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Hybrid Image Compression Using DWT, DCT and Arithmetic Coding

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Abstract: Digital images are often used in several domains. Large amount of data is necessary to represent the digital images, so the transmission and storage of such images are time-consuming and infeasible. Hence the information in the images is compressed by extracting only the visible elements. Normally the image compression technique can reduce the storage and transmission costs. During image compression, the size of a graphics file is reduced in bytes without disturbing the quality of the image beyond an acceptable level. Several methods such as Discrete Cosine Transform (DCT), DWT, etc. are used for compressing the images. But, these methods contain some blocking artefacts. To overcome this difficulty and a combination of DWT, DCT and Arithmetic encoding image compression techniques are proposed. This paper proposed a scheme for image compression using of DWT, DCT and Arithmetic Encoding named as hybrid compression technique. The implementation result shows the effectiveness of the proposed scheme in compressing the medical image. Also, a comparative analysis is performed to prove that our system is competent to compress the images in terms of Peak Signal to Noise Ratio (PSNR), Mean square error and Compression Ratio (CR).
Keywords: **Image compression, DCT, DWT, Arithmetic coding, and PSNR.**

I. INTRODUCTION

Compression refers to reducing the quantity of data used to represent a file, image or video without reducing the quality of the original data. [1] Image compression is the application of data compression on digital images. The main purpose of image compression is to reduce the redundancy and irrelevancy present in the image, so that it can be stored and transferred efficiently.[2]
The compressed image is represented by less number of bits compared to original. So that, the required storage size will be reduced, and maximum images can be stored, and it can have transferred in faster way to save the time and transmission bandwidth. [3]Compression of image plays an important role in medical field for efficient storage and transmission. There are many types of medical image compression techniques are available. Different techniques used in different image like X-ray angiograms(XA), magnetic resonance image (MRI), etc.[4] Compression is achieved by the removal of one or more of three basic redundancies: (1) Coding redundancy, which is present when less than optimal (i.e. the smallest length) code words are used. (2) Interpixel redundancy, which results from correlations between the pixels of an image. (3) Psycho visual redundancy which is due to data that is ignored by the human visual system (i.e. visually no essential information).[5]
Most of existing image coding algorithm is based on the correlation between adjacent pixels and therefore the compression ratio is not high. Image compression may be lossy or lossless. Lossless compression is preferred for archival purposes and often for medical imaging, technical drawings, and clipart. This is because lossy compression methods, especially when used at low bit rates, introduce compression artefacts.[6] Lossy methods are especially suitable for natural image such as photographs in applications where minor loss of fidelity is acceptable to achieve a substantial reduction in bit rate. It is possible to compress many types of digital data in a way that reduces the size of computer file needed to store it, with no loss of the full information contained in the original file.[7]
A recent technique was implemented by Harjeetpal singh, Sakhi Sharma which is hybrid image compression using DWT, DCT and Huffman encoding techniques this technique used two-levels decomposition of DWT and 2-D DCT and Huffman encoding as entropy encoder this technique gives PSNR from 24 10 34. While the proposed technique used three-levels decomposition of DWT and 1-D DCT and Arithmetic encoder as entropy encodeand mainly used for mammogram images and gives PSNR from 25 to 35.

II. HYBRID IMAGE COMPRESSION USING DWT, DCT & ARITHMETIC ENCODINGCOMPRESSION TECHNIQUE.

In this paper we presented hybrid image compression technique for image compression is to exploit the properties of both the DWT and the DCT as illustrated in Figure1. The image is compressed first by 3-level DWT then is transformed by one-dimensional DCT and Finally encoded by Arithmetic Encodingas illustrated in Figure 1.

