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A Hybrid Wavelet Shrinkage-Hierarchical Method for Enhancement of Medical Images

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Abstract: In this research, presented a hybrid Wavelet Shrinkage-Multilayer Hierarchical Clustering (MLHC) method for image enhancement (IE) of medical images making use of discrete wavelet transform (DWT). The principle issue in IE medical pictures is that non-uniform illumination and low-brightness. In this approach, firstly take gray image and apply MLHC on input image. After that apply DWT on generated image after MLHC method. Wavelet shrinkage is applied on all band of image. Finally, merge all the modified bands using inverse DWT. The new result is applied on peak signal Noise Ratio (PSNR), Entropy and time execution. This algorithm is compared with three algorithms, namely Ref 87 [1], brightness bi histogram equalization (BBHE), Contrast Adjustment (CA) method. The proposed algorithm shows that better performance as compared to other algorithms.

Keywords: DWT; Wavelet Shrinkage; Hierarchical Clustering; Medical Image Enhancement; PSNR; Entropy.

I. INTRODUCTION

In modern world due to the changing life style of human beings, everyday new types of diseases are emerging. It's an everyday challenge for doctors to effectively diagnose these diseases and provide remedy. Many of the diseases like breast cancer, retinal fundus, kidney disorders, spinal card problems, heart problems result in enormous amount of digital data either in the form of sound, images, or videos. Efficient analyses of these images are necessary for successful diagnosis of diseases [1].

Medical image enhancement technologies have attracted much attention since advanced medical equipment's were put into use in the medical field. Medical diagnostic techniques analyzed the output images/signal to identify the abnormality [2]. In this digital x-rays are widely used for breast cancer detection due to their reliability. The output x-ray images are sent to certified radiologists for interpretation. Radiologists should have expert knowledge about the basics and physics of x-ray modelling. Hence human interpretation is subjective in nature and is dependent on expertise of the individual. Also if large number of x-rays is to be interpreted, operator fatigue affects the accuracy of the interpretation. Hence the paradigm has shifted to computer aided analysis of medical x-ray images. However the major challenge in automated x-ray interpretation is due to poor contrast, artifacts and inherent noise in radiographs. Hence it is necessary to enhance the contrast of the radiographs before performing image segmentation to isolate the region of interest. Image processing can improve the quality of the image in order to facilitate the interpretation and diagnosis of information [3]. Medical image includes various imaging method to diagnosis human body image and in treatment purpose plays an important role in initiatives to improve public health for all population groups. It is crucial at all major levels of health care. In public health and preventive medicine as well as in both curative and palliative care, effective decisions depend on correct diagnoses [4]. In this research work, we used X-ray medical images on which apply Multi-level hierarical Clustering with Wavelet shrinkage transform to quantify and classify x-ray images. The proposed algorithms are designed to enhance chest X-ray medical images. Experiments are also conducted to compare and evaluate their performances. The rest of the paper is organized as follows: in section II we discuss the hierarical clustering models. Section III introduces Wavelet Transform method. Section IV discuss the method of Wavelet Shrinkage. Section V presents the research study on medical x-ray images and in next section present experiment results.

II. HIERARICAL CLUSTERING

Hierarchical clustering [5] creates a hierarchical tree of similarities between the vectors, called a dendrogram. The usual implementation is based on agglomerative clustering, which initializes the algorithm by assigning each vector to its own separate cluster and defining the distances between each cluster based on either a distance metric (e.g., Euclidean) or similarity (e.g., correlation). Next, the algorithm merges the two nearest clusters and updates all the distances to the newly formed cluster via some linkage method, and this is repeated until there is only one cluster left that contains all the vectors. Three of the most common ways to update the distances are with single, complete or average linkages. This process does not define a partition of the system, but a sequence of nested partitions, where each partition contains one less cluster than the previous partition. To obtain a partition with K clusters, the process must be stopped K − 1 steps before the end. Different linkages lead to different partitions, so the type of linkage used must be selected according to the type of data to be clustered. For instance, complete and average linkages tend to build compact clusters, while single linkage is capable of building clusters with more complex shapes but is more likely to be affected by spurious data.

III. DWT

In DWT method an image is decomposed into different frequency ranges that allows frequency isolation into certain sub-bands. The image decomposition of 2D wavelet transform is perform by applying 1D DWT along the first row of an image, then, the result is decomposed into columns. The decomposition is 4 sub-images is represented as low-low (LL), low-high (LH), high-low (HL), and high-high (HH). Haar wavelet is a bipolar step function. The other wavelets are Daubechies Wavelet, Morlet Wavelet, Mexican Hat Wavelet and Shannon Wavelet [6].

