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Fuzzy-PCA Hybrid Approach For Image Fusion Using Laplacian Features

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Abstract*: The process of acquiring a clear image by combining two blur images is known as image fusion. In order to accomplish this process, a novel approach has proposed in this paper which collaborates two medical images together to form a fused image. The proposed technique is the hybridization of two techniques which is used to evaluate the weight values using PCA and makes decision about these weight values using fuzzy approach. The designed fuzzy logics let the system to choose the relevant weight values for the manipulations of pixels. Furthermore, the proposed technique is compared with the traditional technique using MATLAB software tool to evaluate the performance. Both the techniques are compared on the basis of three parameters such as AMI, AQI and PSNRusing five different sets of edical images. From the results acquired, it has shown that proposed technique performs effectively better than the traditinal technique in terms of Quality, mutual information and Signal to noise ratio.

Index Terms: Image Fusion, PCA, Fuzzy Logics, Laplacian Pyramid, AMI, AQI, PSNR

I. INTRODUCTION

In 1950's and 1960's the idea of data fusion was introduced. This introduction was resulted in various techniques used for fusion of images from different sensors in order to produce the composite image. This composite image can be further utilized for efficient identification of both natural and man-made objects [1]. Various researchers have started doing experiments in the field of image fusion and their literatures different terms like combination, integration, merging etc were introduced. Data fusion technique may be described as framework used to express the integration of data arised from various sources. The main objective behind the image fusion is to acquire the data with higher quality. Various advantages of image fusion technique are described below:

Increases the reliability of imformation with the help of redundant data.

As it has the complementary data therefore its capability increases.

Nowadays, engineers are taking great interest in the field of image fusion for further further research and development. The image fusion technique can be used in medical field in order to obtain enhanced quality images. Researchers also done experiments to use this technique in atomative industry in order to improve the vision of road to acquire high quality image when the weather conditions are not suitable like rainy or foggy [2]. In Image fusion, one fused image is obtained at the output by using different set of images in the input. The images fed at the input can be of any type like multi sensor, multi focal, multimodal. In this technique, the most important phase while preprprocessing is image registration. Now image registration may be described as changing the coordinates of one image in accordance with the other image. Image fusion technique is the sequel version of data fusion method as represented in figure 1. To fullfil the demands of industrial units, it is required to develop various new techniques of image fusion

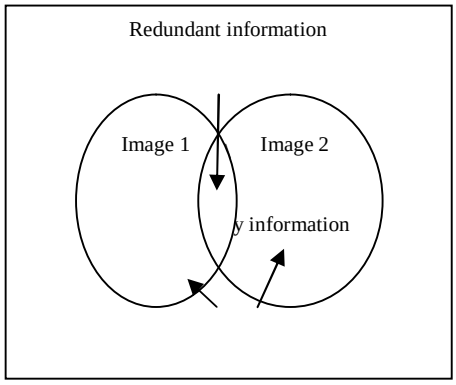

Figure 1 Fusion process on a venn diagram [4]

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One of techgnique that can be used in sensor fusion is Artificial Neural Network (ANN) and Fuzzy Logic method. In this technique output decision is taken on the basis of trained input samples. The central idea used here is to relate the sensory input data set with the output decision. Once the system is developed then another set of input data is implemented in order to examine the operation of the system[3]. Another technique that can be implemented for image fusion is PCA based method. In PCA technique weighted sum of input images are used. To acquire the weights associated with each input image, the normalized Eigen vector of covariance matrices associated with each input image is used. Laplacian pyramid algorithm and wavevelet technique are also one of the techniques used for image fusion. In Laplacian image fusion technique data obtained from various source is integrated at basic level in order to produce more precise, efficient and detailed information. This technique does not consider detailed content such as boundaries, edges and salient features greater than one pixel. This detailed information is usually considered in high pass subbands. Therefore, this technique should be implemented to LL subabnd and SF-based wavelet paradigm should be implemented to higher subbands in order to obtain the good quality images.

