



## Image Fusion using Wavelet Transform and Neuro Fuzzy Logic (Anfis Tool)

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**Abstract--** Image Fusion is a technique that integrates complementary information from multiple images such that the fused image is more suitable for processing tasks. The goal of image fusion is to integrate complementary multi sensor, multi temporal and/or multi view data into a new image containing more information. The purpose of this paper is to propose an image fusion algorithm based on Wavelet Transform and Fuzzy Logic (anfis tool) to improve the geometric resolution of the images. In this, images will be processed, then decomposed into sub-images and then the information fusion is performed using these images under the certain criteria such as Wavelet Transform and certain fusion rules, and finally these sub-images are processed under Fuzzy Logic (anfis tool) and reconstructed into the resultant image with plentiful information.

**Keywords--** Wavelet Transform, Fuzzy Logic, Neural Network, Neuro-Fuzzy Logic, PSNR.

### I. INTRODUCTION

Information is used in many forms to solve problems and monitor conditions. When multiple source information is combined, it is essentially used to derive or infer more reliable information. Which information and how to combine it is an area of research called Data Fusion. Data fusion techniques combine data and related information from associated databases, to achieve improved accuracies and more specific inferences. [3]

Image fusion deals with integrating data obtained from different sources of information for intelligent systems. Image Fusion provides output as a single image from a set of input images. The fusion should provide a human/machine perceivable result with more useful, complete information. A great deal of interest has recently been shown in literature in Image Fusion because of its application in automotive, medical and other areas. Image Fusion has become a topic of great interest to a variety of engineers working in different disciplines. It is being used for medical applications so as to get a better image. It's also being researched in automotive industries to enhance the vision of road so as to see a better image during a rainy or a foggy weather. Image fusion has the following advantages:

1. It improves the reliability by taking care of the redundant information.
2. It improves the capability as it keeps complementary information.[1]

### BASIC PRINCIPLE

The goal of this paper is to provide an overview of the methods and techniques to be used in the process of Image Fusion.

#### A. Multi Focus Image Fusion

Optics of lenses with a high degree of magnification suffers from the problem of a limited depth of field. The larger the focal length and magnification of the lens the smaller the depth of field becomes. As a result, fewer objects in the image are in focus. Multi focus digital image fusion attempts to increase the apparent depth of field through the fusion of object within several different fields of focus. Multi Focus Image Fusion fuses images which are partly focused and partly defocused. This study focuses only the multi focus image fusion.[4]

#### B. Information level Approach

Image fusion starts with dividing the source images into sub regions and then calculating a measure of information level in the regions (in the literature often referred to as a activity level -AL) and then utilizing some fusion rules to combine the images. In this paper, spatial frequency and visibility are used to measure the information level in the regions. Let A and B are the source images, and if  $IL_{Ai} > IL_{Bi}$  then  $F_i = A_i$ . The multi focus images are fused by calculating the information level using measures like Spatial frequency and Visibility in the regions of the images. [4]

#### C. Wavelet based Image Fusion

##### Wavelet Theory

Wavelets are finite duration oscillatory functions with zero average value. The irregularity and good localization properties make them better basis for analysis of signals with discontinuities. Wavelets can be described by using two

functions viz. the scaling function  $f(t)$ , also known as “father wavelet” and the wavelet function or “mother wavelet”. “Mother wavelet”  $\psi(t)$  undergoes translation and scaling operations to give self similar wavelet families as defined in the equation where  $a$  is the scale parameter and  $b$  the translation parameter. Practical implementation of wavelet transforms requires discretisation of its translation and scale parameters by taking, Thus, the wavelet family can be defined as: If discretisation is on a dyadic grid with  $a_0 = 2$  and  $b_0 = 1$  it is called standard DWT. Wavelet transformation involves constant  $Q$  filtering and subsequent Nyquist sampling. Orthogonal, regular filter bank when iterated infinitely gives orthogonal wavelet bases. The scaling function is treated as a low pass filter and the mother wavelet as high pass filter in DWT implementation. [3]

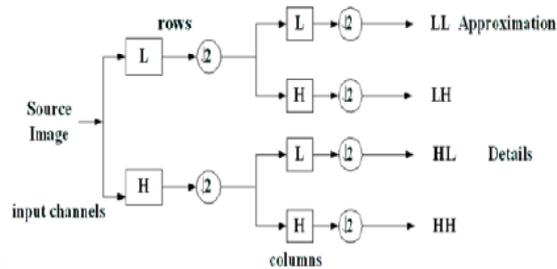


Fig. 1. Two-dimensional subband coding algorithm for DWT: The source image is decomposed in rows and columns by low-pass (L) and high-pass (H) filtering and subsequent downsampling at each level to get approximation (LL) and detail (LH, HL and HH) coefficients. Scaling function is associated with smooth filters or low pass filters and wavelet function with high-pass filtering. [3]

The advantages of the wavelet transform algorithm are:

1. A better preservation of both edge features and component information of the objects from different modalities in new fused image;
2. Fusion can be performed at different levels and bandwidths. [6]

