An Enhanced Downsampling Approach for Image Fusion Using Advance Neuro Fuzzy

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***Abstract*—** The image fusion has been most trending topic for research work among the domain of digital image processing. The image fusion is done by applying various techniques such as PCA etc. this study is organized to develop a novel image fusion mechanism by using Laplacian pyramid technique and Adaptive neuro Fuzzy inference system (ANFIS). The proposed work (LP-ANFIS) is implemented in MATLAB for performance evaluation. The performance of proposed work is measured and compared with the traditional techniques such as CNN, MWGF, DSIFT, MSCNN and SSSDI in the terms of MI and QAB/F. On the basis of the comparison analysis, the proposed technique is observed to be outstanding than traditional work in the terms of image quality, information quality etc.

Keywords— *Digital image processing, image fusion, Laplacian pyramid, adaptive neuro fuzzy inference system.*

I. INTRODUCTION

There are two types of visions; one is human and another s computer. As per the human vision, the human has the capability to feel sense and see each and every object from every aspect of it [1]. Whereas in computer vision such as camera, it is not possible to focus all the objects of a scene into a single image. For example the sharp images are capable to provide the better view of an image in comparison to the blur image [2]. Thus to enhance the quality of the blur image, two blur images are concatenated in order to achieve a single but sharp image comprised of all the meaningful and important information. The process of image concatenation refers to the image fusion [3].

The image fusion facilitates the efficient procedure for plummeting the escalating amount of information even as at the same time to haul out the imperative information from the input images [4]. The implementation of this procedure leads to an increment to the volume of available data. The major aspire of image fusion, apart from reducing the amount of data is to craft new image that is highly pertinent for human or machine perceptions and for different image processing tasks like image segmentation [5], object segmentation, object recognition etc.

For purpose of achieving qualitative fused image a large number of techniques are applied to the input images. Some of these techniques are Principal Component Analysis, Laplacian Pyramid, Intensity Hue Saturation, Wavelet Transform technique etc [6].

The traditional image fusion techniques are found to be inefficient and thus this study is organized with an objective to develop a novel image fusion technique by using the Laplacian pyramid mechanism and ANFIS. To implement this technique, the Laplacian Pyramid technique is implemented in place of the down sampling approach. Main objective to choose the Laplacian pyramid technique is that it is a lossless method. This technique is used to sub divide the images into various segments in such a way that it does not affect the data embedded inside the image. One more problem associated with the conventional technique is that it is dependent on CNN and it is not an optimum technique when the exception cases take place in the network. This technique can be used for information processing on learning basis. Therefore this method is not good for different cases.

II. PROBLEM FORMULATION

Image fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more informative than any of the input images. In image fusion information from the multiple images of the same scene is combined that are captured from the different sensors at different times having different spatial and spectral characteristic. Standard Image Fusion generates a fused image in which each pixel is determined from a set of pixels in each source image Many techniques of image fusion have been discovered so far, that help in the fusing the images and the resultant image is more informative. Traditionally, the image fusion was done by using convolution neural network. The work was done by segmenting the input image into sub blocks and then these sub blocks were passes to the CNN in order to get final fused image. The process of dividing input image to sub blocks is known as down-sampling. The down-sampling leads to the loss in information while sub dividing the image which makes the traditional work less efficient. Other drawback of traditional work was that it utilizes the CNN which is a learning method. Thus CNN is able to process only that data which is trained under network. It will not process for other data. Thus there is a requirement to update the traditional work, to achieve more qualitative fused image.

III. PROPOSED WORK

After having a review to the problem statement given in previous section, it is concluded that the traditional image fusion technique lacks at several points. The proposed work aims to overcome the drawbacks of the traditional work. In order to do so, the concept of down-sampling is replaced with Laplacian pyramid method. The reason behind selecting Laplacian pyramid method is that it is a lossless mechanism. It sub divide the input images in to segments without affecting the informative content of the image. Another issue in traditional work is that it was based on CNN which is proved quite old and insufficient mechanism in case when an exceptional case occurs in the network. As it can only process the data on the basis of the learning thus it is not compatible to handle the exceptional cases. In proposed work, the CNN is replaced by the Neurofuzzy mechanism. Neurofuzzy is the combination of neural network and fuzzy inference system which makes it capable to perform auto processing in case of exceptional situations. It takes decision on the basis of available data sets.

