Quality Enhancement of Pixel Level Image Fusion using DT-CWT and Neuro-Fuzzy

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ABSTRACT

Image fusion is the process of combining two or more image to form single image by extracting the essential features of both the image. The aim of fusion is to produce an image which designates a scene better or even higher than whichever single image with respect to some significant properties providing an informative image. There are lots of techniques has been evolved for the image fusion while in this we proposes DT-CWT with neuro-fuzzy for extracting the useful information from two or more image of enhanced quality. The experimental analysis of the proposed work is done in MATLAB simulation toolbox using the parameters such as MSE, PSNR and IQI. The experimental result of proposed work generates an improved quality of image than the existing methodology DT-CWT. The result of MSE, PSNR is about 6-7% more than the existing methodology.

Keyword:- *Image Fusion, DT-CWT, MATLAB, MSE, PSNR, IQI.*

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1. INTRODUCTION

Image processing is a wide area of research; it offers alternatives quantities of fields and area in which examination work can be completed. Image fusion is one such field within the range of image processing amid which differed investigates are carried out to get improvement results Image fusion is the technique of merging several images from multi-modal sources with respective complementary information to form a new image, which carries all the common as well as complementary features of individual images. With the recent rapid developments in the domain of imaging technologies, multisensory systems have become a reality in wide fields such as remote sensing, medical imaging, machine vision and the military applications. Image fusion provides an effective way of reducing this increasing volume of information by extracting all the useful information from the source images. Image fusion provides an effective method to enable comparison and analysis of Multi-sensor data having complementary information about the concerned region. Image fusion creates new images that are more suitable for the purposes of human/machine perception, and for further image-processing tasks such as segmentation, object detection or target recognition in applications such as remote sensing and medical imaging.

Images from multiple sensors usually have different geometric representations, which have to be transformed to a common representation for fusion. This representation should retain the best resolution of either sensor. The alignment of multi-sensor images is also one of the most important preprocessing steps in image fusion. Multi-sensor registration is also affected by the differences in the sensor images. However, image fusion does not necessarily imply multi-sensor sources. There can be single-sensor or multi-sensor image fusion, which has been vividly described in this report.

Analogous to other forms of information fusion, image fusion is usually performed at one of the three different processing levels: signal, feature and decision. Signal level image fusion, also known as pixel-level image fusion, represents fusion at the lowest level, where a number of raw input image signals are combined to produce a single fused image signal. Object level image fusion, also called feature level image fusion, fuses feature and object labels and property descriptor information that have already been extracted from individual input images. Finally, the highest level, decision or symbol level image fusion represents fusion of probabilistic decision information obtained by local decision makers operating on the results of feature level processing on image data produced from individual sensors.

Figure 1 shows the structure of the single sensor image fusion system. The fused image can be directly displayed for a human operator to aid better scene understanding or used in a further local feature extractor. Feature extractors act as simple automatic target detection systems, including processing elements such as segmentation, region characterization, morphological processing and even neural networks to locate regions of interest in the scene. The product of this process is a list of vectors describing the main characteristics of identified regions of interest. Feature level fusion is then implemented on the feature sets produced from the individual sensor outputs and the fused image. This process increases the robustness of the feature extraction process and forms a more accurate feature set by reducing the amount of redundant information and combining the complimentary information available in different individual feature sets. Feature level fusion may also produce an increase in the dimensionality of the feature property vectors.

