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Medical Image Fusion using Transform Based Fusion Techniques

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Abstract*: The principal resolution of the image fusion is to merging indication from different images; CT (Computed Tomography) scan and an MRI (Magnetic Resonance Imaging) and to obtain more informative image. In this paper various transform based fusion methods like; discrete wavelet transform (DWT) and two specialisms of discrete cosine transform (DCT); DCT variance and DCT variance with consistency verification (DCT variance with CV) and stationary wavelet transform (SWT) image fusion procedures are instigated and associated in terms of image evidence. Fused outcomes attained from these fusion techniques are evaluated through distinctive evaluation metrics. A fused result accomplished from DCT variance with CV followed by DCT variance out performs DWT and SWT based image fusion methodologies. The potentiality of DCT features creates value-added evidence in the output fused image trailed by fused results proficient from DWT and SWT based image fusion methods. The discrete cosine transforms (DCT) stranded methods of image fusion are auxiliary accurate and concert leaning in real time solicitations by energy forte of DCT originated ideologies of stationary images. In this effort, a glowing systematic practice for fusion of multi-focus images based on DCT and its flavors are obtainable and demonstrated that DCT grounded fused outcomes exceed other fusion methodologies.

***Index Terms*: fusion, DCT, DWT, MRI, CT.**

I. INTRODUCTION

Highlight a section that you want to designate with a
Recommends a new medical image fusion centered on the united effect of Discrete Wavelet Transform (DWT) and Discrete Ripplet Transform (DRT). The source images are originally converted into multiresolution image by means of DWT. The estimate images are additionally converted by utilizing DRT. The ripplet constants are useful to Pulse Coupled Neural Network (PCNN) and sacking maps are created. Relating the supreme fusion instruction and inverse DRT, the bonded factors of the estimate image are attained. The aspect images of the DWT are now fused expending outright supreme fusion instruction. The output image is acquired by relating inverse DWT to the united factors. The enactment of the output image is assessed by using parameters; entropy, standard deviation and average gradient and it overtakes the further standing approaches [1].

Endorsed a redundant discrete wavelet transform (RDWT) grounded image fusion approach for multimodal medical images. The shift invariance nature of RDWT shows its effectiveness for image fusion. The projected technique customs maximum arrangement for fusion of medical images. Proposed method explored with numerous groups of medical images and exposed outcomes for three groups of medical images. The success of fusion outcomes has remained exposed expending edge strength, and mutual information fusion assessment parameters. The subjective and objective evaluation of the projected technique with dimensional province fusion methods (Linear, Sharp, and principal component analysis (PCA)) and wavelet province image fusion approaches (discrete wavelet transform (DWT), lifting wavelet transform (LWT), and multiwavelet transform (MWT)) demonstrates the preeminence of the projected image fusion technique [2].Multimodal medical image fusion procedures and instruments have exposed distinguished accomplishments in enlightening clinical correctness of determinations constructed on medical images. The province where image fusion is willingly utilized currently is in medical diagnostics to fuse medical images. Proposed a new procedure to advance the excellence of multimodality medical image fusion expending Discrete Wavelet Transform (DWT) method. DWT approach has been engaged by utilizing various image fusion methods for medical image fusion. Concert of image fusion is intended on the foundation of PSNR, MSE and the total handling time and the outcomes illustrates the efficiency of fusion organization founded on DWT [3].A new weight map structure procedure founded on visual saliency is established. Weight maps of this procedure are proficient of perceiving and recognizing attentive and defocused sections of the input images. Method is competent to assimilate only attentive and refined sections into the output image. Concert of the projected technique is associated with that of the advanced multi-focus image fusion procedures. Projected technique outpaces them in positions of visual quality and image fusion evaluation parameters [4]. MRI and PET images are preprocessed beside with augmenting the excellence of the source images which are despoiled and non-readable owing to numerous features by expending spatial filtering procedures similar Gaussian filters. The improved image is then united grounded on DWT for brain sections with diverse activity planes.

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The scheme exhibited about 80-90% additional precise outcomes with condensed color alteration and without trailing any functional evidence in association with the standing methods in standings of concert metrics [5].