IV. WAVELET SHRINKAGE

Consider the noisy input signal vector xT = (x1, x2, x3…………xN*N). Choose a threshold vector λT= (λ1, λ2, λ3………………… λN*N). Initially initialize each threshold values of threshold vector to Universal Threshold Value which is given by [7]:

$$\lambda = \sigma\sqrt{2 * \log(M)}$$

where

M – Number of samples in the image. λ – Threshold Value

σ – Noise level

$w_s = subbands\ (LH, HL\ or\ HH)$

$$\sigma = \frac{\text{median}(|w_s|)}{0.6745}$$

The wavelet shrinkage estimator vector $\hat{\mathbf{x}}$ is obtained by the following three steps.

Step1: Apply DWT to obtain the empirical wavelet coefficient vector w

$$w = W.\ x$$

Step2: In the wavelet domain, obtain the wavelet domain shrinkage estimator wavelet coefficient with a non-linear threshold function η (Soft Threshold)

w= η (wu, λu), u = 1, 2, ………., N

Step3: Apply IDWT to obtain the wavelet Shrinkage estimator

$$\text{vector } \hat{\boldsymbol{x}} = \widehat{\boldsymbol{x}_1} \ldots\ldots \widehat{\boldsymbol{x}_N}$$

$$\widehat{\boldsymbol{x}_k} = \sum_{\boldsymbol{u}=1}^{\boldsymbol{N}} \boldsymbol{W}_{\boldsymbol{u},\boldsymbol{k}}.\widehat{\boldsymbol{w}_{\boldsymbol{u}}}$$

V. LITERATURE SURVEY

Wen et al. [8] medical X-ray image with low brightness, low contrast and noise, is necessary to enhance the brightness and contrast, but avoid the noise amplification and over-enhancement problem. In this research work proposed an enhancement algorithm which is based on wavelet homomorphic filtering and contrast limited adaptive histogram equalization (CLAHE), can enhance the image brightness, contrast and details and effectively suppress the noise amplification, also avoid over-enhancement phenomenon, with good enhancement effect. Compared with several other similar enhancement algorithms, the proposed algorithm in the subjective visual effect and objective quantitative evaluation are superior to other algorithms.

Savitha et al. [9] presented a unique technique of chest x-ray image enhancement where the enhancement is carried out using multiple ranges of operation. In proposed introduced techniques for enhancing chest x-rays using non-linear enhancement, primary enhancement, secondary enhancement algorithms on JSRT database. For an efficient analysis, an extensive experiment with various numbers of images, altering the weight, variance, correction factor, etc. and monitoring the outcomes. Also accomplishing better PSNR values even in comparison to the most frequently used median filters in medical image processing.

Elena et al. [10] in this work, the problem of contrast enhancement in automatic mode for medical images with small-size low-contrast objects was considered. The histogram-based method for automatic contrast enhancement of low-contrast images with small-size objects on the basis of the analyzing of contrast distribution at boundaries of objects and background was proposed.

Research of the effectiveness of the proposed and known methods of contrast enhancement were carried out by measuring the contrast using known no-reference metrics of image contrast for the four groups of test images.

Tiwari et al. [11] proposed an efficient method to enhance contrast as well as to preserve brightness of medical images. The proposed method works in two step: in first step use of adaptive gamma correction to enhance global contrast of image and in second step sharpening of image is done using homomorphic filtering, in order to preserve image brightness this filtering if followed by image normalization. The result quality of proposed image produce have better contrast with good interpretation of local details. Also the proposed method is able to minimize mean brightness error in the processed image more accurately than other contrast enhancement methods.

VI. PROPOSED METHODOLOGY

This algorithm presented a medical IE using DWT and wavelet shrinkage with hierarchical clustering technique. In this process, first take an input chest X-ray gray-level image. Change the size of an input image with NXN dimension. Perform multilayer hierarchical clustering on input image. In MLHC method we sub divide the input image into several sub images, and then applying the HC method on the sub divided input image. Apply DWT on MLHC image and get these bands which namely iLL (Low band) , iHH (high band), iLH (low-high) and iHL (High-low). Perform wavelet shrinkage method on all band image. For the high and low frequency coefficients of image wavelet decomposition, considering that it may contain the details and noise information, so carry on the wavelet threshold shrinkage processing, in order to reduce the impact of the image noise. Finally, merge all the modified bands using inverse DWT.