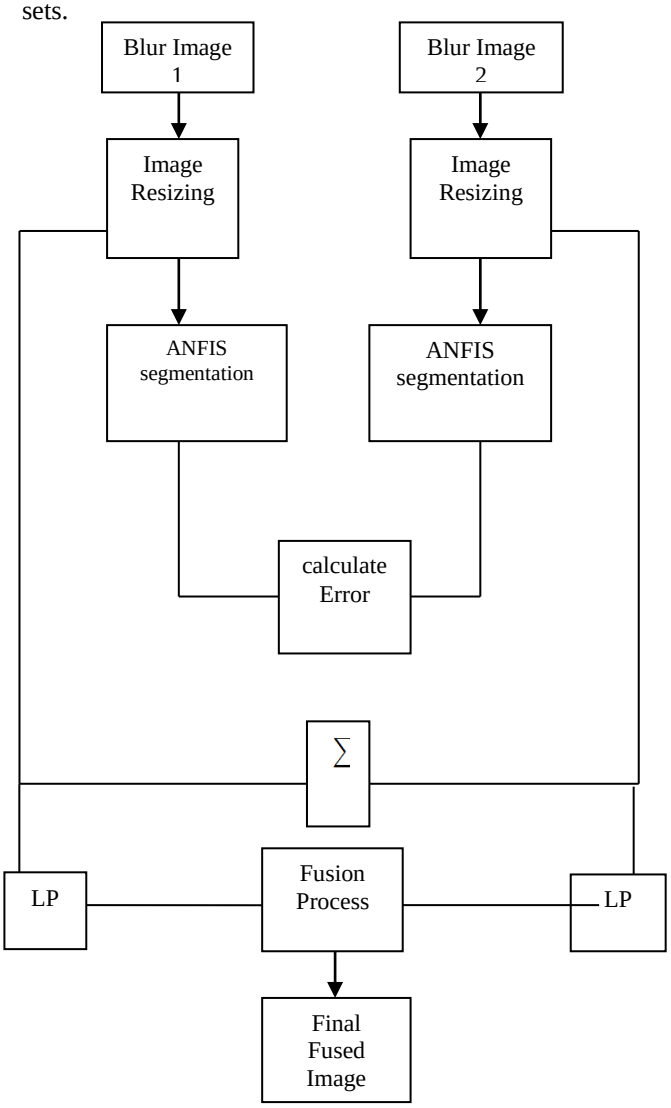

Figure 1 Framework of proposed work

Step 1. First step is to select the images for the purpose of image fusion. In this step the user have to select two input images from available dataset of images.

Step 2. In this step the selected image is resized for further processing.

Step 3. Next step is to segment the images. In this the major objects of the images are highlighted by highlighting the boundaries of the objects in the images. This is done to highlight the important information from the image. In proposed work the ANFIS is used for the purpose of segmentation.

Step 4. From segmented images the error is calculated and the addition is performed.

Step 5. In this step the Laplacian pyramid image fusion technique is applied to fuse the two of the images.

Step 6. At last, the final fused image is received.

IV. RESULTS

The graph in figure 2 shows the input membership function Lx and graph in figure 3 depicts the input membership function Ly. The figure 4 shows the proposed ANFIS model for image fusion. It shows that two input are fed to the system and then the Sugeno FIS is applied to the input membership functions on the basis of 16 rules set. The rule set is defined by the user and the respective output is generated on its basis.