II. BACKGROUND

The main objective of pixel level fusion methods is to have faithful integration of image details from two or more source images into a single image without any image distortion and loss of image details. According to fusion of information at different stages, image fusion algorithms are classified into pixel level fusion, feature level fusion and decision level fusion. Many researchers are working in this field from many years. The popular domains used for this are basically frequency, transform based etc. recently from the literature study it was seen that the most work is now focused on mixing of the feature on basis of analysis over the components the techniques those are focused for those are principle component analysis but as the feature are form the transform based techniques there might be variation in the pixel information if the threshold chosen will be not appropriate so there is need to develop a threshold finding approach which will work effectively.

III. PROPOSED WORK

As it was studied form the literature that the techniques those were implemented are basically on basis of wavelet and the PCA which work on the transformation and the threshold selection approach but as the transformation approach provides results which can be varied the internal features of the image also because of that the final image at the final stage can be varied. For this a technique is proposed in this work that firstly the transform based approach will be replaced with the laplacian pyramid along with the Fuzzy and PCA. Where the role of PCA and the fuzzy logics is to choose the final threshold value so can be effectively fuse the images.

IV. METHODOLOGY

The proposed method works on five different sets of images. The methodology used to implement the proposed method is as follows:

The very first step is to select the two different images which will be fused together. The images are selected from a set. There are five different sets are considered. The image first is the one image itself and second one is the second image of that set.

Apply laplacian pyramid technique over the selected image to convert them into different levels.

In this step, three level feature extraction techniques have applied over the images on which laplacian pyramid technique is already performed.

Now calculate weight values using the Principal Component Analysis technique.

The fuzzy set approach is described in this step where decision will be taken which weight values will be considered. This decision will e totally dependent upon the fuzzy.

After evaluating the decision about the weight values, next step will be the fusion of images.

At last, inverse of laplacian pyramid has applied to combine the levels which were diversified in the second step.

The final fused image is acquired through this step.

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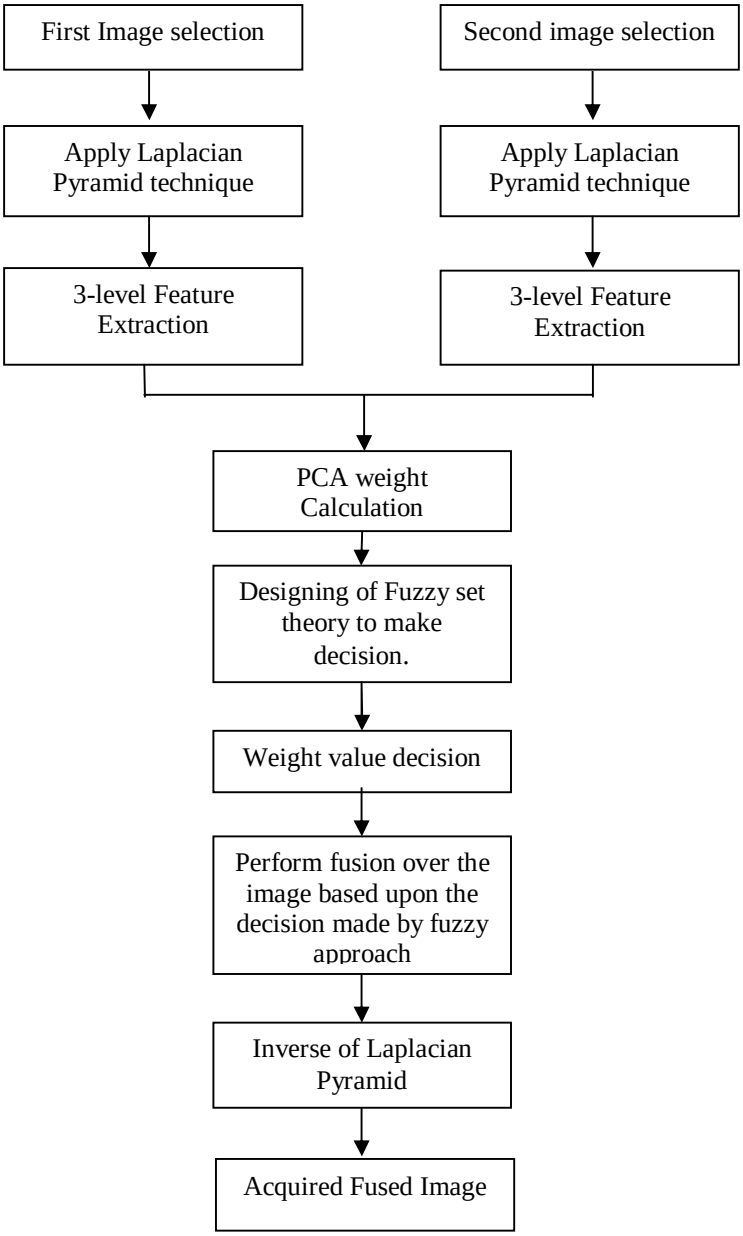

Figure 2 Block Diagram of Proposed technique

A. Algorithm Of Proposed Technique

1) Initialization of input blur image 1 and input blur image 2.

