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Image Fusion Approach to Enhance Histogram using PCA Method

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Abstract: ***The image fusion is done to preserve the actual information from the images so that the images can be used for decision making process. Various authors have developed techniques that are capable to fuse the images in an effective manner with qualitative results. After having a review to the previous image fusion work, it is observed that there are some backlogs in these mechanisms such as less effective to preserve the originality of the information of input image, leads to the degradation in the quality of the fused images. Thus to overcome the previous flaws, this work develops a novel image fusion technique i.e. HT-PCA. This study also implies the IHS model to the input RGB image, pre-processing techniques for enhancing the quality of input images, 2DHT for processing the I coefficient of IHS model. The PCA image fusion technique is applied for fusing the images. The simulation of proposed work is done in MATLAB by using a dataset of MRI and PET images. On the basis of the evaluated performance it is observed that the HT-PCA outperforms the traditional IHS technique, DHT-IHS, Gradient Pyramid, FSD Pyramid, 2DHT and Haar Wavelet.***

Keywords: Image Fusion, Medical Images, 2DHT, IHS transformation, PCA.

I. INTRODUCTION

Image fusion is a procedure that is followed in digital image processing for obtaining more enhanced and meaningful image. The image fusion is implemented when two different images are available with partial information then these images are merged together to form a complete useful image. Image fusion is comprised of various steps such as image acquisition, image pre processing and image fusion. Along with this there are some other steps that are also the part of image fusion. The selection of steps relies upon the requirement of the fusion techniques and output image.

A large number of research works has been done till now to enhance the effectiveness and quality of fused images. On the basis of the traditional work, it is observed that the following are some major requirements for image fusion:

1) The fused image should have all the relevant information.

2) The final fused image should not comprise of manufactured objects since this can leads to the wrong decision.

On the basis of these requirements, this study develops a novel image fusion mechanism for MRI and PET images by using IHS model, 2DHT (Discrete Hilbert Transformation), image enhancement techniques and PCA (Principal Component Analysis) image fusion technique. The purpose of this study is to remove the flaws from the input images by using color model and image enhancement techniques before fusing them.

II. PROBLEM FORMULATION

The procedure of combining compatible information from two or more images into a single image is known as Multisensory Image fusion. The resulting image will be more informative than any of the input images. Increase in availability of space borne sensors provides motivation for different image fusion algorithms. There are several situations in image processing where high spatial and high spectral resolution in a particular image is required. Most of the available equipments are not proficient of providing such data decisively. Image fusion techniques allow the assimilation of various information sources. There are number of techniques have been developed suffering from several issues such as low quality and loss of information. In the traditional technique, image pre-processing steps are not included which means that the fusion process is accomplished directly that degrades the actual quality of the original image and does not preserve its identity. Moreover, at the time of fusion, the part which is degraded is not considered and directly fused that resultant into low precision.

III.PROPOSED WORK

Considering the issues of existing technique, a novel approach has proposed in this work. In the proposed work, image pre-processing steps are included where blur images which are fused together are enhanced firstly and then process of image fusion is applied. By introducing the image enhancement procedure in the proposed technique, the quality of image can be enhanced while preserving its originality. Secondly, no direct fusion will be applied over blur images. Consequently, PCA i.e. Principal Component

Analysis techniques will be introduced. This approach helps in reducing the size of data while retaining the quality of images. Moreover, this technique considers the part of images which requires high attention while fusion.

A. Techniques Used

1) 2DHT: The 2DHT is a mechanism that is applied for signals processing. It is a linear operator that considers a function of a real variable to generate another function of real variable. The 2DHT formulation for spatial domain is explained as follows:

$$S_H(X) = s(X) * \frac{1}{\pi^2 xy} \ldots (1)$$

The function for frequency domain is as follows:

$$S_H(U) = -sgn(u)sgn(v)S(U) \ldots (2)$$

From (1), the 2DHT is evaluated as:

$$S_A(U) = [1 - isgn(u)sgn(v)]S(U) \ldots (3)$$

2) IHS Transformation: The Intensity, Hue and Saturation transformation is a mechanism that is widely applied for the image fusion for sharpening. In HIS, spectral information is relies on hue and saturation section. From the visuals, we can conclude that the intensity variations have little effects on the spectral section and it can handle easily.