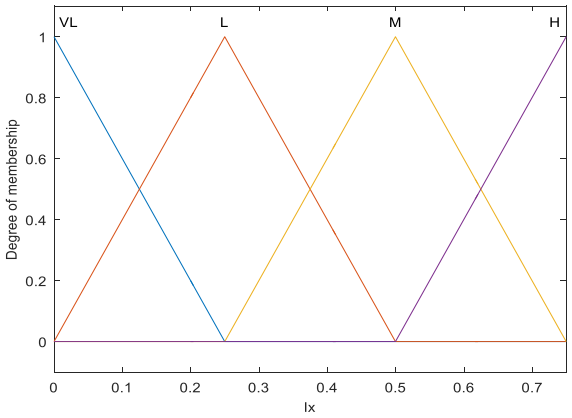

Figure 2 Input Membership Function1

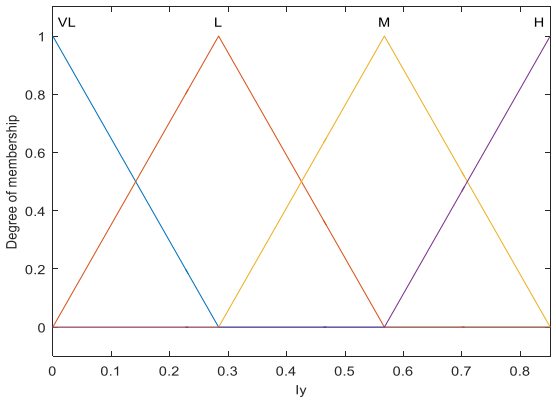

Figure 3 Input Membership Function 2

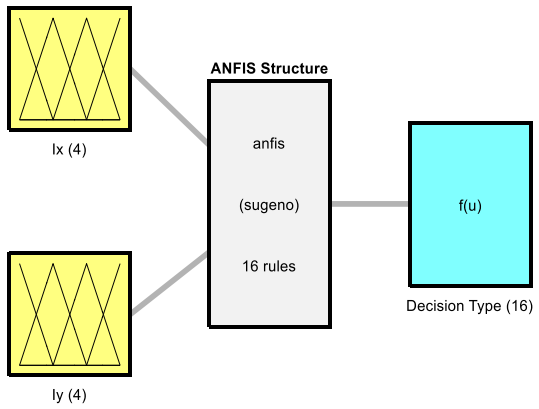

Figure 4 Proposed ANFIS models

The figure 5 shows the image 1 and image 2 that is used as an input to the system for the purpose of the image fusion. For the purpose of image fusion, it is mandatory to select two images initially. In proposed work the user has permission to select the both input images.

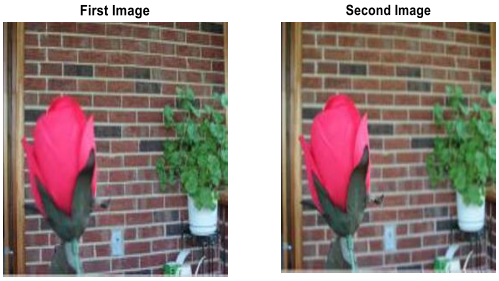

Figure 5 Image 1 and Image 2 for Fusion

After selecting the input images, the image segmentation mechanism is applied to the selected images. The segmentation is done to extract the object wise information from the images. The image segmentation, segments the image on the basis of the objects that are included in the image. The figure 6 shows the segment images for input image 1 and input image 2.

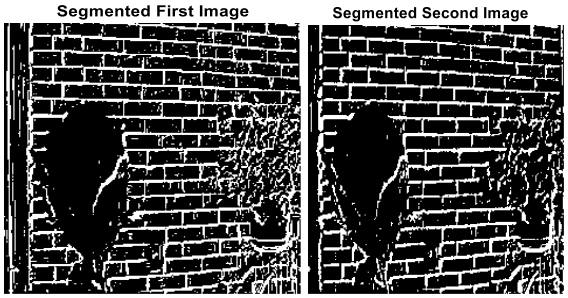

Figure 6 Segmented Image 1 and Image 2s

Figure 7 Final Fused Image

The image in figure 7 is obtained after fusing the image 1 and image 2 that are obtained after implementing the image segmentation mechanism to the both of the input images. The purpose of the image fusion is to fuse two images that are individually not capable to generate a meaningful image.

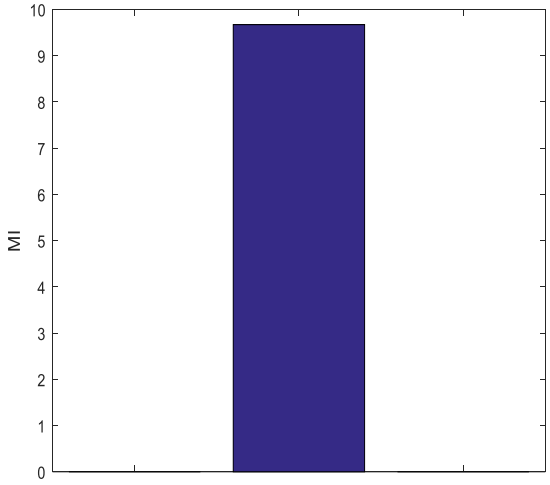

Figure 8 MI of Fused Image

The graph in figure 8 depicts the MI of fused image that is achieved after implementing the proposed image fusion technique on two different images. The x axis in the graph shows the MI for fused image. The y axis calibrates the data in the terms of MI and it ranges from 0 to 10. The MI is a parameter that defines the level of mutual information. The following is the mathematical equation fro MI.

$$MI(x,Y) = \sum_{x}\sum_{y} P(x,y) log \frac{P(x,y)}{P(x)P(y)} \ldots\ldots (1)$$

$P(x,y)$ *is the probability of distributed function,*

$P(x)$ *and* $P(y)$ *is the marginal probability function of both modalities.*

The MI for final fused image is obtained to be 9.67 that is quite high and proves the proposed work quite effective.