2) Design Fuzzy system

a) Add input variable PCA_1 and PCA_2 and their membership functions

b) Add Output Variable Weightvalue 1 and Weightvalue 2 and their respective memberhsip functions.

c) Define Rule List based on which output will be produced.

3) Apply Laplacian base Fusion

a) Set For loop from 1 to number of levels i.e. 3

b) Perfrom Reduction and Expansion for both input images using DCT approach.

Image1= Reduceimage(Input Image 1);

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Laplacian Pyramid1=Input image1-Expanding (Image1);
Image 2= Reduceimage(Input Image 2);
Laplacian Pyramid2= Input image 2-Expanding (Image 2);
Evaluate final features as:
Final features= Laplacian Pyramid 1+ Laplacian Pyramid 2
End of For Loop

B. Perform Fusion using PCA approach

1) Compute Covariance matrix of Image 1 and Image 2.C= Covariance (Image 1 (:), Image 2 (:))

2) Compute eigenvalues (D) and eigenvectors (V) of matrix C

[V D]=eig(C)

3) Compute PCA based weight values

$$W_{12} = \frac{V}{\sum V}$$

4) Evaluate fuzzy Output

FW_{12}=evalfis(W_{12},weightfuzzy)

5) Perform Fusion

Fused_Image= Image1+Image2;

6) Acquired Final Fused Image.

C. Evaluate Performance Parameters.

1) Calculate AMI of source images x and y and fused image z as

$$AMI = \frac{I_{(x,z)}+I_{(y,z)}}{2} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

2) Calculate AQI of Source image x and z as a fused image:

$$AQI = \frac{QI_{(x,z)}+QI_{(y,z)}}{2} \ldots\ldots\ldots\ldots\ldots (2)$$

3) Calculate PSNR as

$$PSNR = \frac{PSNR_{(x,z)}+PSNR_{(y,z)}}{2} \ldots\ldots\ldots\ldots (3)$$

V. RESULTS AND DISCUSSION

This section described the list of results obtained after applying the proposed hybrid technique for image fusion. The performance evaluation of proposed work is done in the form of various parameters such as AMI (Average Mutual information), PSNR (Peak Signal to Noise Ratio) and AQI (Average Quality Index). The results of proposed work are compared with the results of existing image fusion techniques such as DWT and PCA.

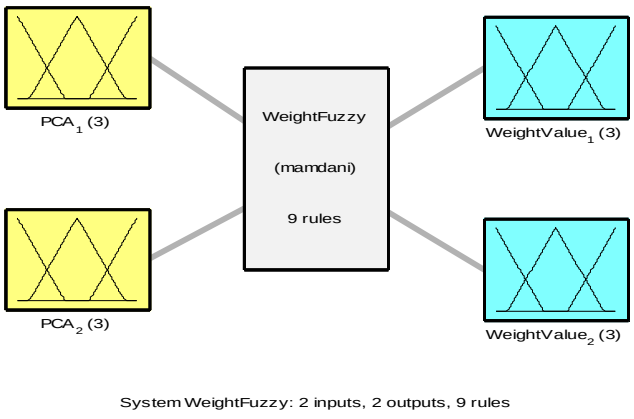

Figure 3 Fuzzy inference system of the proposed work

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The above figure 3 depicts the fuzzy inference system of the proposed work. In the system, there are two inputs to the Mamdani fuzzy model which are PCA1 and PCA2. Each PCA input has 3 rules so in total there are 9 rules based upon which decisions are taken. While processing these inputs using the defined rules two outputs have produced considered as weight value 1 and weight value 2. This system able to decide how much amount of weight value should be calculated to get a fused image.