A. Algorithm

1) Consider an input medical image is denoted as '$input_{img}$' with 418 X 602 size.

$$[m, n] = size\left(input_{img}\right) \qquad (1)$$

Where m, n is a row and column of $input_{img}$

2) Apply multilayer hierarchical clustering method for improving the image edges.

3) Apply DWT on Out which is decomposed the image into four sub-bands such as iLL, iLH, iHL, iHH. Select all bands (iLH, iHL, iHH) for further processing because this band shows noisy pixels and except iLL band which is clear to show approximate image.

4) We use the soft threshold function to perform wavelet shrinkage denoising on the wavelet transform high frequency coefficients, its expression is as follows:

$$\omega_\delta = \begin{cases} sign(\omega)(|\omega| - \delta), & |\omega| \geq \delta \\ 0, & |\omega| < \delta \end{cases}$$

Wherein, ω is the wavelet coefficients, δ is the threshold. When the absolute value of the wavelet coefficients are greater than the threshold, make them subtract the threshold; when the absolute value of the wavelet coefficients are less than the threshold, set them to zero.

5) The threshold is calculated by the unified threshold calculation model proposed by Donoho and Johnstone.

$$\delta = \sigma\sqrt{2log_e N}$$

Wherein σ is the standard deviation of the noise, N is the length of the signal, in reality, image noise standard deviation is usually unknown, it is generally estimated using the following model:

$$\sigma_{iHH} = \frac{Median(|w_{iHH}|)}{0.6745}$$

$$\sigma_{iLH} = \frac{Median(|w_{iLH}|)}{0.6745}$$

$$\sigma_{iHL} = \frac{Median(|w_{iHL}|)}{0.6745}$$

6) Reconstruct the matrix using inverse DWT for obtaining the final enhanced image.

7) Calculate Peak Signal Noise Ratio (PSNR) between input image and enhanced image.

$$PSNR = 10 \times log10 \frac{maxValue(size(s))}{sqrt(mean(mean(MSE)))} \qquad (2)$$

8) Calculate Mean Square Error (MSE) between the input image and enhanced image.

$$MSE(x) = \frac{1}{M}\sum_{i=1}^{M}(s - s^\wedge)^2 \quad (3)$$

Where s is input image, $s^\wedge$ is enhanced image, MSE is mean contrast

9) Calculate entropy of an image:

$$E = -\sum_{i=0}^{N-1} p(xi)\, logp(xi) \quad (4)$$

Where **E**: Entropy,
N: highest value of gray level ,
p(xi): prospect of rate of xi

Entropy is a calculation of uncertainty or turmoil of an object in this condition the dissimilar image between the filtered and the noise free images.

In fig 1 of proposed system flow chart, first of all take RGB image.Apply multilayer hierarchical on gray level image. Apply DWT, split the input image into four bands: LL, LH, HL and HH. Consider LH, HL and HH band for further processing. Apply the Wavelet Shrinkage filter on all chnnel. Finally merged all bands using inverse DWT.

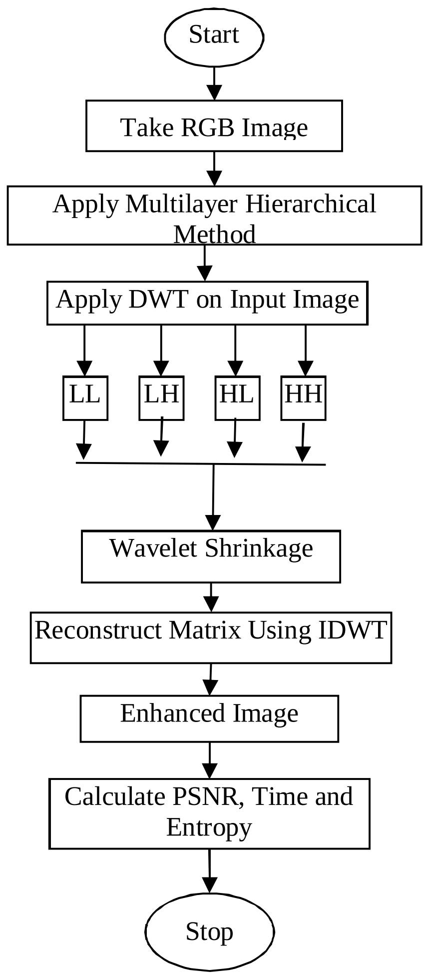


Fig. 1. Flow chart of Proposed System

VII. RESULT ANALYSIS

The implementation result is performed on medical images. It takes low contrast medical gray images for evaluation. It estimates the value of PSNR, execution time and Entropy using below formulas. The algorithm is designed on MATLABR14 using Image Processing toolbox. In this implementation, this algorithm is compared with three different algorithms. As we seen in experimental result.