3) PCA (Principal Component Analysis): PCA is conversion method which converts the number of associated variables into the format of set of unassociated variable. It works effectively and efficiently in case of image compression and image classification. The conversion of associated variables is done with the help of mathematical calculations and functions. It leads to the concise and finest description of data set. The function of PCA is implemented in the form of principal component.

The first principal component examined much of the dissents in the available data as supple. The second principal component is encumbered within the subspace which is perpendicular to first component. Then the value of maximum variance is selected as a third component.

The figure above defines the working of PCA transformation technique. The figure represents the conversion of MS bands into principal components and matching with histogram etc. The PCA is an alternative mechanism which can be used in place of HIS technique. The working of PCA is as follows:

a) First step is to electrocute IR to the value of PAN and MS and also resample the MS.
b) Conversion of MS bands into components such as PC1, PC2, and so on.
c) Twin of histogram between PAN and PC1.
d) Reconstitute the PC1 with PAN.
e) Conversion of PAN to left principal components.

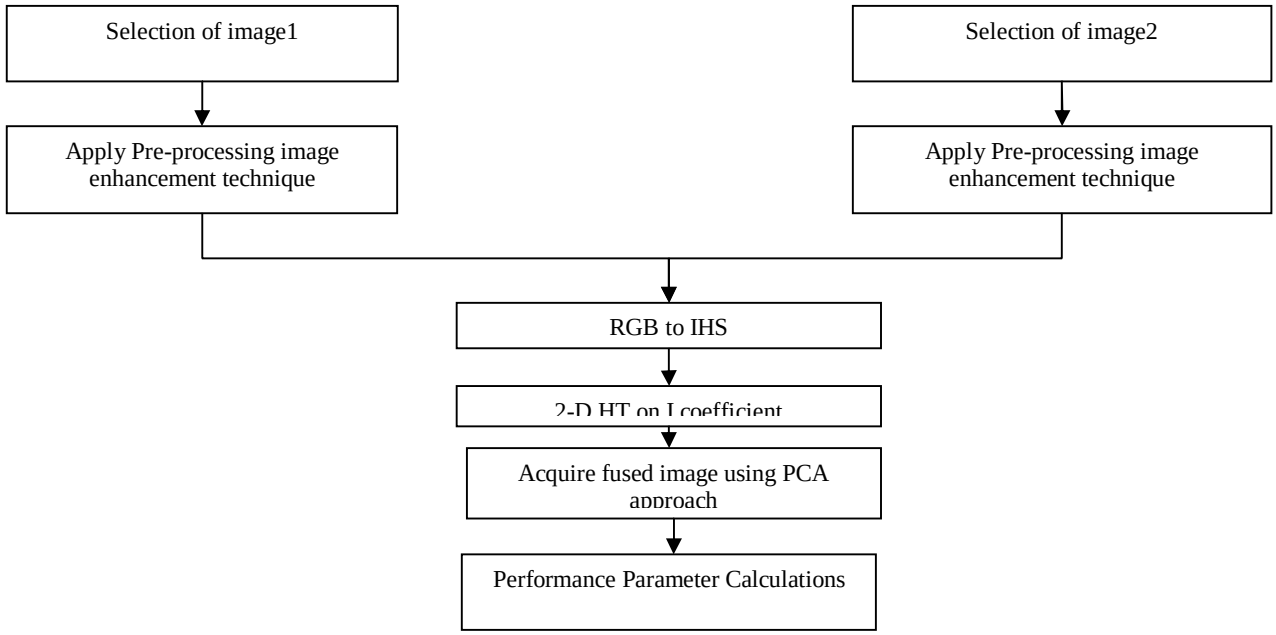

Fig. 1 Framework of Proposed Work

The stepwise process of propose work is as follows:

i) *Input Images:* In this step, the input image is selected by the user from available dataset of images. The dataset is comprised of various MRI and PET images. Users have privilege to select the images from these images. Two images are required to select from available images to perform image fusion.