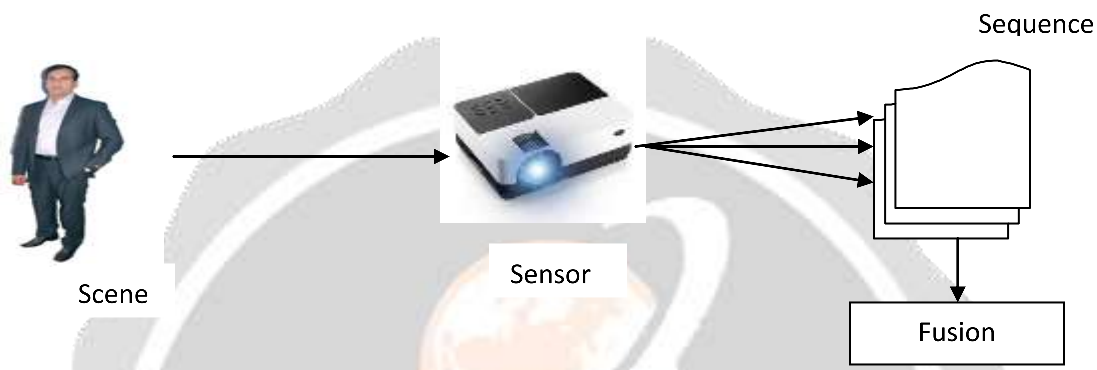

Fig. 1 Single Sensor Image Fusion System

The final processing stage in an ATD system is the classification stage. Individual sensor and fused feature property vectors are input to local decision makers which represent object classifiers, assigning each detected object to a particular class with proper decision. Decision level fusion is performed on the decisions reached by the local classifiers, on the basis of the relative reliability of individual sensor outputs and the fused feature set. Fusion is achieved using statistical methods such as Bayesian inference and the Dempster-Schafer [1], [2], [3] method with the aim of maximizing the probability of correct classification for each object of interest. The output of the whole system is a set of classification decisions associated to the objects found in the observed scene. In this research work, a novel architecture with a hybrid algorithm is defined in which pixel based maximum selection rule to low frequency approximations and filter mask based fusion to high frequency details of wavelet decomposition is applied. Multisensor image fusion was proposed for surveillance systems in which fuzzy logic modelling utilized to fuse images from different sensors, in order to enhance visualization for surveillance systems a novel hybrid multispectral image fusion based on fuzzy logic approach is proposed using combine framework of wavelet transform and fuzzy logic and it provides novel solution between the spectral and spatial fidelity and preserves more detail spectral and spatial information. Fuzzy logic based image fusion for multi-view through-the-wall radar technique proposed where global fusion operator considered and it is desirable to consider the differences between each pixel using a local operator an image fusion algorithm based on fuzzy logic and wavelet was proposed and was aimed at the visible and infrared image fusion and addresses an algorithm based on the discrete wavelet transform and fuzzy logic approach. In a new algorithm is proposed for sharpening multi-spectral images using their corresponding high-resolution panchromatic images. It uses a nonlinear fuzzy fusion rule to combine features extracted from the original images. The experimental results clearly show that the introduction of the proposed image fusion using fuzzy logic gives a considerable improvement on the quality of the fusion system.

2. RELATED WORK

Tongdi He, Zongxi Che (2018) discussed using a remote sensing fusion method, based on' adaptive sparse representation (ASP)', to provide improved spectral information, reduce data redundancy and decrease system complexity. First, the training sample set is formed by taking random blocks from the images to be fused, the dictionary is then constructed using the training samples, and the remaining terms are clustered to obtain the complete dictionary by iterated processing at each step. Second, the self-adaptive weighted coefficient rule of regional energy is used to select the feature fusion coefficients and complete the reconstruction of the image blocks. Finally, the reconstructed image blocks are rearranged and an average is taken to obtain the final fused images. Experimental results show that the proposed method is superior to other traditional remote sensing image fusion methods in both spectral information preservation and spatial resolution.[5]

Zhu et al.(2018) Image fusion technology is widely used in different areas and can integrate complementary and relevant information of source images captured by multiple sensors into a unitary synthetic image. Image fusion technology as an efficient way to integrate information from multiple images plays a more and more important role in smart city. The quality of fused image affects the accuracy, efficiency, and robustness of the related applications. Existing sparse representation-based image fusion methods consist of overly complete and redundant dictionaries learning and sparse coding. However, overly complete and redundant dictionary does not consider the discriminative ability of dictionaries that may seriously affect the image fusion. A good dictionary is the key to a successful image fusion technique. To construct a discriminative dictionary, a novel framework that integrates an image-patches clustering and online dictionary learning methods is proposed for visible-infrared image fusion. The comparison experiments with existing solutions are used to validate and demonstrate the effectiveness of the proposed solution for image fusion.[4]

Al-Mualla et al. (2017) The perceptual image fusion method is proposed that employs explicit luminance and contrast masking models. These models are combined to give the perceptual importance of each coefficient produced by the dual-tree complex wavelet transform of each input image. This combined model of perceptual importance is used to select which coefficients are retained and furthermore to determine how to present the retained information in the most effective way. This paper is the first to give a principled approach to image fusion from a perceptual perspective. Furthermore, the proposed method is shown to give improved quantitative and qualitative results compared with previously developed methods. The proposed method has therefore been demonstrated to form a fused output that not only contains the most perceptually important content from the input images but is able to present the retained information with its original perceptual importance. Subjective test results show that the proposed method can be considered the best perceptually performing method compared to the other considered fusion algorithms with a high confidence of over 92%. It should be noted however, that due to the extremely large number of possible parametric and algorithmic variations, the results of the subjective tests can only be used to gain a sense of direction in the research.[6]