TABLE I. PSNR COMPARISON OF PROPOSED SYSTEM WITH REF,BBHE AND CA SYSTEM

Original Image	BBHE PSNR	CA PSNR	Ref PSNR	Proposed PSNR
(a)	24.5944	25.1348	45.726	46.601
(b)	20.8499	28.0657	45.797	46.018
(c)	21.48	22.851	45.618	46.151
(d)	23.684	23.322	45.219	46.489
(e)	20.671	19.970	45.5326	46.007
(f)	22.562	24.789	45.634	46.286

TABLE II. ENTROPY COMPARISON OF PROPOSED SYSTEM WITH REF SYSTEM

Original Image	Ref ENT	Proposed ENT
(a)	0.9742	1
(b)	0.8802	0.9999
(c)	0.9686	0.99993
(d)	0.9725	0.99999
(e)	0.9850	0.99987
(f)	0.9983	1

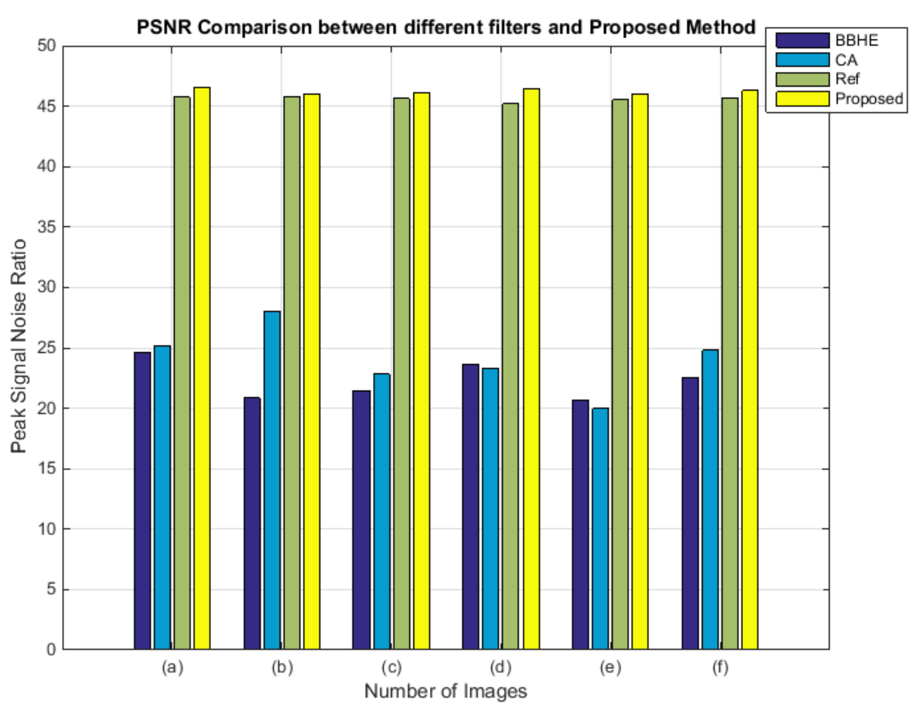


Fig. 2.PSNR Comparison with different filters and proposed filter

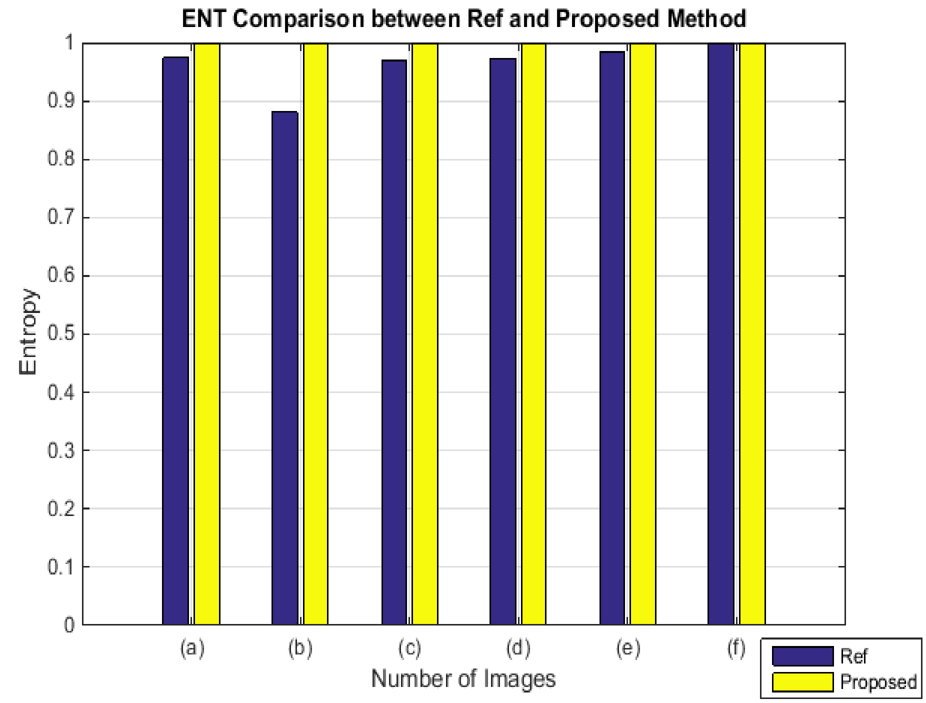
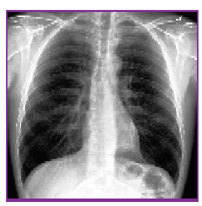
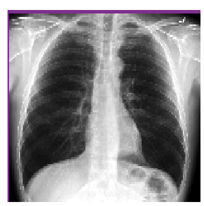
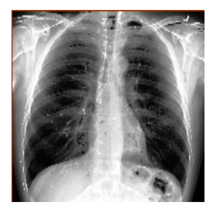
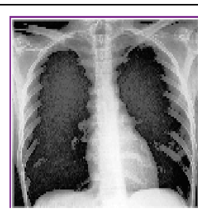
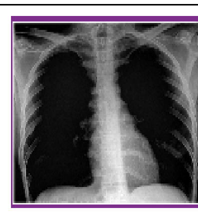
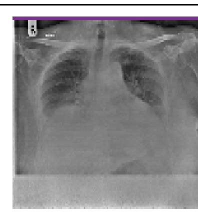
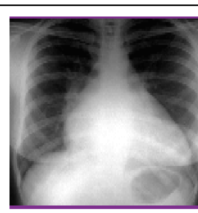
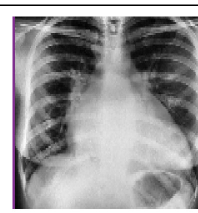
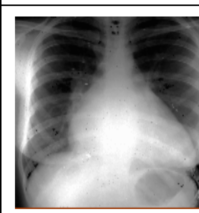
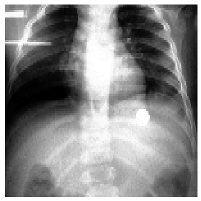