ii) *Image Pre-processing:* After selecting the images, the pre-processing is applied to the selected images. The images pre-processing is done to enhance the quality of the image.

iii) *Image Conversion:* After enhancing the images, in this step the image conversion is done. As the selected image is in RGB format, then it is converted to the IHS format. This is done to extract the Intensity feature of the image.

iv) *Apply 2DHT:* In this step the 2DHT mechanism is applied to the coefficients of Intensity from HIS.

v) *Image Fusion:* The PCA fusion technique is applied for fusing the images that are obtained after applying the 2DHT. The reason behind selecting the PCA as a fusion technique is that it is quite efficient and less complex to implement.

vi) *Performance Evaluation:* After getting the final fused image, the performance is evaluated by using performance metrics i.e. Discrepancy Value, Average Gradient and Overall performance.

IV. RESULT

The present study develops the image fusion technique for MRI and PET images by using the image pre processing techniques to them in order to enhance the quality of the images before fusing them. First of all the selected RGB images are converted to the IHS format. Along with this the 2DHT is applied to the I coefficient. After this the PCA fusion technique is implemented to fuse the images. This section of the work is organized to show the results of the proposed work that are obtained after simulating it in the MATLAB. The results are evaluated in the terms of various performance parameters i.e. Discrepancy value, Average Gradient and Overall Performance of the technique. These parameters are defined as follows:

1) Discrepancy Value: Discrepancy refers to the evaluation of the capability of fused image to preserve the spectral features of the input image. It can be measured as follows:

$$D_k = \frac{1}{M * N} \sum_{i=1}^{M} \sum_{j=1}^{N} |f_k(x,y) - f_{2k}(x,y)| \ldots\ldots (1)$$

Where, $f_k(x,y)$ and $f_{2R}(x,y)$ refers to the pixel values for fused images with respect to the x and y pixel.

2) Average Gradient is a performance metrics that defines the capability of the fused image to preserve the spatial features of the original image. It is evaluated by using the following formulation:

$$AG_K = \frac{1}{(M-1) * (N-1)} * \sum_{i=1}^{M} \sum_{j=1}^{N} \sqrt{\frac{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2}{2}} \ldots\ldots (2)$$

3) The overall performance is evaluated on the basis of the average gradient and discrepancy value of the techniques. The following mathematical equation is followed to evaluate the overall performance of the techniques.

$$O.P = \frac{\sum_K |D_K - AG_K|}{3}$$

Where, k can be red, green or blue.

The process of image fusion is initialized by selecting the input images. The figure 2 depicts the input image 1 and input image 2 that is selected by the user from available dataset of the images. The selected images are then pre processed by using the image enhancement techniques. The images in figure 2 show the first and second image that is received after applying the pre processing techniques. The final fused image is also shown in the figure 2. the final fused image is received after applying the PCA image fusion technique.