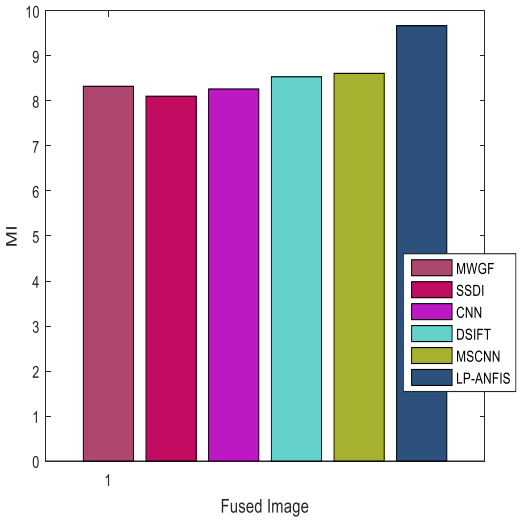

Figure 9 Comparison Analysis of MI

The graph in figure 9 shows the comparison of proposed and traditional work in the terms of MI. the x axis shos the data for fusion techniques and y axis depicts the value of MI. The MI of proposed technique is quite higher i.e. 9.67 in comparison to the MSCNN (8.613), DSIFT (8.537), CNN (8.266), SSDI (8.105) and MWGF (8.325). The graph proves that the proposed work outperforms the traditional techniques in terms of MI.

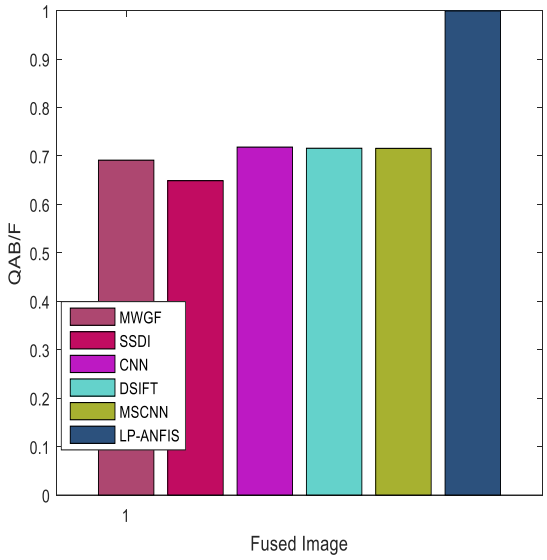

Figure 10 Comparison Analysis of QaB/F

The comparison of proposed and traditional techniques is done on the basis of the QAB/f in figure 10. The QAB/F is used to evaluate the edge strength. The proposed work poses the 1, MSCNN poses the 0.7157, DSIFT poses the 0.7159, CNN has 0.7183, SSDI has 0.649 and MWGF has 0.6913 QAB/F. On the basis of these facts and figures it can be concluded that the CNN mechanism has second higher QAB/F and proposed work has the highest value of QAAB/F. Whereas the SSDI has the least value of QAB/F.

Table 1 shows the facts and figures that are obtained from above comparison graphs corresponding to the traditional and proposed work in the terms of MI and QAB/F. The shown statistics proves the efficiency of the proposed work over traditional work.

Table 1: Comparison Analysis for different image fusion techniques in terms of QAB/F and MI

Technique	QAB/F	MI
MWGF	0.6913	8.325
SSDI	0.649	8.105
CNN	0.7183	8.266
DSIFT	0.7159	8.537
MSCNN	0.7157	8.613
LP-ANFIS	1	9.67

V. CONCLUSION

Image fusion is considered as a process that combines two blur images to form a single enhanced image. There are several wavelet based techniques have been developed. However, these techniques have been suffering from several issues such as low quality image and high noise in the acquired image. Considering a novel approach has been proposed in this work. Initially Laplacian Pyramid approach is used to extract the features from set of images and then ANFIS is applied to acquire optimum solution for the process of fusion. The performance of proposed approach is computed under MATLAB software. From the simulation analysis, it has concluded that proposed technique outperformed the traditional technique in terms of different performance parameters such as QAB/F and MI. The proposed technique in every aspect performs significantly in comparison with traditional approach. Furthermore, the acquired fused image from proposed technique is of high quality with less noise. Additionally, the fused image generated through the proposed technique is highly similar to the original image that shows the optimality of the proposed technique.

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