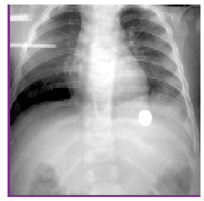
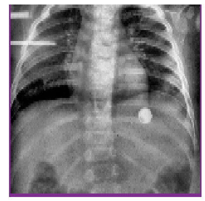
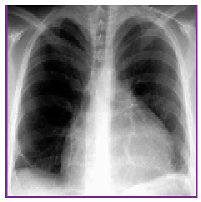
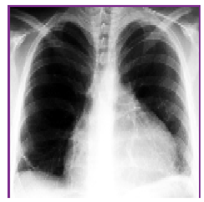
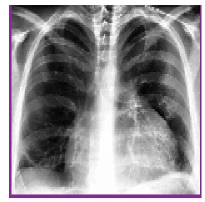


Fig. 3.Entropy Comparison with ref filter and proposed filter

TABLE III. COMPARISON OF PROPOSED SYSTEM ON MEDICAL IMAGES WITH REF, BBHE AND CA SYSTEM

Tick Label	Original Image	BBHE Result	CA Result	Ref Result	Proposed Result
(a)					
(b)					
(c)					
(d)					

(e)					
(f)					

VIII. CONCLUSION

The hybrid approach for medical IE using DWT and MLHC with wavelet shrinkage. The proposed technique PSNR is better in medical images where the issue of low illumination and low down contrast are major issues. With brief implementation, we can assert that the proposed algorithm is able to get good contrasted image which increases the brightness of the low contrasted images. This algorithm is tested on various type of images and results are encouraging. The proposed can be further extended for breast cancer images, and other applications of medical images with the other optimization algorithm.