II. LITERATURE SURVEY

Image fusion has come to be a collective tenure utilized inside medical diagnostics and action to be taken. The tenure is utilized when numerous inputs of a patient are recorded and overlapped or combined to deliver further evidence. Fused output images may be designed from various images from the similar imaging modality, or by conjoining evidence from various modalities, for example magnetic resonance image (MRI), computed tomography (CT), positron emission tomography (PET), and single photon emission computed tomography (SPECT). In radiology and radiation oncology, these images assist diverse determinations. For specimen, CT images are utilized additional frequently to establish variances in tissue density whereas MRI images are characteristically utilized to analyze brain tumors.Proposed an innovative medical image fusion technique grounded on an adaptive local geometrical construction inside wavelet framework. The local image construction is designated by the eigenvalues and eigenvectors of construction tensor of each image. The fused great incidence wavelet factors are collected by an adaptive weighted sum of that of two input images. Adequate edifices, for instance edges and corners, can be conserved with this technique. Investigational outcomes on medical images display that the concert of an innovative method [6]. Proposed method designated that intensity-hue-saturation (IHS) transform and principal component analysis (PCA) can reserve additional spatial information and added essential well-designed evidence without color misrepresentation. The proposed procedure incorporates the benefits of both IHS and PCA image fusion approaches to progress the fused image eminence. Pictorial and measurable examination indicates that the planned procedure meaningfully advances the fusion eminence [7].By directing the evaluation it has been revealed that the mainstream of the standing procedures are grounded on transform domain consequently it could outcomes in some items which may reduce the accomplishment of the transform built vision fusion procedures. Furthermore it is previously been revealed that the subject of the uneven lighten has even now ignored in the utter greatest of standing effort on image fusion. Consequently to stunned these matters, a renewed technique which assimilates the larger valued Alternating Current (AC) factors intended in iterative block level principal component averaging (IBLPCA) domain grounded fusion with brighten normalization and fuzzy development has been projected here. The investigational outcomes display that the productivity of projected procedure over standing techniques [8]. An innovative multimodality medical image fusion procedure which comprises gradient minimization smoothing filter (GMSF) and pulse coupled neural network (PCNN). Primarily, an excellent multi-scale edge-preserving disintegration framework based on GMSF is suggested to decompose every input image into one base image and a series of particular images. For mining and conserving additional noticeable features and specific information, various fusion instructions are intended to fuse the parted sub descriptions. The base images are fused by utilizing the local subjective totality of pixel energy and gradient energy, and a biologically inspired feedback neural network is utilized to fuse the feature images. The concluding fused image is attained by synthesizing the fused base image and feature images. Investigational outcomes on numerous datasets of CT and MRI images display that the projected procedure outclasses other associated approaches by means of both particular and impartial evaluation [9].Medical image fusion is utilized to develop additional valuable evidence from various modality medical images. Medical image fusion technique grounded on multiscale transforms is projected. The projected technique practices the combination of Non-Subsampled Contourlet Transform (NSCT) and Stationary Wavelet Transform (SWT) for the disintegration of images. The decomposed factors are fused twice by means of maximum selection, spatial frequency and variance fusion instructions. The recreated image is attained by compelling inverse multiscale converts on fused factors. The investigational examination of the projected technique is achieved with numerous groups of medical images. The image fusion outcomes demonstrated that projected image fusion technique achieves plentiful improved than standing advanced image fusion approaches in terms of measureable and eminence results [10]. A fuzzy and neuro fuzzy based iterative image fusion is planned and proved that suggested method outperforms image fusion on medical images [14].A neuro fuzzy based iterative image fusion technique projected and proved that the suggested method improves the image quality through fusion on satellite and medical images [15]. Numerous assessment parameters are utilized to evaluate fused images obtained from fuzzy and neuro fuzzy based image fusion approaches [16,17 and 18]. The proposed work is illustrated in Fig.1.

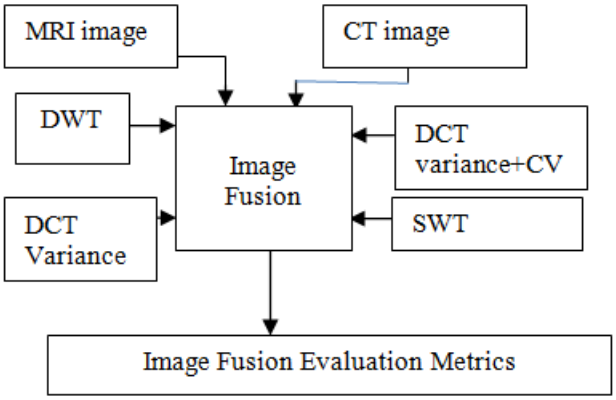


Fig. 1. The organization of the proposed work

III. IMAGE FUSION USING DWT

The stages intricate in DWT based procedure are as succeeding [11]

- Get two source images, I1 and I2 to perform fusion.
- Conduct self-governing wavelet disintegration of two source images
- Relate pixel based procedure for estimates which comprises fusion founded on enchanting the supreme appreciated pixels from estimates of input images I1and I2

- Grounded on the extreme appreciated pixels among the calculations, a binary decision map is produced bounces the conclusion instruction for fusion of estimations factors in two input images I1and I2.
- The concluding fused image converts consistent to estimations concluded extreme assortment pixel instruction is attained.
- Concatenation of fused calculations and particulars provides an innovative amount matrix.
- Relate inverse DWT to rebuild the ensuing output image and exhibit the outcome.

IV. IMAGE FUSION USING DCT VARIANCE

- Discrete cosine transform (DCT) is an important transform almost exploited in many applications of image processing [12]. Immense DCT measures are engrossed in the short frequency segment; from now, it is renowned to have remaining dynamism determination properties.
- Stages complicated in DCT founded image fusion process [13]
- Attain source images to conduct image fusion.
- Accomplish level shifting and distribute source images interested in 8*8 blocks and accomplish the image fusion
- Calculate the 2-D DCT of 8*8 segments and compute standardized transmute factors
- Compute mean significance of 8*8 segment of images and Variance of 8*8 segment of images
- Compute the 2-D inverse DCT of 8*8 segments and construct the fused image.

V. DCT VARIANCE WITH CONSISTENCY VERIFICATION BASED IMAGE FUSION

In adding to stages convoluted in DCT variance grounded image fusion the subsequent stages are besides included.

- Attain source images to conduct image fusion.
- Accomplish level shifting and distribute source images interested in 8*8 blocks and accomplish the image fusion
- Calculate the 2-D DCT of 8*8 segments and compute standardized transmute factors
- Compute mean significance of 8*8 segment of images and Variance of 8*8 segment of images
- Compute the 2-D inverse DCT of 8*8 segments and construct the fused image.
- Calculate consistency verification by wealth of a main stream filter
- Compute consistency verification alongside with variance in DCT purview
- Accomplish inverse level shifting to acquire finishing fused image [13].

