT on two source images, are represented by  $xxDF^L_I$  and  $xxDF^L_{II}$ .
- D. Apply different pixel level fusion rules like minimum selection, averaging, PCA rule, Maximum selection and Laplacian Pyramid to FDCT coefficients matrix,  $xxD^F_{LI}$  and  $xxD^F_{LII}$  and fused image is represented by  $xxD^F_{Lf}$ .

For Minimum selection rule, fusion is done by taking the minimum valued pixels from  $xxDF^L_I$  and  $xxDF^L_{II}$  sub images.

$$xxDF^L_f = \text{minimum}(xxDF^L_I(i,j), xxDF^L_{II}(i,j)) \quad (1)$$

The PCA rule, fusion is done with principal component analysis calculation for  $xxDF^L_I$  and  $xxDF^L_{II}$  sub images and then integrating product of principal components ( $P_I, P_{II}$ ) with each source sub images into a single image.

$$xxDF^L_f = P_I(xxDF^L_I(i,j)) + P_{II}(xxDF^L_{II}(i,j)) \quad (2)$$

Averaging Rule, fusion is done by taking the average of pixels values from coefficients matrix obtained after DFCT applied on two source images I and II, namely  $xxDF^L_I$  and  $xxDF^L_{II}$  sub images.

$$xxDF^L_f = (xxDF^L_I(i,j) + xxDF^L_{II}(i,j)) / 2. \quad (3)$$

For Maximum selection rule, fusion is done by taking the maximum valued pixels from coefficients of source images I and II.

$$xxDF^L_f = \text{maximum}(xxDF^L_I(i,j), xxDF^L_{II}(i,j)). \quad (4)$$

Based on the maximum valued pixels between  $xxDF^L_I$  and  $xxDF^L_{II}$  images from Eq. (1), a binary decision map is formulated. Eq. (2) gives the decision rule  $Dr$  for fusion of discrete DCTG2 coefficients in the two source images I and II as

$$Dr(i, j) = 1, \text{ if } dI(i, j) > dII(i, j) = 0, \text{ otherwise} \quad (5)$$

For Laplacian pyramid rule, fusion is done by first filtering the  $xxDF^L_I$  and  $xxDF^L_{II}$  sub images and then difference is calculated by expansion or interpolation way and discrete convolution is performed to reconstruct the fused image,  $xxDF^L_f$ .

E. Thus, the concatenated image corresponding to FDCT output is obtained by selecting any of the above discussed pixel level fusion rules.

F. Apply Inverse 2D Fast Discrete Curvelet Transform to reconstruct the resultant fused image and display the result.

#### IV. EXPERIMENTAL PROCESS AND PERFORMANCE METRICS

Results acquired by applying proposed calculation to intertwine CT and MR pictures are appeared graphical UI in Fig.6.7 For execution assessment of intertwined picture, the visual quality just as quantitative examination is finished by considering 7 quality estimation

parameters talked about in Table I which demonstrates improved execution than Wavelet change and other curvelet change based combination calculations. The quality measurements parameters esteem for better combination must be as appeared Table I.

TABLE 1: STATISTICAL PARAMETER VALUE OF FUSED IMAGE

| Sr.N | Performance Metrics   | values |
|------|---|--------|
| 1.   | Entropy (E), Average Gradient (AG) and Peak Signal to Noise Ratio (PSNR), Mean and Standard deviation(SD) | High   |
| 2.   | Root Mean Square Error(RMSE)  | Low    |
| 3.   | Correlation Coefficient, Cc   | Near1  |

The statistical parameter value of fused image is high after the transform is applied. The resolution is increasing when the cross correlation is small.