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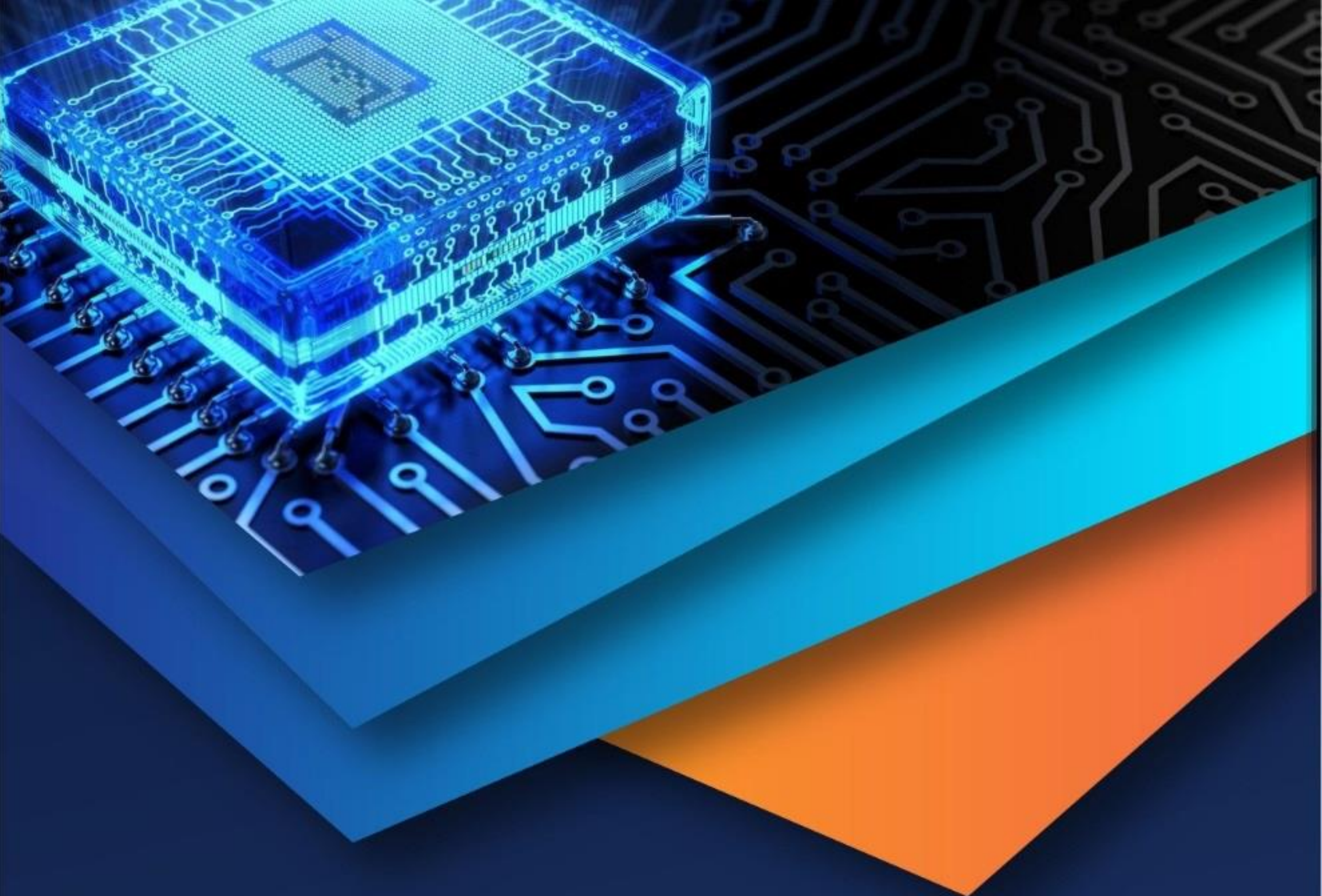

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