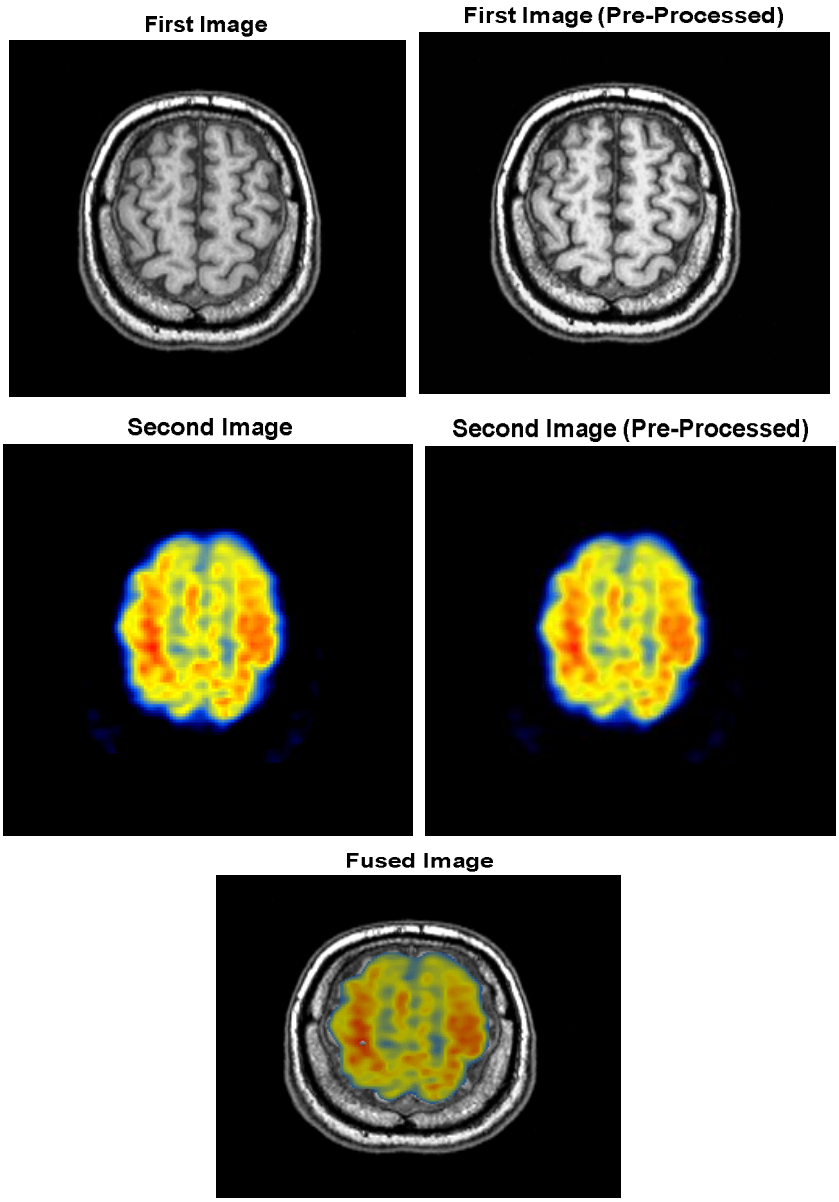

Fig.2 Input Images, Pre-processed images and final fused image

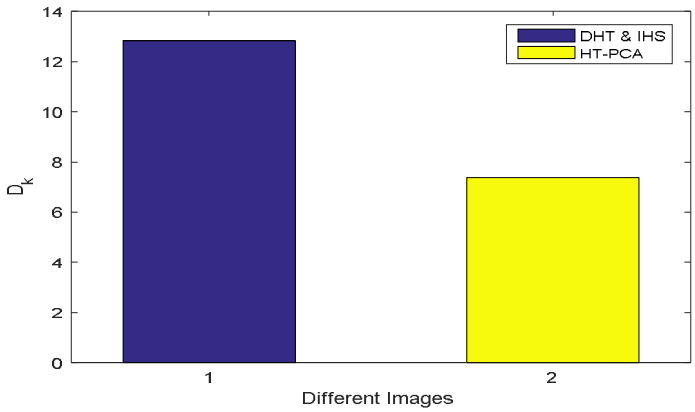

Fig.3 Comparison analysis of Discrepancy

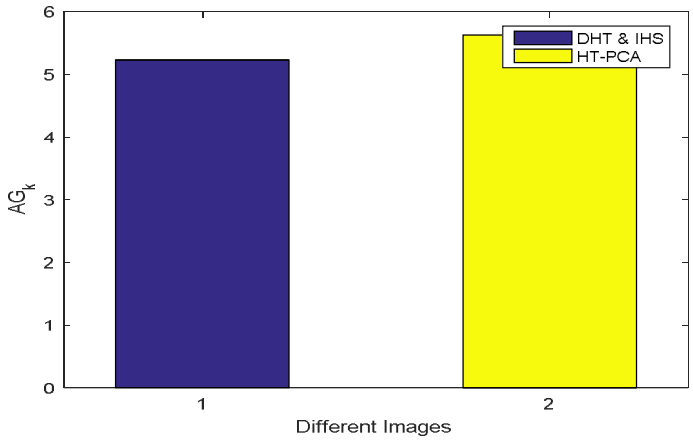

Fig.4 Comparison analysis of Average Gradient

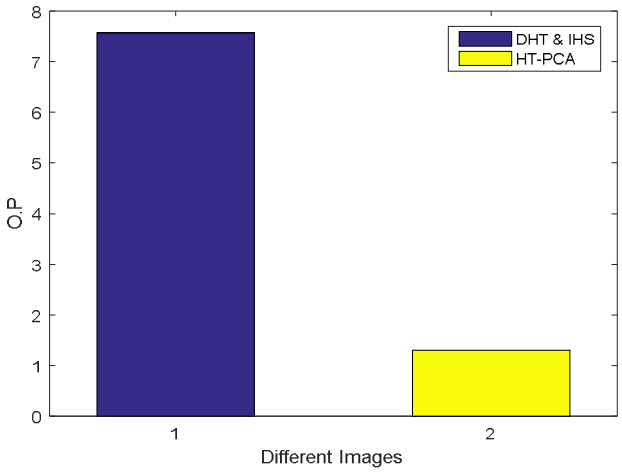

Fig.5 Comparison analysis of Overall Performance

TABLE I
ANALYSIS OF IMAGE FUSION TECHNIQUES

Techniques	Discrepancy	Average Gradient	Overall Performance
IHS	14.773	5.171	9.61
DHT and HIS	12.826	5.227	7.568
Gradient Pyramid	15.941	4.664	11.249
FSD Pyramid	16.095	4.728	11.367
2DHT	20.285	4.891	15.189
Haar Wavelet	13.326	5.194	8.311
HT-PCA	7.3718	5.653	1.3098

The Figure 3, 4, 5 and table 1 calibrates the data in the form of facts that represents the discrepancy, average gradient and overall performance of the proposed work i.e. HT-PCA and traditional image fusion techniques. For the purpose of comparison analysis the techniques like IHS, DHT-IHS, Gradient Pyramid, FSD Pyramid, 2 DHT and Haar Wavelet is considered. On the basis of the values that are shown in the table, it is observed that the proposed work has better discrepancy, average gradient and overall performance in comparison to the traditional techniques. The discrepancy of the proposed work is 23.65, Average Gradient is 7.2 and overall performance 18.114.

V. CONCLUSIONS & FUTURE SCOPE

The digital image processing plays a major role in each and every field for decision making process. The medical science is a field in which the image processing is performed on a large scale to diagnose the disease in the patient on the basis of the various images such as MRI, CT scan, X-Ray, PET etc. Since the decision related to the diagnosed disease in the patient is mandatory to be highly accurate therefore a large number of image processing techniques have been developed till now. Image fusion is one of the image processing techniques which is done to merge two incomplete images in order to generate a single meaningful image. In this work, an advanced HT-PCA based medical image fusion technique has been introduced. In HT-PCA, the MRI and PET images are considered for fusing. The IHS, PCA, 2DHT is implemented to achieve the proficient results in terms of discrepancy, average gradient and overall performance. The simulating results prove that the proposed work outperforms the traditional work in terms of respective performance parameters.

The proposed work is proved to be quite effective and efficient technique for image fusion. In present work the whole image is considered for the purpose of image fusion which indirectly leads to higher cost and also time consuming. Therefore, in future the propose work can be enhanced by working on it to make it cost effective. In order to do so, the interested or required part of the input images can be extracted for the purpose of fusion.