VI. IMAGE FUSION USING SWT

The discrete wavelet transform (DWT) is time off of translation alternative control which can be eradicated by spending stationary wavelet transform (SWT).

- Steps involved in SWT founded image fusion.
- Attain input images to perform fusion.
- image disintegration by utilizing discrete stationary wavelet transform
- Apply suitable fusion instruction to perform image fusion
- Apply inverse SWT to attain output fused image

VII. RESULTS AND DISCUSSIONS

Transform based image fusion process implemented on two different datasets. Fused outcomes are assessed through various evaluation parameters like image quality index (IQI), mutual information measure (MIM), fusion factor (FF), fusion symmetry (FS), fusion index(FI), root mean square error (RMSE), peak signal-to- noise ratio (PSNR) entropy, correlation coefficient (CC) and spatial frequency(SF) and results are illustrated below.

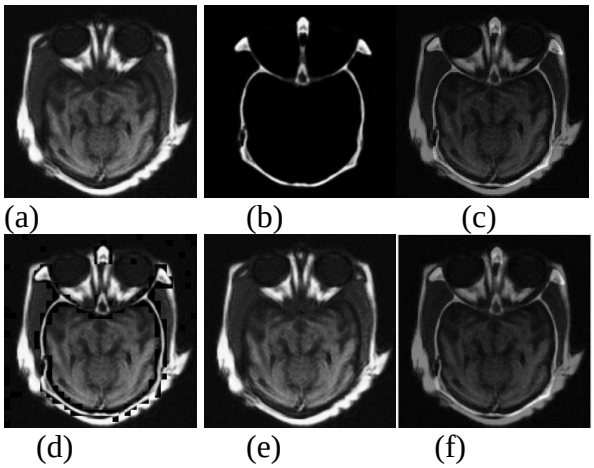


Fig. 2. Input images (a, b) to be fused, (c) DWT based fused image (d) DCT variance based fused image, (e) CV combined with DCT variance based fused (f) SWT based fused image for Dataset 1.

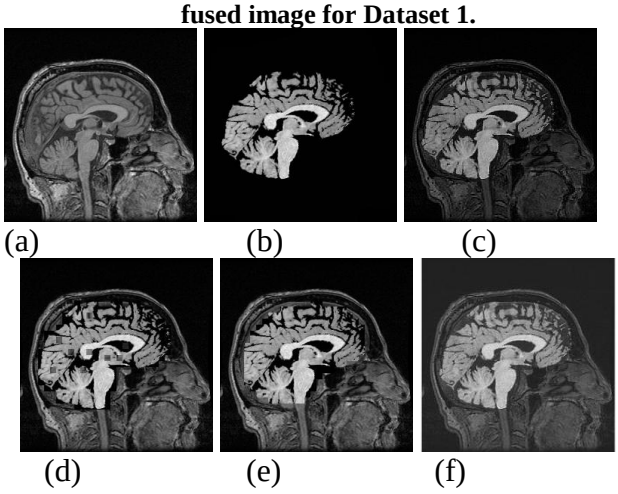
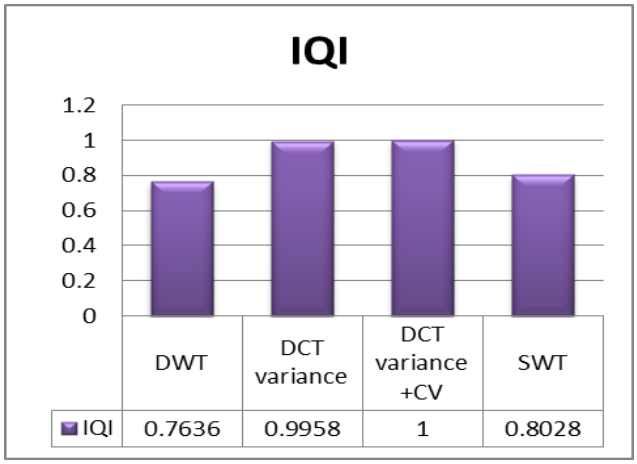
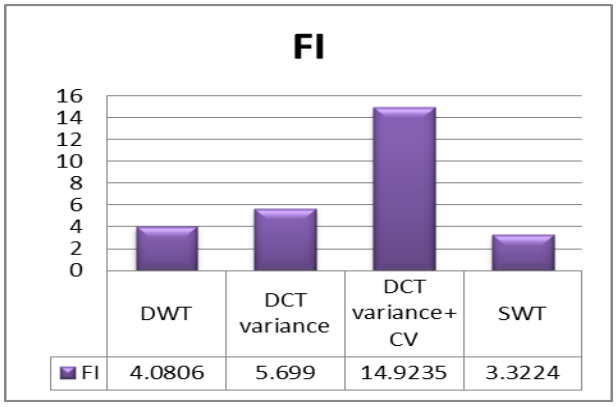
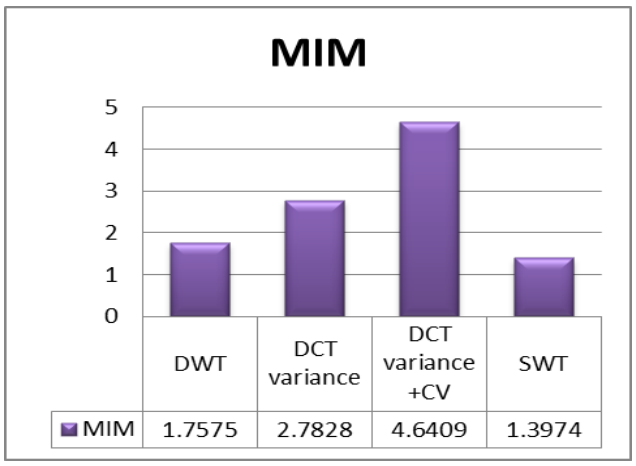
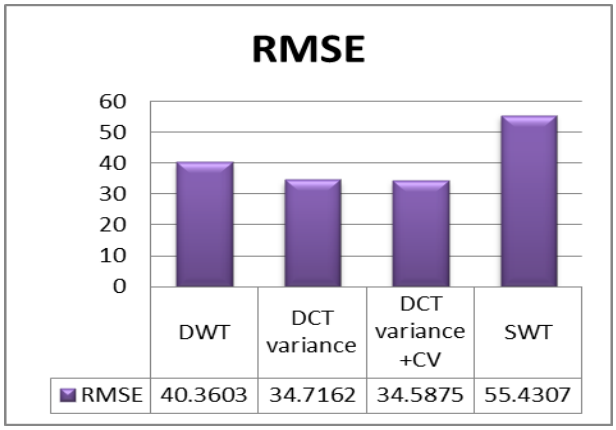