Liua et al.(2018) By integrating the information contained in multiple images of the same scene into one composite image, pixel-level image fusion is recognized as having high significance in a variety of fields including medical imaging, digital photography, remote sensing, video surveillance, etc. In recent years, deep learning (DL) has achieved great success in a number of computer vision and image processing problems. The application of DL techniques in the field of pixel-level image fusion has also emerged as an active topic in the last three years. This survey paper presents a systematic review of the DL-based pixel-level image fusion literature. Specifically, we first summarize the main difficulties that exist in conventional image fusion research and discuss the advantages that DL can offer to address each of these problems. Then, the recent achievements in DL-based image fusion are reviewed in detail. More than a dozen recently proposed image fusion methods based on DL techniques including convolutional neural networks (CNNs), convolutional sparse representation (CSR) and stacked autoencoders (SAEs) are introduced. At last, by summarizing the existing DL-based image fusion methods into several generic frameworks and presenting a potential DL-based framework for developing objective evaluation metrics, we put forward some prospects for the future study on this topic. The key issues and challenges that exist in each framework are discussed.[7]

Chai et al. (2017) Multi-scale based Image fusion is one of main fusion methods, in which multi-scale decomposition tool (MSD) and feature extraction play very important roles. The quaternion wavelet transform (QWT) is one of effective multi-scale decomposition tools. Therefore, this study proposes a novel multimodal image fusion method using QWT and multiple features. First, we perform QWT on each source images to obtain low frequency coefficients and high frequency coefficients. Second, a weighted average fusion rule based on the phase and magnitude of low frequency subband and spatial variance is proposed to fuse the low frequency subbands. Next, a choose-max fusion rule based on the contrast and energy of coefficient is proposed to integrate the high frequency subbands. Finally, the final fused image is constructed by inverse QWT. The proposed method is conducted on multi-focus images, medical images, infrared-visible images and remote sensing images, respectively. Compared to traditional MSD tools, the QWT can provide abundant magnitude and phase information, which meet approximate translation invariance and limited redundancy. Different from the traditional fusion methods using a single feature as the activity level measure, we combine the magnitude, phase and spatial variance of low frequency coefficient into a comprehensive feature as the activity level measure of low frequency coefficient and combine the contrast and energy of high frequency coefficient into the other comprehensive feature as the activity level measure of high frequency coefficient. These two multi-features are reliable and robust, which are available for image fusion. Finally, the experimental results demonstrate the proposed method is effective in all kinds of image fusion.[8]

Muhadi et al. (2018) Digital elevation models (DEMs) play an important role in producing terrain-related applications such as curvature and contour maps for planning and management of oil palm plantation. Data fusion of DEMs derived from terrestrial laser scanning (TLS) and interferometric aperture radar (IfSAR) was developed with the intention to increase the accuracy of IfSAR-derived DEM at a lower cost thus, provide a high-quality data for plantation management. In this research, fusion by weights was carried out after applying regression analysis to integrate both TLS and IfSAR data. The results showed a significant reduction in root mean square error (RMSEs) after fusion. RMSEs of both stations reduced from 1.83 m to 0.35 m and from 3.13 m to 0.41 m for Station 1 and Station 2, respectively. In addition, data fusion technique for an area with no TLS data were tested around the stations at 200 m distance. The RMSEs decreased from 2.52 m to 2.33 m for Station 1 but the value increased from 2.09 m to 2.13 m for Station 2. It was concluded that the proposed fusion technique in the extension area could be done in a relatively flat area but not be used in a steep-slope area.[9]