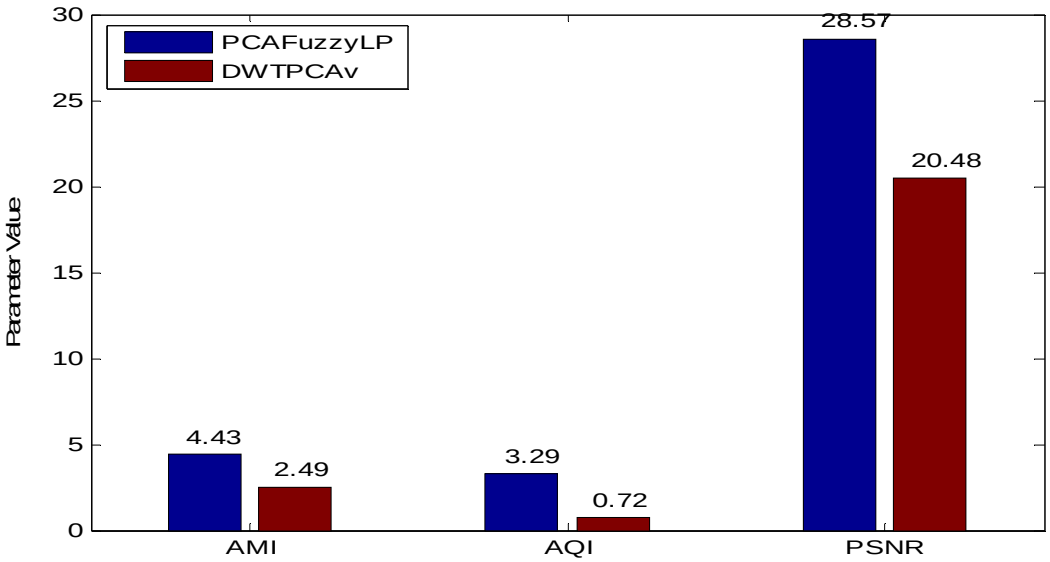

Figure 4 comparison between traditional and proposed technique for Set 1

After evaluating the model, results are acquired in terms of bar graph which has shown in the figure 4 to 8. In the figure 4, different parameters have mentioned such as AMI, AQI and PSNR. The comparison has been taken between the traditional and proposed technique. The very first parameter is AMI that shows how mutually the source and fused image are connected. The AMI of the technique should be high which is 4.43 of proposed work that concludes that proposed technique is better than traditional technique whose AMI is 2.49 i.e. lesser than proposed technique. The second parameter shows that Quality of producing fused image which is also higher in proposed technique i.e. 3.29 which is almost 5 times to traditional technique. Lastly the PSNR, which portrays the amount of noise with respect to data. In the proposed technique, the results acquired contain less noise in comparison with traditional work.