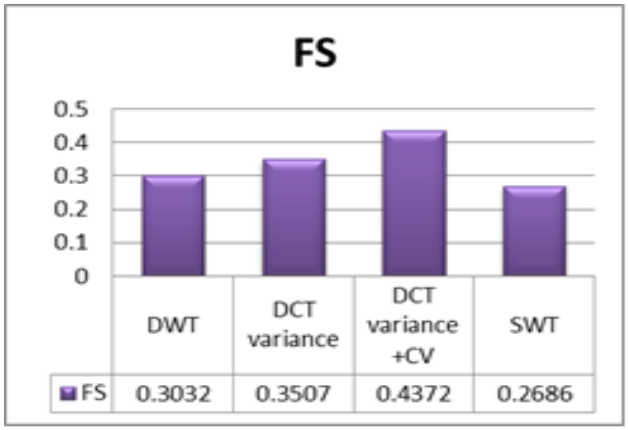
Figure 3. Input images (a, b) to be fused, (c) DWT based fused image (d) DCT variance based fused image, (e) CV combined with DCT variance based fused (f) SWT based fused image for Dataset 2.

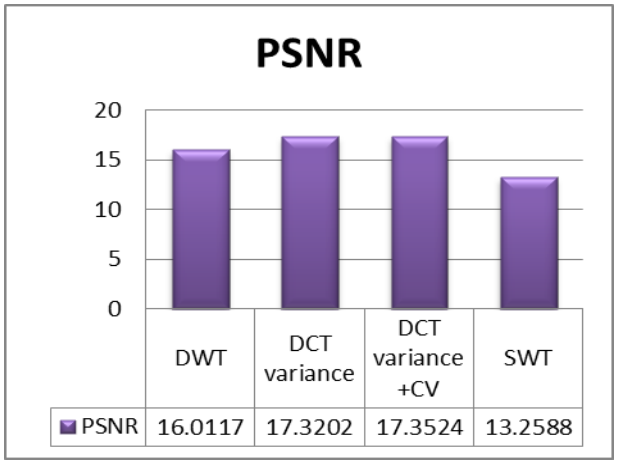

IQI
1.2
1
0.8
0.6
0.4
0.2
0
DWT
DCT variance
DCT variance +CV
SWT
IQI
0.7636
0.9958
1
0.8028

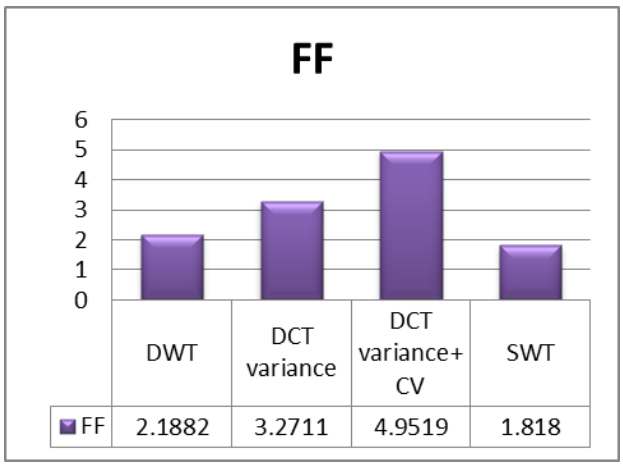

FI
16
14
12
10
8
6
4
2
0
DWT
DCT variance
DCT variance+ CV
SWT
FI
4.0806
5.699
14.9235
3.3224

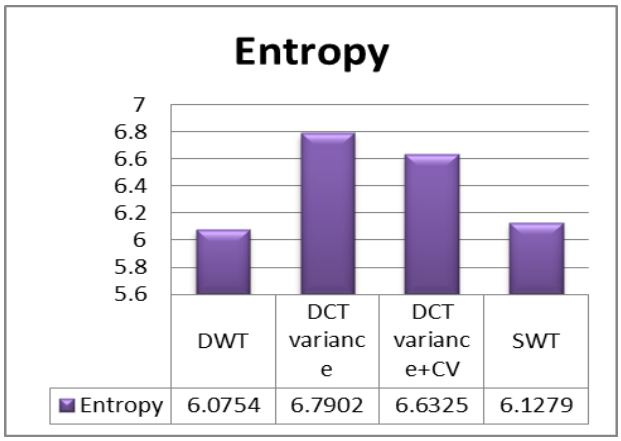

MIM
5
4
3
2
1
0
DWT
DCT variance
DCT variance +CV
SWT
MIM
1.7575
2.7828
4.6409
1.3974