TIRUPAL et al. (2018) The objective of image fusion for medical images is to combine multiple images obtained from various sources into a single image suitable for better diagnosis. Most of the state-of-the-art image fusing technique is based on non-fuzzy sets, and the fused image so obtained lags with comple-mentary information. Intuitionistic fuzzy sets (IFS) are determined to be more suitable for civilian, and medical image processing as more uncertainties are considered compared with fuzzy set theory. In this paper, an algorithm for effectively fusing multimodal medical images is presented. In the proposed method, images are initially converted into Yager's intuitionistic fuzzy comple-ment images (YIFCIs), and a new objective function called intuitionistic fuzzy entropy (IFE) is employed to obtain the optimum value of the parameter in membership and non-membership functions. Next, the YIFCIs are compared using contrast visibility (CV) to construct a decision map (DM). DM is re-fined with consistency verification to create a fused image. Simulations on several pairs of multimodal medical images are performed and compared with the existing fusion methods, such as simple average, discrete cosine transform (DCT), redundant wavelet transform (RWT), intuitionistic fuzzy set, fuzzy transform and interval-valued intuitionistic fuzzy set (IVIFS). The superior-ity of the proposed method is presented and is justified. Fused image quality is also verified with various quality metrics, such as spatial frequency (SF), average gradient (AG), fusion symmetry (FS), edge information preservation (QAB/F), entropy (E) and computation time (CoT). Better results are obtained using YIFCS because it considers a greater number of uncertainties and incorporates a hesitation degree. As medical images are a low contrast with vague regions and boundaries, IFS aids in solving these problems. This algorithm is also included with intuitionistic fuzzy entropy to optimize the best parameter for membership, non-membership and hesitation degree functions.[10]

3. Methodology

In proposed work for image fusion where the fused image is obtained by inverse transforming a synthetic wavelet transform array which combines information from the two input images. A medical image fusion based on discrete wavelet transform using Java technology approach described to combine the salient feature of images obtained from different compatible medical devices and integrated this method into a distributed application In a novel image fusion scheme based on biorthogonal wavelet decomposition is presented in which two images are decomposed into sub-images with different frequency, and information fusion is performed using these images under the certain criterion, and finally these sub-images are reconstructed into the result image with plentiful information. In an introduction to wavelet transform theory and an overview of image fusion techniques are given, and the results from a number of wavelet-based image fusion approaches are compared and it has been proved that, in general, wavelet-based schemes perform better while minimizing color distortion.

A novel architecture with a hybrid algorithm is defined in which pixel based maximum selection rule to low frequency approximations and filter mask based fusion to high frequency details of wavelet decomposition is applied. A Region based Pan Sharpening Method using Match Measure and Fuzzy Logic approach provides novel trade off solution to preserve spectral and spatial quality using fuzzy logic in which match measure, region based approach and fuzzy logic methods are combined to produce quality Pan sharp image proposed a theoretical framework mimicking the aggregation process, based on the use of fuzzy logic approach, fusion operators to enrich the classical fusion process with the introduction of spatial information modelling. Multisensor image fusion was proposed for surveillance systems in which fuzzy logic modelling utilized to fuse images from different sensors, in order to enhance visualization for surveillance systems a novel hybrid multispectral image fusion based on fuzzy logic approach is proposed using combine framework of wavelet transform and fuzzy logic and it provides novel solution between the spectral and spatial fidelity and preserves more detail spectral and spatial information. Fuzzy logic based image fusion for multi-view through-the-wall radar technique proposed where global fusion operator considered and it is desirable to consider the differences between each pixel using a local operator an image fusion algorithm based on fuzzy logic and wavelet was proposed and was aimed at the visible and infrared image fusion and addresses an algorithm based on the discrete wavelet transform and fuzzy logic approach. In a new algorithm is proposed for sharpening multi-spectral images using their corresponding high-resolution panchromatic images. It uses a nonlinear fuzzy fusion rule to combine features extracted from the original images.

In image fusion based on wavelet transform, discrete wavelet transform of each of the source images is computed which gives the wavelet coefficient of both the images. The fusion rules are then applied in order to fuse the corresponding coefficients of the decomposed source images. Selection of fusion rules is the most important step in image fusion. The proposed algorithm focuses on defining the fusion rule so as to suppress the background information and enhance the information of the changed region in the source images. The rules are defined so as to maximize the edge features in the fused image and suppress the background information as maximum as possible. Different fusion rules are applied on the coefficients of low frequency and high sub-band because both the sub-bands contain the difference features. However, two fusion rules are proposed here. The fusion rule for low frequency sub-band combines the maximum value with the average of the mean ratio and log ratio coefficient. The rule for high frequency sub-band calculates the neighborhood mean of the log ratio and mean ratio image. Then the fused coefficients are obtained by differencing the minimum value from the maximum value of the coefficients.