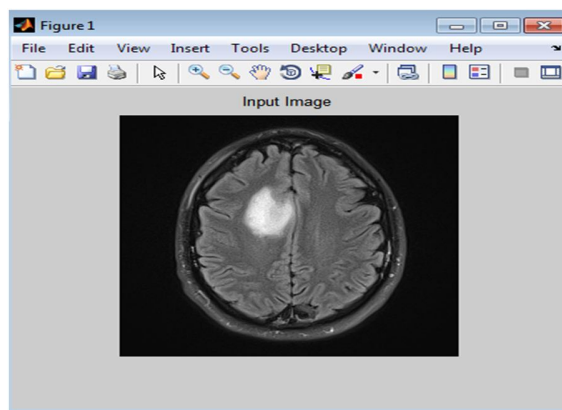


Fig6.1 Input image

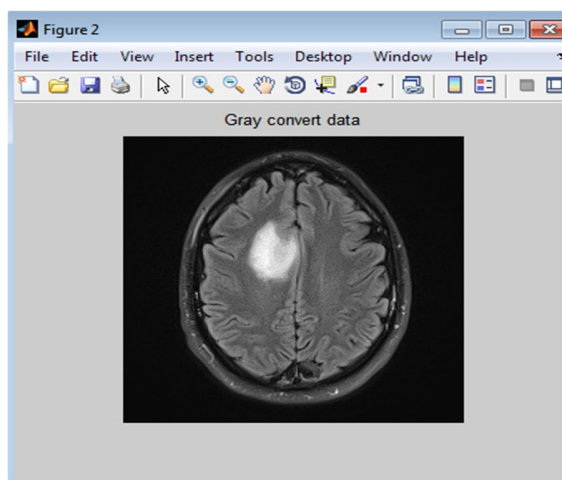
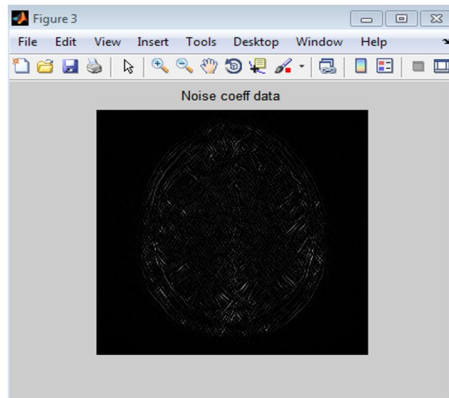
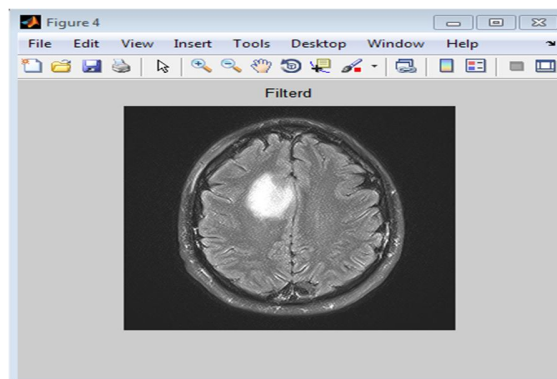


Fig6.2 Gray convert image

The input images of CT and MRI are taken and that can be fused together shown in fig.1. Grayscale images are distinct from one-bit bi-tonal black-and-white images which, in the context of computer imaging, are images with only two colors: black and white. Grayscale images have many shades of gray in between is shown in fig.2



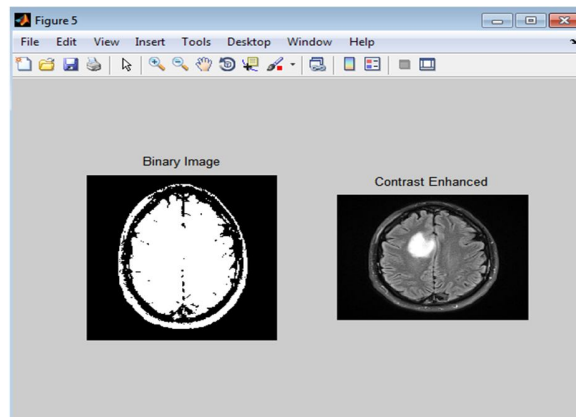
**Fig6.3 noise co-efficient image**



**Fig6.4 Filtered image**

Image noise is random variation of brightness or color information in images, and is usually an aspect of electronic noise. It can be produced by the sensor and circuitry of a scanner. That noises can be determined in the fig. 6.3.