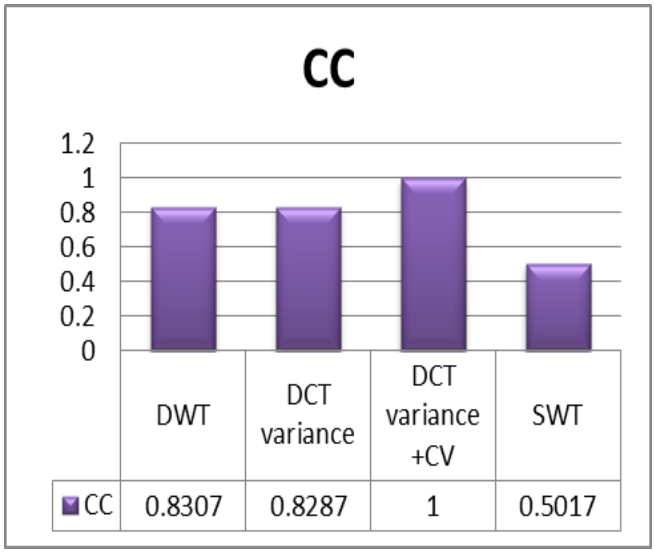

RMSE
60
50
40
30
20
10
0
DWT
DCT variance
DCT variance +CV
SWT
RMSE
40.3603
34.7162
34.5875
55.4307


FS
0.5
0.4
0.3
0.2
0.1
0
DWT
DCT variance
DCT variance +CV
SWT
FS
0.3032
0.3507
0.4372
0.2686


PSNR
20
15
10
5
0
DWT
DCT variance
DCT variance +CV
SWT
PSNR
16.0117
17.3202
17.3524
13.2588


FF
6
5
4
3
2
1
0
DWT
DCT variance
DCT variance+ CV
SWT
FF
2.1882
3.2711
4.9519
1.818


Entropy
7
6.8
6.6
6.4
6.2
6
5.8
5.6
DWT
DCT variance
DCT variance+CV
SWT
Entropy
6.0754
6.7902
6.6325
6.1279



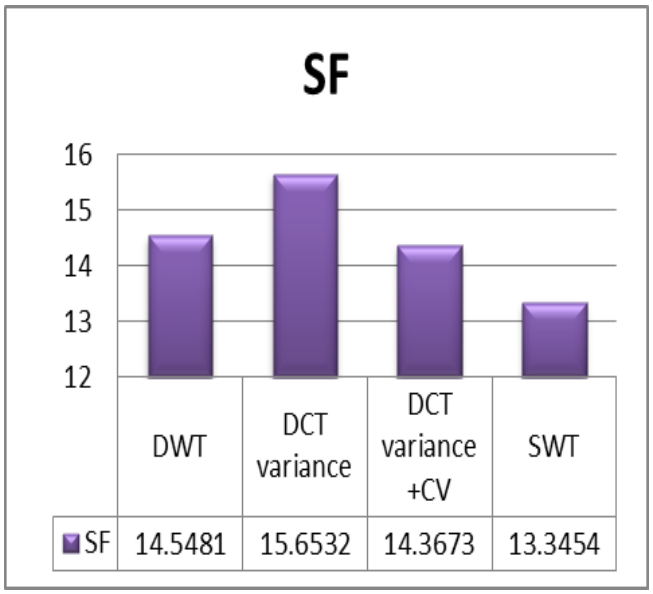
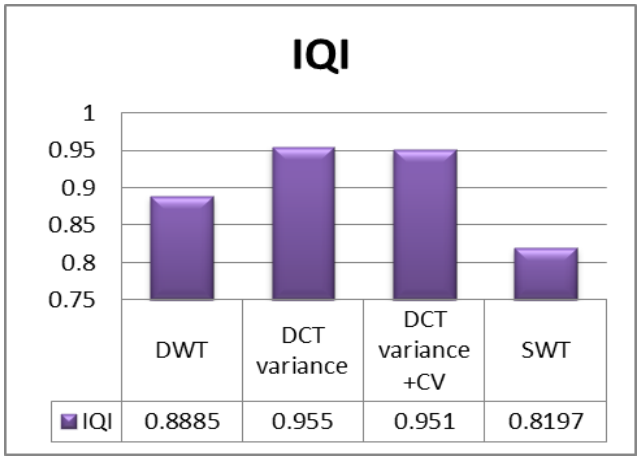
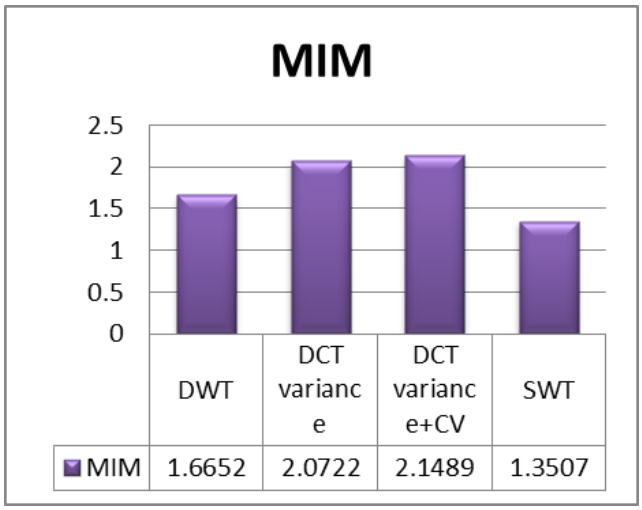
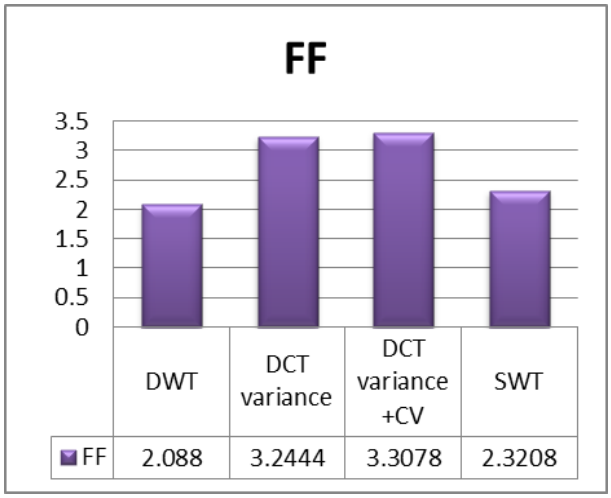