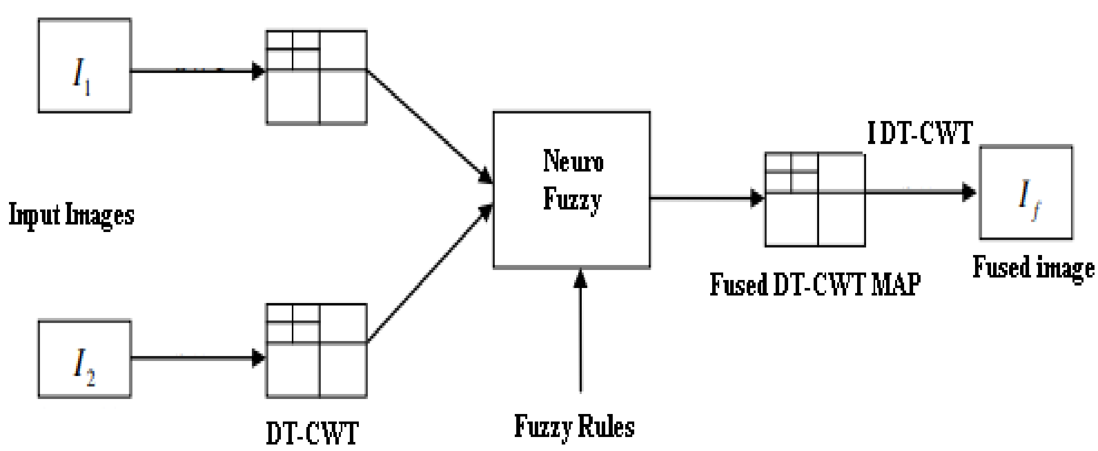

Fig. 2: Schematic diagram of Quality Enhancement of Pixel Level Image Fusion using DT-CWT and Neuro-Fuzzy Image fusion

Proposed Algorithm:

1. Choose first image from source data, then assign into variable A.
2. Choose second image from source data, then assign into variable B.

3. Apply layer 1 dual tree wavelet into image to decompose in sub-bands (LL, LH, HL, HH).
4. Again decomposed band LL into sub bands (LLLL, LLLH, LLHL, LLHH).
5. Measurement of the wavelet coefficient of A and B.
6. Apply transform function on selected image A and B.
7. Apply high pass filter into decomposed layers of images.
8. Apply Gaussian filter to removes extra noise from the images.
9. Apply fusion rule so as to suppress the background information and enhance the information of the changed region in the source images.
10. Followed fusion rule:

$$F_p^k(i,j) = \begin{cases} A_p^k(i,j), if \;\; A_p^{km}(i,j) \; > B_p^{km}(i,j) \\ B_p^k(i,j), \qquad\qquad x \geq 0 \end{cases}$$

11. Fused wavelet coefficients.
12. Apply Neuro-fuzzy for sharpening multi-spectral images using their high-resolution panchromatic images.
13. Apply Inverse wavelet transform DT-CWT^{-1}.
14. Measurement of MSE is as follows:

$$\mathrm{MSE} = \frac{1}{\mathrm{mn}} \sum_{i=1}^{m} \sum_{j=1}^{n} (\mathrm{A_{ij}} - \mathrm{B_{ij}})^2$$

15. Measurement of PSNR as follows:

$$\mathrm{PSNR} = 10 \times \log_{10}\left(\frac{\mathrm{peak}^2}{\mathrm{MSE}}\right)$$