Wavelet theory has gradually been used in the field of graphics and imagery, and been proven to be an effective tool to process the signals in mutiscale spaces. The image fusion algorithm based on wavelet transform is proposed to improve the geometric resolution of the images. [2]

#### **D. Fuzzy Logic**

Fuzzy approaches are used where there is uncertainty and no mathematical relations are easily available. Fuzzy Logic approach is finding a lot of applications in different branches of engineering. These approaches are comparatively easy and software tools are available so that these approaches could be implemented. Matlab has developed a Fuzzy Logic Tool Box. We propose a robust approach to image enhancement based on fuzzy logic that addresses the seemingly conflicting goals of image enhancement: (i) removing impulse noise, (ii) smoothing out non impulse noise, and (iii) enhancing (or preserving) edges and certain other salient structures.[1]

#### **E. Neuro Fuzzy approach to Image Fusion**

Neural Network (NN) is a network which stores the experimental knowledge and uses it for test data. Neuro- Fuzzy is a combination of Artificial Neural Network (ANN) and Fuzzy logic. Using this method we can train the system with input dataset and desired output. After training the system, this system can be used for any other set of input data. A Neuro-fuzzy system is a fuzzy system which is trained by any of neural network learning algorithms and according to the training data system parameters are modified automatically. Implementation of Neuro-Fuzzy system is done using ANFIS. ANFIS stands for Adaptive Neural Fuzzy Inference System. The Fuzzy Inference System (FIS) is a model that does the following mappings:

- A set of input characteristics to input membership functions
- Input membership functions to rules
- Rules to a set of output characteristics
- Output characteristics to output membership functions and
- The output membership function to a single-valued output [7]

## **II. RELATED WORK**

### **Image Fusion using Fuzzy Logic and Applications, Department of Electrical and Computer Engineering, (Wayne State University)**

Image fusion deals with integrating data obtained from different sources of information for intelligent systems. Image Fusion provides output as a single image from a set of input images. The fusion should provide a human/machine perceivable result with more useful complete information. A great deal of interest has recently been shown in literature in Image Fusion because of its application in automotive, medical and other areas. Some techniques are currently available for image fusion. Some new approaches have been suggested in this work in particular, Fuzzy and Neuro-Fuzzy. Algorithms are also proposed for the above said techniques for image fusion process, The work is also supplemented by algorithms, which help us analyze the output qualitatively on attributes like Entropy, Statistical moments, Uniformity etc. [1]

**Image Fusion based on Wavelet Transform for Medical Application** (MAEER's MIT College of Engineering, Kothrud, Pune, India)

Image Fusion is a technique that integrates complementary information from multiple images such that the fused image is more suitable for processing tasks. The paper starts with the study of initial concepts for image fusion. In this paper, the fusion of images from different sources using multiresolution wavelet transform with preprocessing of Image Fusion is proposed. The fused image has more complete information which is useful for human or machine perception. The fused image with such rich information will improve the performance of image analysis algorithms for medical applications. [3]

**Multi focus image fusion based on the information level in the regions of the images, Dept of Mathematics** (Sri Sai Ram Engineering College, Chennai-44)

An image fusion algorithm based on activity measures like Spatial frequency and Visibility for fusing multi focus images is presented in this paper. For each sub window in the source multi focus images, the spatial frequency and Visibility is calculated. The fusion procedure is performed by a selection mode according to the magnitude of the spatial frequency and Visibility. The fused images are then assessed using the same activity measures that is used for fusion. Experiments results shows that the proposed algorithm works well in multi focus image fusion. [4]

**Current Research on Wavelet-based Image Fusion Algorithm** (College of Automation, Northwestern Polytechnical University, China)

Wavelet transform is efficiently applied to the area of image fusion because it's properties such as multiresolution analysis, accurate reconstruction and similarity to people's vision understanding. This paper describes the principle and method of wavelet based image fusion and analyzes it's current research and future trend from the two respects: the modality of wavelet transform and fusion rules. [5]

**Medical Image Fusion by Wavelet Transform Modulus Maxima**(Department of Automation, Tsinghua University, Beijing)

Medical image fusion has been used to derive useful information from multimodality medical image data. In this research, a novel method for multimodality medical image fusion is proposed. Using wavelet transform, we achieved a fusion scheme. A fusion rule is proposed and used for calculating the wavelet transformation modulus maxima of input images at different bandwidths and levels. To evaluate the fusion result, a metric based on mutual information (MI) is presented for measuring fusion effect. The performances of other two methods of image fusion based on wavelet transform are briefly described for comparison.[6]

**Pixel Level Image Fusion: A Neuro-Fuzzy Approach** (Dept. of Electrical and Electronics Engineering MA College of Engineering Kothamangalam, Kerala, India)

Image fusion is done for integrating images obtained from different sensors, which outputs a single image containing all relevant data from the source images. Five different image fusion algorithms, SWT, fuzzy, Neuro-Fuzzy, Fuzzylet and Neuro-Fuzzylet algorithms has been discussed and tested with two datasets (mono-spectral and multi-spectral). The results are compared using fusion quality performance evaluation metrics. It was observed that Neuro-Fuzzy gives better results than Fuzzy and SWT. Fuzzylet and Neuro-Fuzzylet were obtained by combining Fuzzy and Neuro-Fuzzy respectively with SWT. It was observed that Fuzzylet gives better results for mono-spectral images and on the other hand, Neuro-Fuzzylet had given better results for multi-spectral images at the cost of execution time.[7]

### III. PROPOSED METHOD

Image fusion is the process that combines information from multiple images of the same scene. These images may be captured from different sensors, acquired at different times, or having different spatial and spectral characteristics. The objective of the image fusion is to retain the most desirable characteristics of each image. The proposed work is done using Wavelet transform along with Fuzzy Logic(anfis tool) to enhance the image resolution.