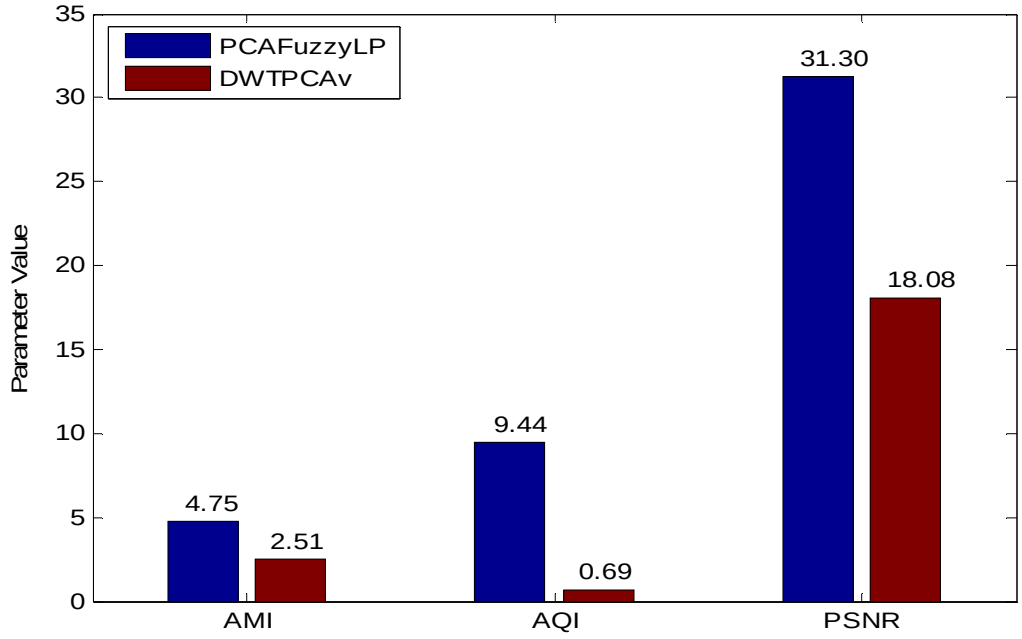

Figure 5 comparison between traditional and proposed technique for Set 2

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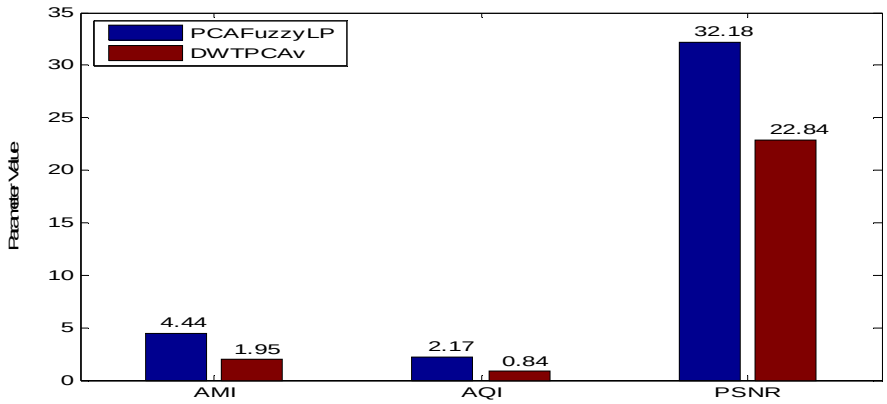

Figure 6 comparison between traditional and proposed technique for Set 3

The figure 5 shows the comparison between traditional and proposed technique performed on set 2 of medical images. The performance of the work is evaluated on three parameters such as AMI, AQI and PSNR. The proposed technique outperforms the traditional technique in terms of individual parameter. The AMI, AQI and PSNR parameter's value is greater than DWTPCA i.e. 4.75, 9.44 and 31.30 respectively. Whereas there is large difference in the traditional techniques parameter's value such as 2.51, 0.69 and 18.08 for AMI, AQI and PSNR correspondingly.