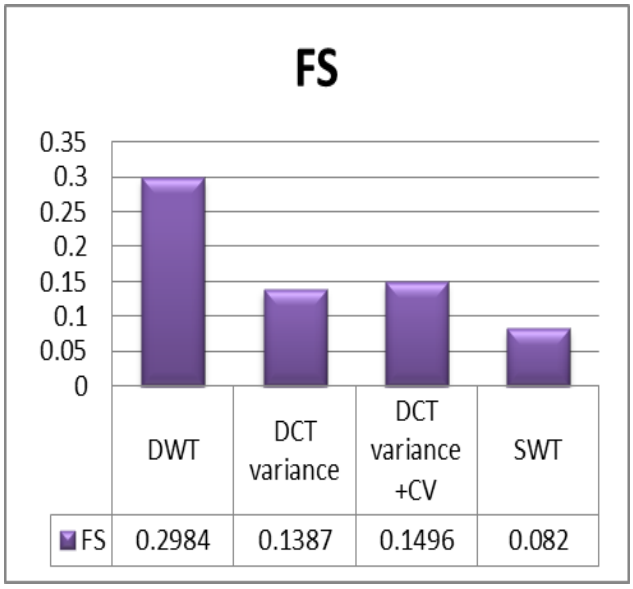
Fig. 4. Fusion assessment metrics for Dataset 1.

DCT variance with CV based image fusion produces better qualitative image through higher IQI (1.0) valued fused image compared to values (0.7636, 0.9958 and 0.8028) obtained from other approaches designates DCT variance with CV improves quality of the fused image. Higher MIM value (4.6409) obtained from DCT variance with CV technique represents that information from both the inputs are mutually taken in to fused image compared to values (1.7575, 2.7828 and 1.3974) obtained from DWT, DCT variance and SWT based image fusion methods respectively. Higher FI and FF values (14.9235 and 4.9519) obtained from DCT variance with CV method indicates that the quality of the fusion and good amount of information is present in both the input images associated with values (2.1882, 3.2711 and 1.8180) attained from other fusion techniques. Smaller FS value (0.2686) obtained from SWT based fusion approach specifies that redundant content is low in fused image. Lower RMSE value (34.5875) produced from DCT variance with CV approach indicates that the amount of change per pixel is low due to fusion process. Higher PSNR and entropy values (17.3524 and 6.6325) obtained from DCT variance with CV and DCT variance fusion methods represents that the amount of information present in the fused image is more and enhanced through fusion process. Higher CC (1.0) value obtained from DCT variance with CV fusion technique indicates that fused image is identical to the reference image represents that great amount of information is enhanced through fusion process associated to values (0.8307,0.8287 and 0.5017) obtained from other image fusion approaches.





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0.3
0.25
0.2
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0
DWT
DCT variance
DCT variance +CV
SWT
FS
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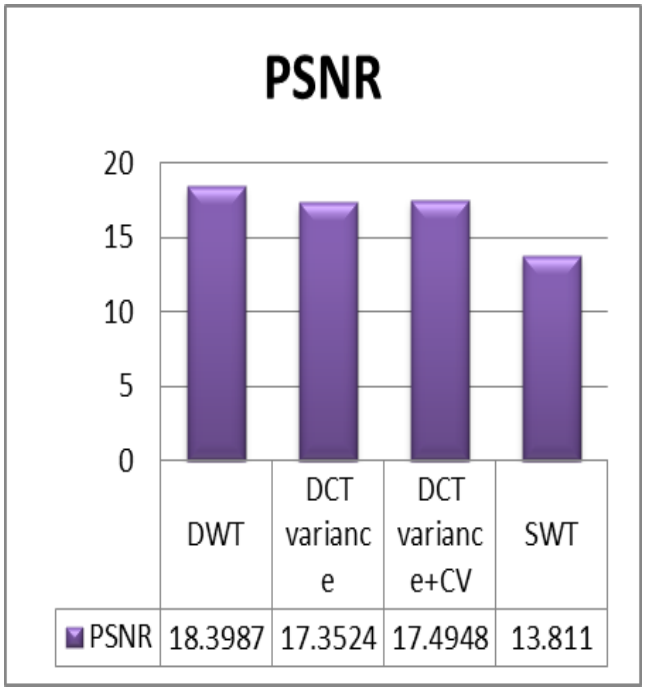
0.1496
0.082