16. Measurement of Image Quality Index is as follows:

$$IQI = \frac{m_{ab}\; 2xy\; 2m_a m_b}{m_a m_b x^2 + y^2 m_a^2 + m_b^2}$$

Block Diagram of Proposed Work

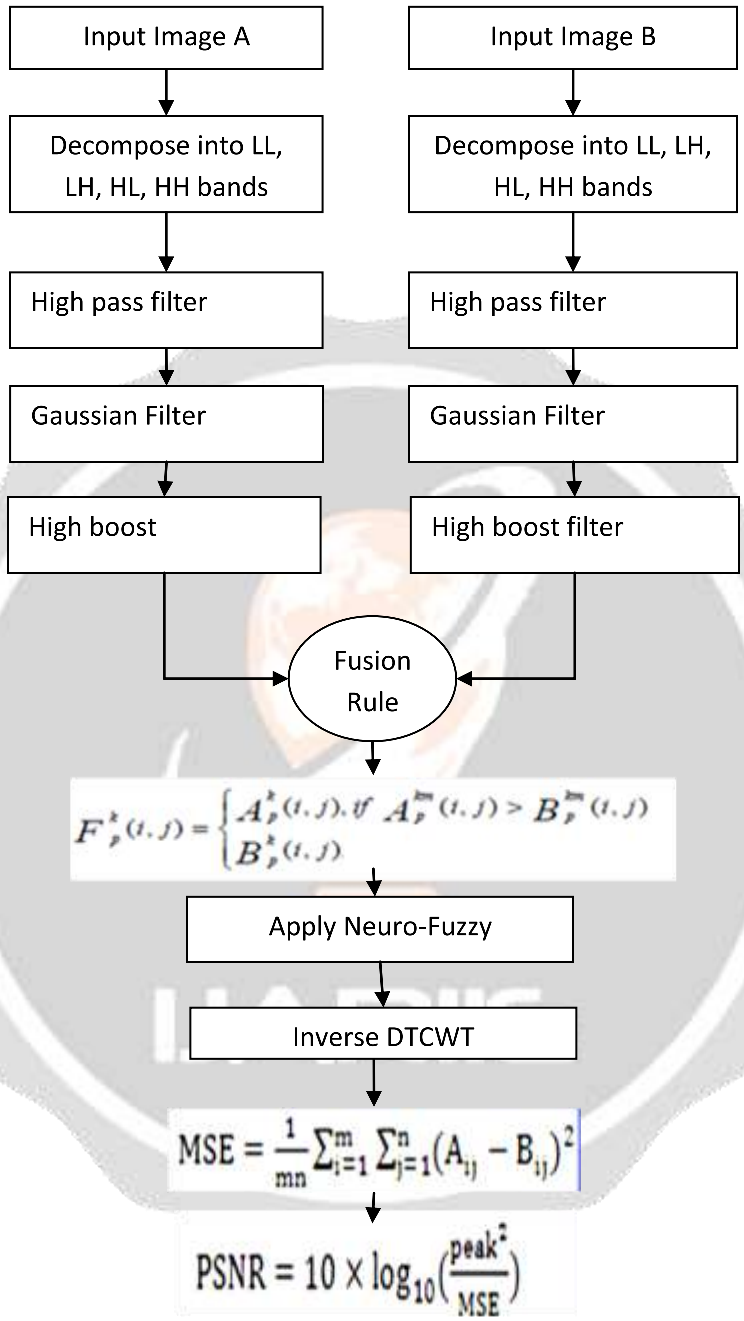

Fig. 3: Block diagram of proposed methodology

4. Experimental Results

This section contains information of tools used while implementing the proposed methodology as well as some other traditional methods. It is used MatLab2012A in Intel I3 800X4 core processor with 4GB primary memory and NVIDIA graphics adapter, which makes our work more reliable and fast performance.

There are many typical applications for image fusion. Modern spectral scanners gather up to several hundred of spectral bands which can be both visualized and processed individually, or which can be fused into a single image, depending on the image analysis task. In this section, input images are fused using fuzzy logic approach. Here some of the snapshot of the simulation environment is presented for different image dataset in which it shows proposed methods is much better than the DT-DWT technique to improve the quality of the images. The proposed method analysis is done using the performance metric MSE and PSNR image processing parameter and for these parameter this proposed method is very much suitable for enhancing the image quality.