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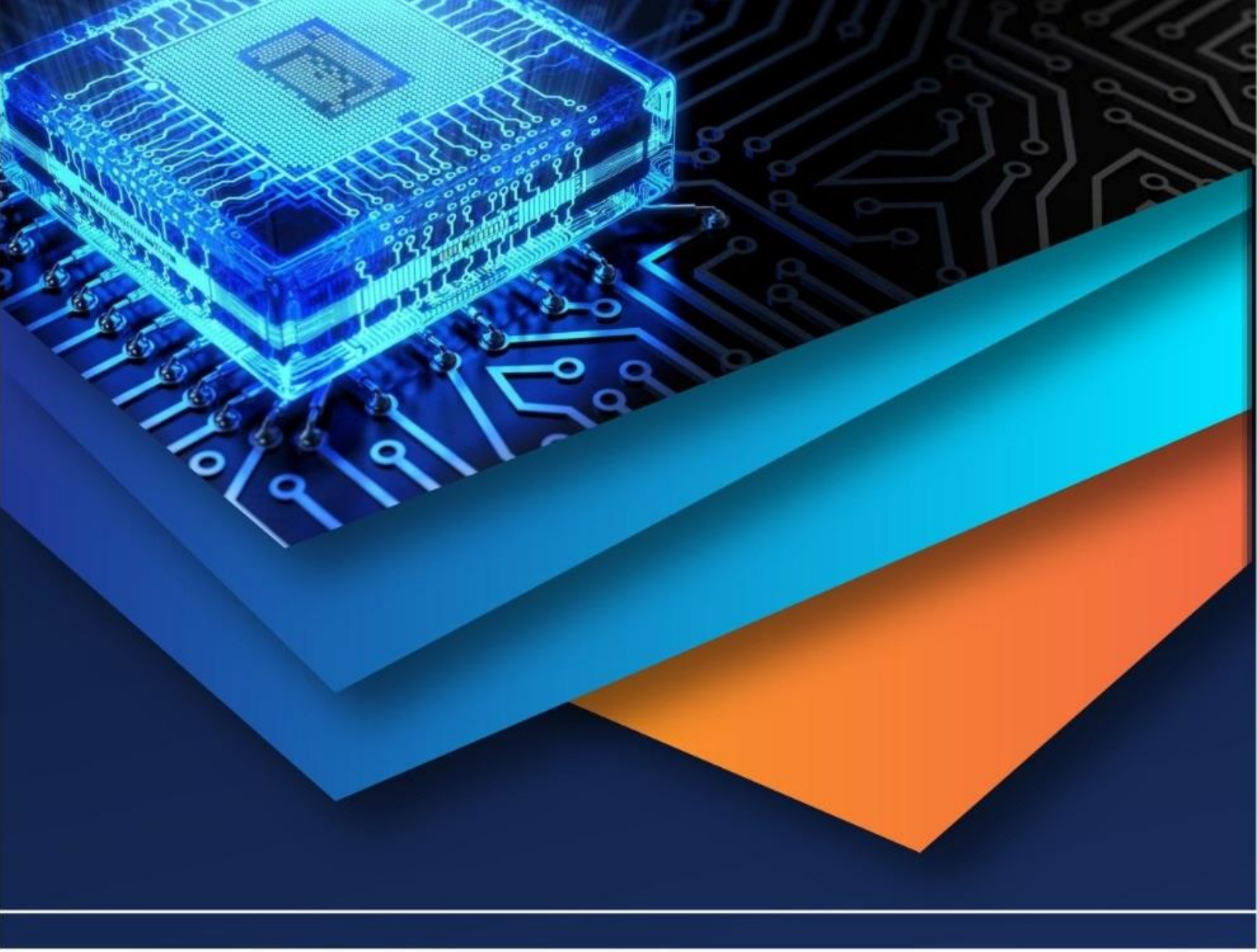

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