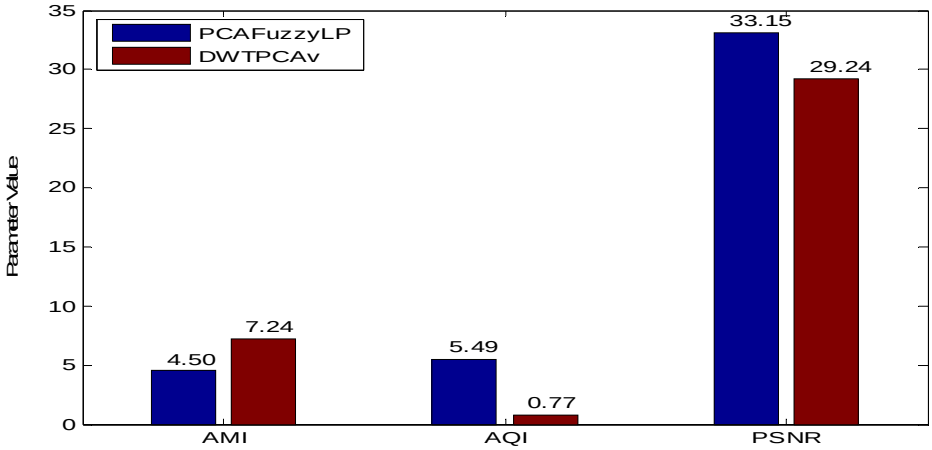

Figure 7 comparison between traditional and proposed technique for Set 4

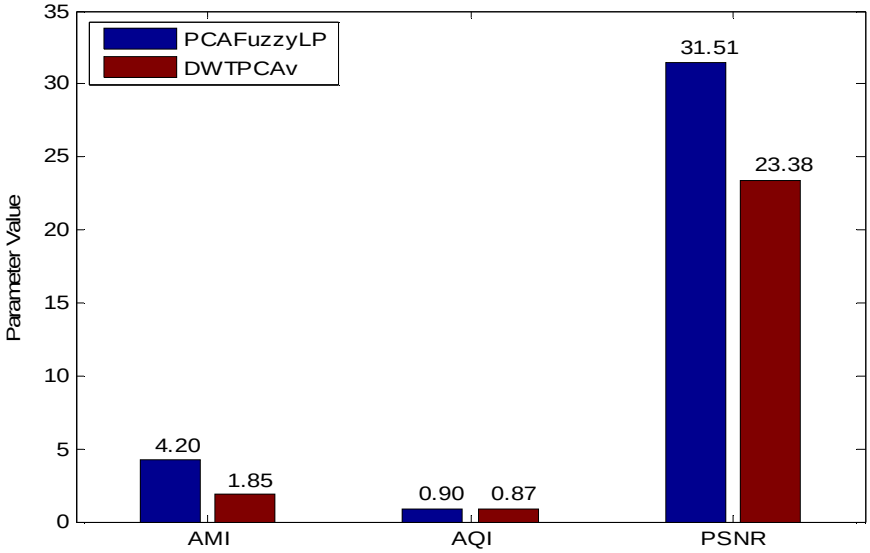

Figure 8 comparison between traditional and proposed technique for Set 5

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Likewise, for each set3, 4 and 5 in the figure 6, 7 and 8 respectively, comparison has performed to evaluate the performance of the proposed technique with respect to traditional technique. From the results acquired, it has been shown that proposed technique generates efficient outcome for individual case and set of images. Consequently, mutual information, quality and signal rather than noise is higher in the projected technique termed as PCAFuzzyLP as compared to DWTPCAv.

A. Statistical results

This section of the work explains simulation results acquired after performing traditional and proposed techniques. Both the techniques are compared on the basis of three different parameters and their statistical results are shown in the table below.

Table 1 AMI metric of traditional and proposed technique for five individual sets of medical images

Average mutual information (AMI)					
	Set1	Set 2	Set 3	Set4	Set 5
PCAFuzzyLP	4.43	4.75	4.44	4.50	4.20
DWTPCAv	2.49	2.51	1.95	7.24	1.85

Table 2 AQI metric of traditional and proposed technique for five individual sets of medical images

Average quality index (AQI)					
	Set1	Set 2	Set 3	Set4	Set 5
PCAFuzzyLP	3.29	9.44	2.17	5.49	0.90
DWTPCAv	0.72	0.69	0.84	0.77	0.87

Table 3 PSNR metric of traditional and proposed technique for five individual sets of medical images

Peak signal to noise ratio (PSNR)					
	Set1	Set 2	Set 3	Set4	Set 5
PCAFuzzyLP	28.57	31.30	32.18	33.15	31.51
DWTPCAv	20.48	18.08	22.84	29.24	23.38

From the above explained statistical results shows the proficiency of the proposed technique in comparison with DWTPCAv technique.

VI. CONCLUSION AND FUTURE SCOPE

In order to fuse the two images effectively, it is required to select appropriate weight value acquired from PCA approach. Thus, Fuzzy logics approach is proposed in this work which is combined with the PCA technique. Basically, three parameters are used for the evaluation such as AMI, AQI and PSNR applied on five different sets of medical images. After making the comparison between both techniques, it has confirmed that proposed technique outperforms the traditional technique in every aspect. Initially, at every set of images, proposed technique performs effectively in terms of AMI parameter except set 4. The values of the parameter acquired are 4.43, 4.75, 4.44, 4.50 and 4.20 respectively whereas in the traditional it lies at 2.49, 2.51, 1.95, 7.24 and 1.85 correspondingly. So there is average 28.136% improvement in the proposed technique. Consider the AQI parameter's value which is 3.29, 9.44, 2.17, 5.49 and 0.90 in the proposed and 0.72, 0.69, 0.84, 0.77 and 0.87 in the traditional technique for each set respectively. Thus, the average enhancement of the proposed technique is 81.72%. Lastly, the PSNR has also improved in the proposed technique in comparison with the traditional technique. Considerably 27.24% improvement can be seen in the proposed

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technique by taking average mean of all the values of each set. Consequently, the proposed technique performs significantly in comparison with traditional technique. Moreover, it could be consider as effective technique in terms of fusing two images together. In future, Further enhancements can be done in order to enhance the performance of image fusion. Various swarm optimization techniques such as PSO, Grey wolf and Genetic Algorithm can be added. With the help of these optimization algorithms the weight values can be optimized using fitness function.