PSNR
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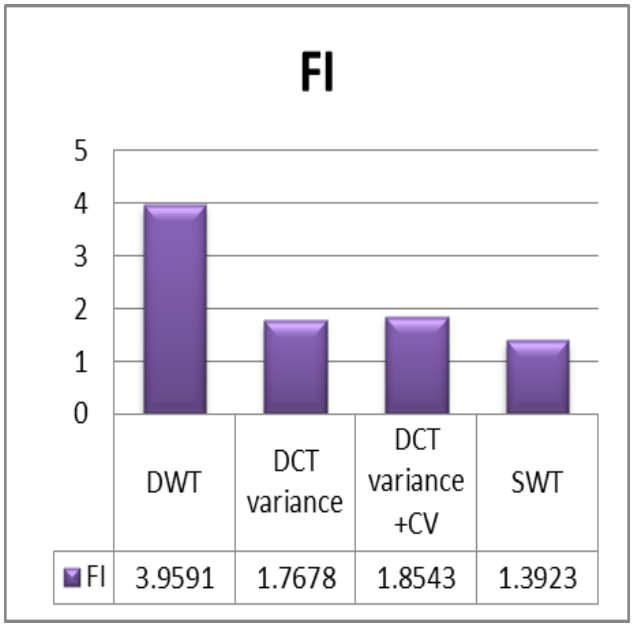
FI
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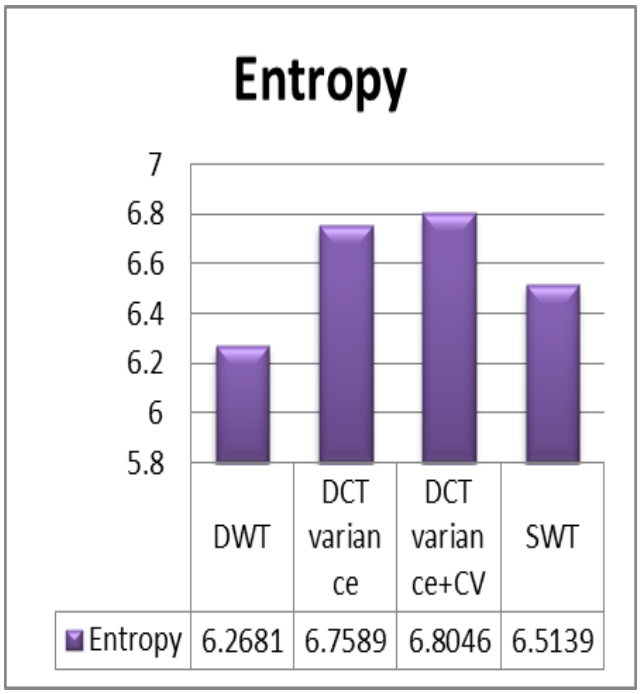
1.3923


Entropy
7
6.8
6.6
6.4
6.2
6
5.8
DWT
DCT varian ce
DCT varian ce+CV
SWT
Entropy
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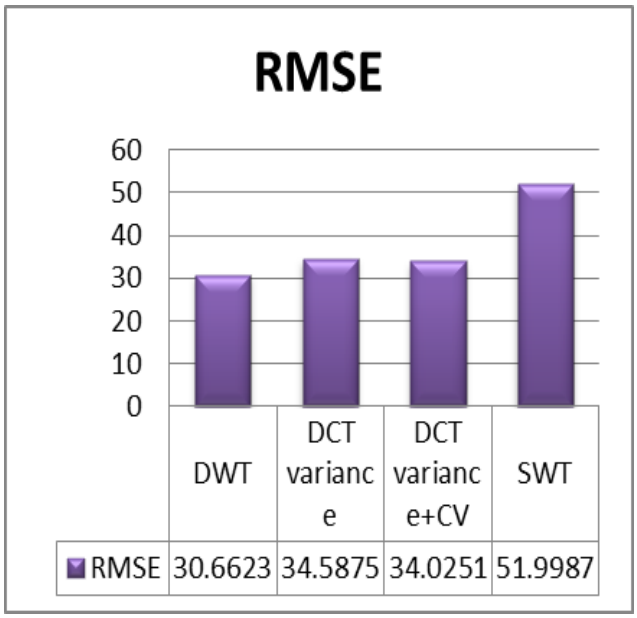
6.5139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40
30
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DCT varianc e+CV
SWT
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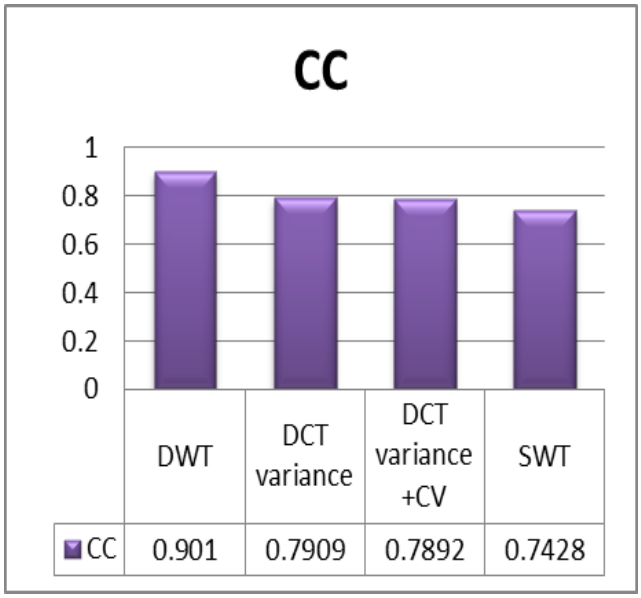
34.0251
51.9987