- We select images which contain incomplete information. These images are converted to true color images.

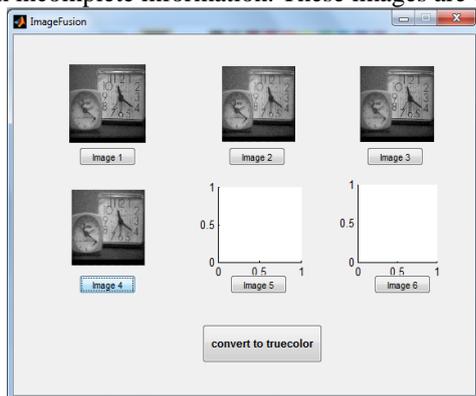


Fig. 2. Selected images to be fused

- Further wavelet decomposition is applied on these images and all the images are fused together.

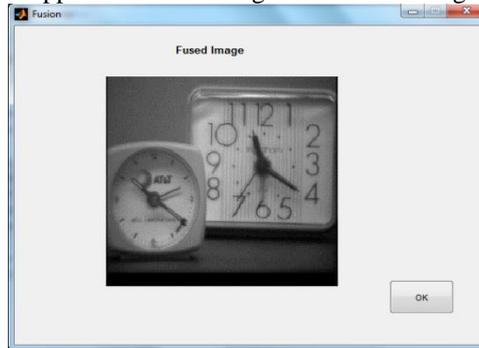


Fig. 3. Fused image using Wavelet Transform

- The fused image is taken as the train image and other images are taken as test images.



Fig. 4. Neuro Fuzzy Approach

- Fuzzy Logic is applied to train and test the images. The number and type of membership functions are decided and a FIS structure is created.

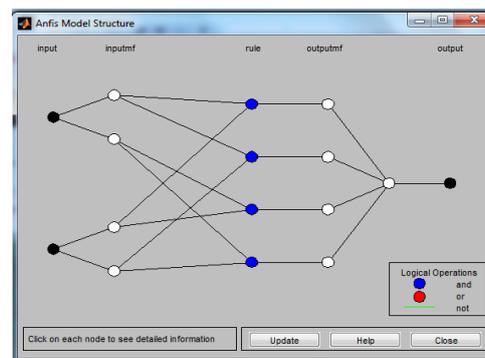


Fig. 5. Anfis Model Structure using 2 Membership Functions

- We now analyze the GUI and obtain the PSNR value.

#### IV. RESULT AND DISCUSSION

The algorithm has been successfully developed and implemented in MATLAB to fuse images with comparatively less information when considered separately. The fused images have better and complete information with better geometric resolution.

- The PSNR value i.e. Peak-Signal-to-noise ratio of the fused image after applying only Wavelet Transform was calculated as 42.799.

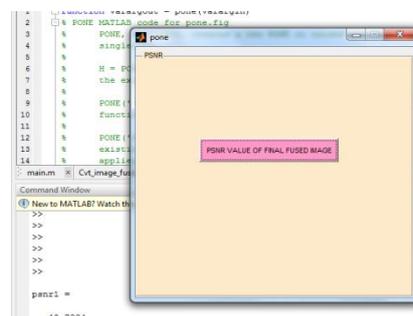


Fig. 6. Psnr value of image after Wavelet Decomposition

- The PSNR value after applying Wavelet Transform and further Neuro-Fuzzy Approach was calculated to be 109.168

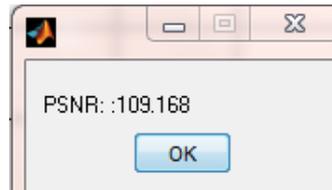


Fig. 7. Psnr Value after applying Neuro Fuzzy Approach

- The PSNR Graph obtained is as shown below

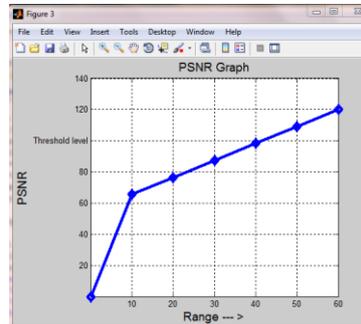


Fig. 8. Psnr Graph

## V. CONCLUSION

This paper proposes an image fusion algorithm based on Wavelet Transform and Neuro Fuzzy Logic to improve the geometric resolution of the images. The generated fused images will be more accurate, all around and reliable. It can result in less data size, more efficient target detection, and target identification and situation estimation for observers.

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