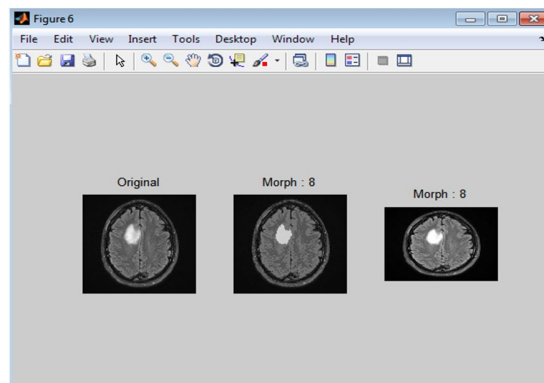
The medium filter is used to changes the appearance of an image or part of an image by altering the shades and colors of the pixels in some manner. Filters are used to increase brightness and contrast as well as to add a wide variety of textures, tones and special effects to a picture shown in fig 6.4.



**Fig6.5 contrast enhanced image**

The contrast is the luminance of the object. The bright values of image produce more bright and dark value are even dark. Differentiation improvement changing the pixels power to use most extreme conceivable receptacles, difference upgrade depends on five procedures such as nearby, incomplete, brilliant and dim difference.

The contrast enhancement image change the image value distribution to cover a wide range and binary image produce the dark and bright value. The shapes and arrangement of parts of organisms can be determined for the development in morphological process.

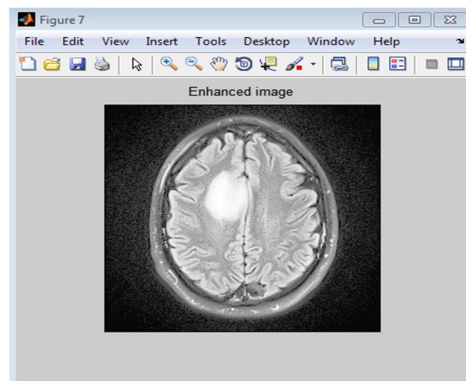


**Fig6.6 Morphological image**

**TABLE II. FUSED IMAGE PERFORMANCE RESULTS**

| Fusion rules      | Mean  | SD    | H    | AG   | PSNR  | CC   | RMSE |
|-------------------|-------|-------|------|------|-------|------|------|
| Minimum selection | 6.78  | 19.13 | 2.98 | 3.04 | 42.77 | 0.51 | 5.32 |
| PCA               | 53.85 | 55.24 | 7.67 | 6.67 | 43.08 | 0.98 | 5.02 |
| Averaging         | 31.76 | 33.7  | 4.93 | 2.61 | 41.46 | 0.75 | 2.68 |
| Maximum Selection | 61.42 | 61.26 | 7.76 | 7.00 | 45.43 | 0.92 | 3.34 |
| Laplacian Pyramid | 66.01 | 58.08 | 8.17 | 6.06 | 54.64 | 0.89 | 0.38 |

The performance of the fused image can be analyzed using different fusion rules. The enhanced resultant image can be obtained with better performance results. Mostly use the PCA fusion rule for the image process in simple manner. The performance value must be differ from one transform to others.



**Fig6.7 Enhanced image**



The enhanced image is obtained after applying the inverse fast discrete curvelet transform and it produce better information than other transform.

## V. CONCLUSION

Thus the two different modality images are fused using the PCA fusion rule based on the Fast Discrete Curvelet Transforms. The performance evaluation of fused image is done firstly through visual quality inspection and then 7 quality metrics are analyzed to prove increased quality of fused image than the two source images while preserving the important details or features. The results obtained using Maximum PCA rules can be helpful for effective medical diagnosis of patient for further treatment. The future work includes further improvements in the algorithm using region level fusion rules instead of pixel level rules to improve the quality of fused image.

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