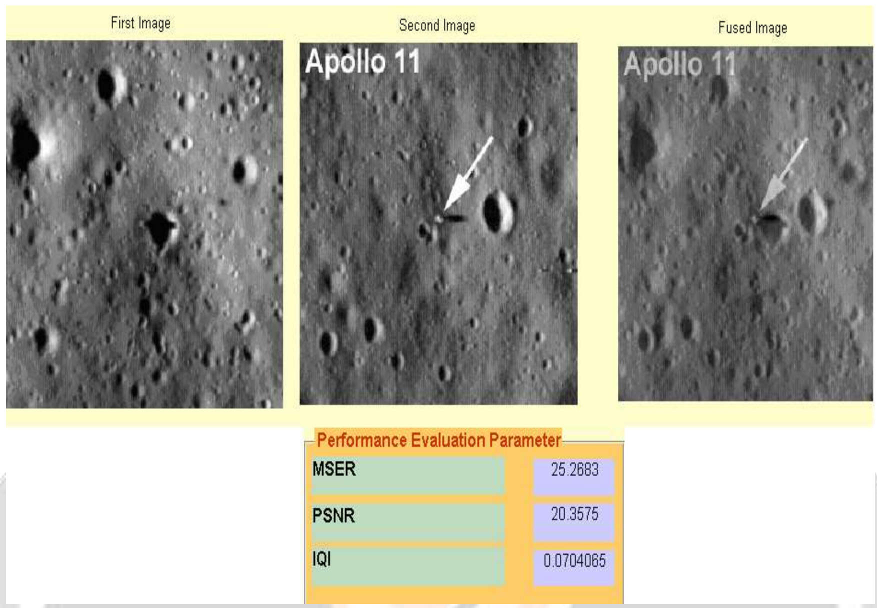

Fig.4 : The relation of MSER, PSNR and IQI based on DT- CWT

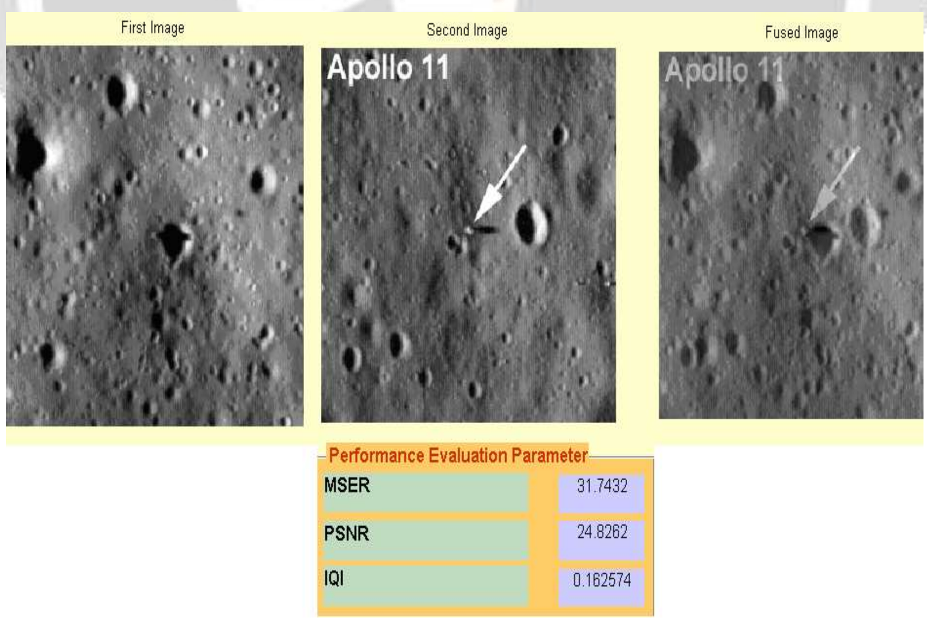

Fig.5: The relation of MSER, PSNR and IQI based on DT- CWT-NF

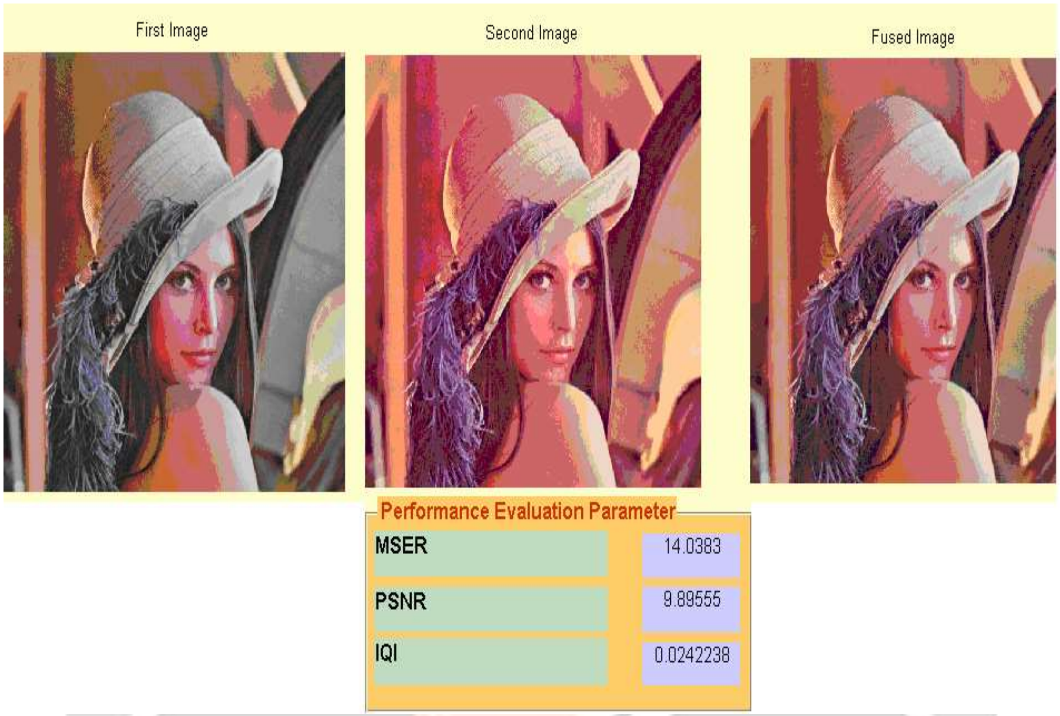

Fig. 6: The relation of MSER, PSNR and IQI based on DT-CWT

Fig. 7: The relation of MSER, PSNR and IQI based on DT- CWT-NF

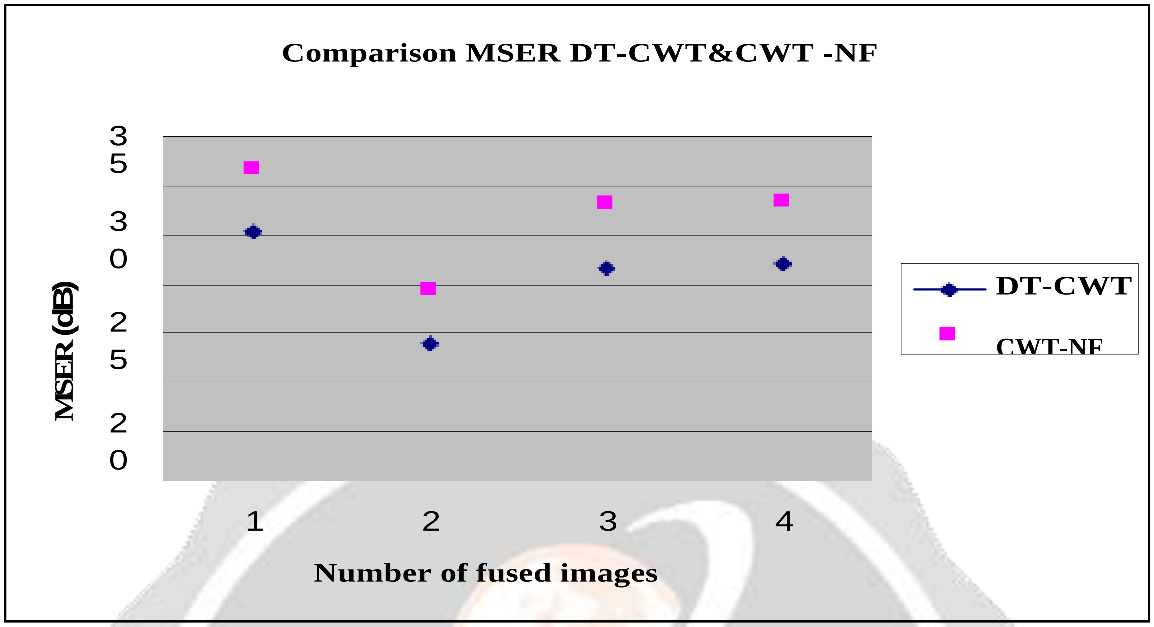

Fig. 8 : Comparison of Proposed Result with Previous Schemes

Table 1 : Measured values of MSER, PSNR and IQI for DT-CWT & CWT-NF of fused images

Fuse Images	Image Fusion Methods	MSER	PSNR	IQI
1.	DT-CWT	25.2683	20.3575	0.0704065
	DT-CWT-NF	31.7432	24.8262	0.162574
2.	DT-CWT	14.0383	9.89555	0.0242238
	DT-CWT-NF	19.5055	13.2694	0.0868949
3.	DT-CWT	21.5555	16.8925	0.0584226
	DT-CWT-NF	28.263	21.5396	0.141052
4.	DT-CWT	22.1628	17.4593	0.0603829
	DT-CWT-NF	28.4099	21.6783	0.14196

6. Conclusion

There are a large number of applications in remote sensing that require images with both spatial and spectral resolution. In this thesis, the potentials of pixel level image fusion using fuzzy logic approach have been explored along with quality assessment evaluation measures. Fused images are primarily used to human observers for viewing or interpretation and to be further processed by a computer using different image processing techniques. All the results obtained and discussed by this method are same scene. The experimental results clearly shows that the introduction of the proposed image fusion using fuzzy logic gives a considerable improvement on the quality of the fusion system. It is hoped that the technique can be further extended to all types of images, for fusion of multiple sensor images and to integrate valid evaluation measures of image fusion using neuro fuzzy logic. Future work fuzzy logic, which efficiently gives good results. There are some likely extensions to this work, apart from the necessary improvement of the image quality enhancement.

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