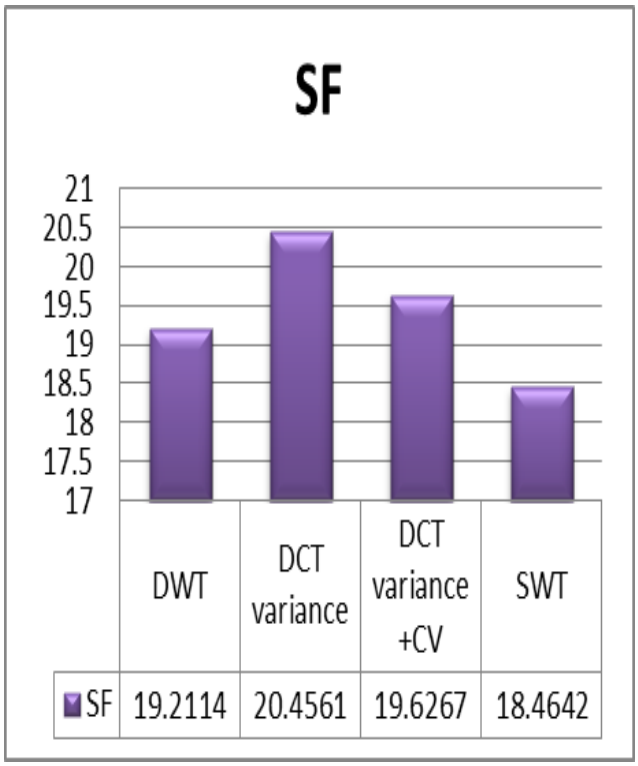


Fig 5. Fusion assessment metrics for Dataset 2.

DCT variance and DCT variance with CV based image fusion approaches produces higher IQI values (0.955 and 0.951) associated to values (0.8885 and 0.8197) obtained from other approaches indicates that DCT variance and DCT variance with CV advances eminence of the fused image. Advanced MIM value (2.1489) attained from DCT variance with CV procedure denotes that evidence from both the inputs are equally occupied in to output image likened to MIM values (1.6652, 2.0722 and 1.3507) acquired from DWT, DCT variance and SWT based fusion approaches correspondingly. Advanced FF value (3.3078) acquired from DCT variance with CV based image technique specifies that the respectable quantity of image content is present in both the input images compared to values (2.088, 3.2444 and 2.3208) achieved from further image fusion procedures. Smaller FS value (0.082) attained from SWT based fusion approach indicates that redundancy in fused image content is low. Advanced FI value (3.9591) attained from DWT followed by the FI value (1.8543) attained from DCT variance with CV based fusion method designates that quality of fusion is more for DWT and DCT variance with CV based fusion methods compared to other fusion techniques. Lower FS value obtained from SWT approach specifies that information redundancy is low in SWT based fused image. Lower RMSE value (30.6623) and higher PSNR value (18.3987) produced from DWT based image fusion method designates that the quantity of modification per pixel is small and quantity of fused image is high due to DWT based image fusion. Higher entropy value (6.8046) obtained from DCT variance with CV signifies that the quantity of evidence existent in the fused image is further and heightened through image fusion practice. Higher CC (0.901) value obtained from DWT based image fusion procedure designates that fused image is almost equal to the ideal image characterizes that excessive quantity of evidence is improved through fusion practice connected to values (0.7909, 0.7892 and 0.7428) attained from further image fusion methods. Higher entropy value (6.8046) obtained from DCT variance with CV based image fusion approach stipulates that image content present in DCT variance with CV based fused image is additional.

Table 1: Assessment of fused results for Dataset 1

Assessment Parameter/ Method	DWT	DCT variance	DCT variance + CV	SWT
IQI	0.8885	0.955	0.951	0.8197
MIM	1.6652	2.0722	2.1489	1.3507
FF	2.088	3.2444	3.3078	2.3208
FS	0.2984	0.1387	0.1496	0.082
FI	3.9591	1.7678	1.8543	1.3923
RMSE	30.6623	34.5875	34.0251	51.9987
PSNR	18.3987	17.3524	17.4948	13.811
Entropy	6.2681	6.7589	6.8046	6.5139
CC	0.901	0.7909	0.7892	0.7428
SF	19.2114	20.4561	19.6267	18.4642

Table 2: Assessment of fused results for Dataset 2

Assessment Parameter/ Method	DWT	DCT variance	DCT variance +CV	SWT
IQI	0.7636	0.9958	1	0.8028
MIM	1.7575	2.7828	4.6409	1.3974
FF	2.1882	3.2711	4.9519	1.818
FS	0.3032	0.3507	0.4372	0.2686

FI	4.0806	5.699	14.9235	3.3224
RMSE	40.3603	34.7162	34.5875	55.4307
PSNR	16.0117	17.3202	17.3524	13.2588
Entropy	6.0754	6.7902	6.6325	6.1279
CC	0.8307	0.8287	1	0.5017
SF	14.5481	15.6532	14.3673	13.3454

VIII CONCLUSIONS

Image fusion is a method to converge different images into fused image combines information from both the input images. Fused images are essential in plentiful solicitations viz image investigation, computer vision, image classification, medical imaging, biometrics, video supervision.

DWT, DCT variance, DCT variance with CV and SWT image fusion methods are executed and compared here. Fused outcomes are assessed by utilizing various evaluation metrics. Due to potentiality of the DCT variance and DCT variance with CV fused outcomes obtained from them outperforms DWT and SWT based fused methods in many parameters and in few parameters DWT and SWT based fusion techniques performs better. Hence the proposed method improves the quality of the fused image and also enhances the image evidence helps in image analysis, image classification and to make useful conclusions.

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