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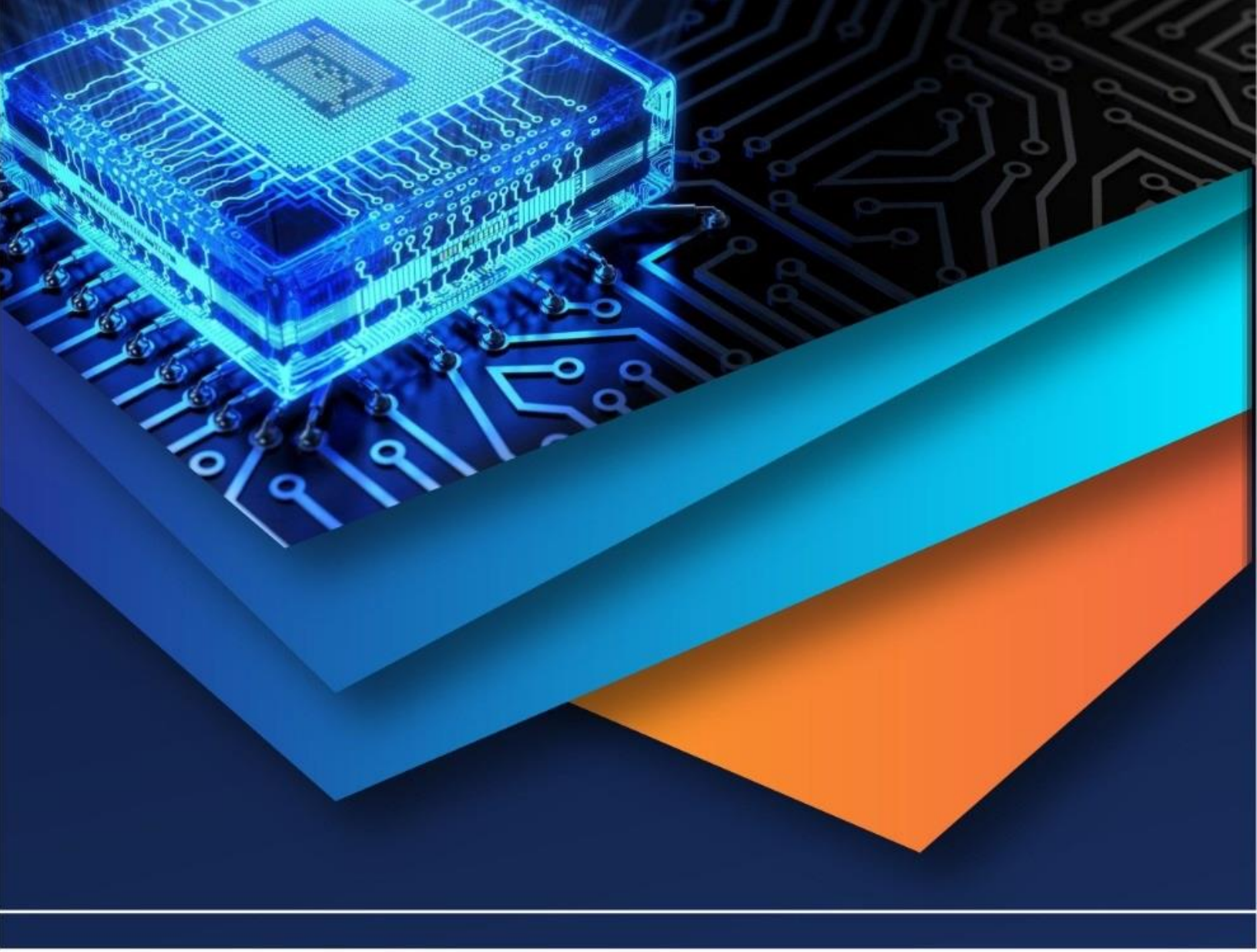

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