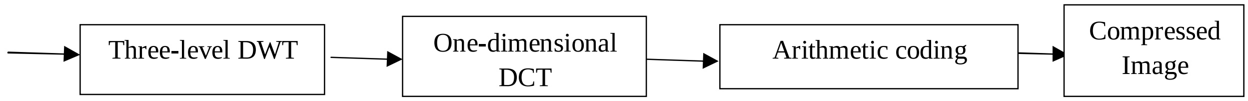

Fig. 1Block diagram of the proposed hybrid DWT-DCT, Arithmetic technique

Initially, three-level DWT is applied on the original image so that after every level of decomposition the lowpass approximation LL is passed to the next stage as it includes most energy of the image and identifies the long-term trends in the original image. While the other high pass components (HL, LH, HH) are discarded as it is capture discontinuities, in the original image so it acts as a complementary part of low-frequency components. Hence LL1the lowpass components of first level DWT decomposition is passed to the second decomposition level while (HL1, LH1 and HH1) are discarded. Then the same procedure is applied on the second decomposition level in which LL2 the low pass components of the second level decomposition is passed to the third level and the detail coefficients (HL2, LH2 and HH2) are discarded. Finally, the LL3 the low pass components of the third level DWT decomposition is passed to the 1-D DCT and the detailed components (HL3, LH3 and HH3) are discarded, this process is shown in figure2. Three-level DWT was used to increase the compression ratio as more decomposition levels mean discarding more detailed information which human visual system cannot observe. The DWT equation is as:

$$\Psi_{a,b}\ (t) = \frac{1}{\sqrt{a}}\Psi\left(\frac{t-b}{a}\right)$$

Where a is a scaling factor and b is a translation factor and Ψ is the mather wavelet function.

Then as shown in figure 2one-dimensional DCT has been applied to the reaming approximate DWT coefficients (LL3) to achieve high compression ratio due to the reduction of AC components (components which have high gray level change across the image) and it is simple to use and provides better energy compaction. Also, 2-D DCT has the following disadvantages 1- false contouring (false contouring occurs when smoothly graded parts of an image is distorted by an aberration which looks like a contour map for specific images having gradually shaded parts)2- blocking artefact, 3- not appropriate to all medical images as it has the gives low PSNR. For these reasons we use 1-D DCT was used to reduce these effects.

The 1-D DCT for an N input sequence can be defined in the next equation:

$$D_{DCT(i)=}\frac{1}{\sqrt{2N}}B(i)\sum_{x=0}^{N-1} M(x)\cos\left[\frac{2x+1}{2N}i\Pi\right]$$

Where

$$B(u) = \begin{cases} \frac{1}{\sqrt{2}} & u = 0\ for\ u = 0, \ldots\ldots\ldots\ldots\ldots.., n-1 \\ 1 & u > 0 \end{cases}$$

Lastly, Arithmetic coding which associates sequences of symbols with different subintervals of (0,1). The width of the subinterval is proportional to the probability of the corresponding sequence of symbols, so that the arithmetic code of a sequence of symbols is a floating-point number in the corresponding interval. [8] In other words Arithmetic coding assign longer codes to low-frequency coefficients and assign shorter codes to the most frequently coefficients and is used to as an entropy coding technique to give more compression by reducing coding redundancy. So that the images are compressed and then in the opposite direction the image is reconstructed by inverse procedure.

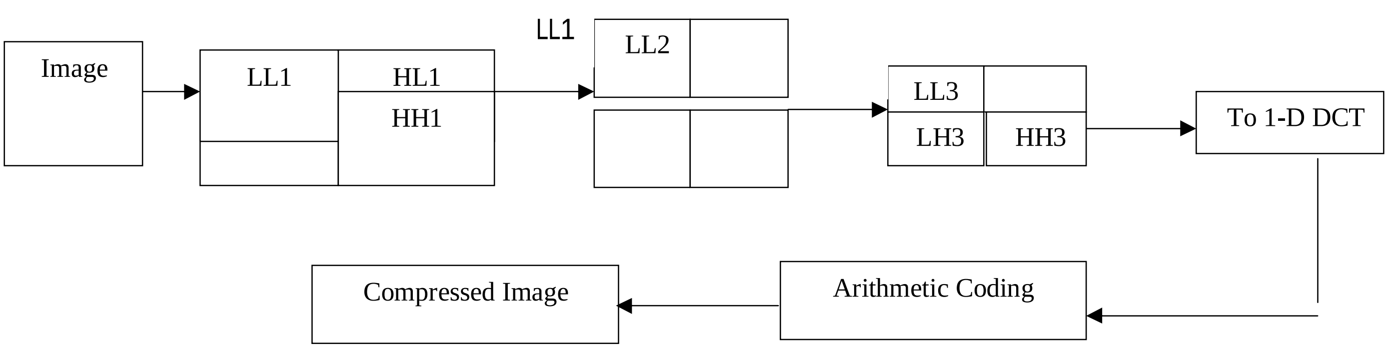

Fig. 2First and secondstep Transform image by using three level Discrete Wavelet Transform and one-dimensional DCT then encoding using Arithmetic coding

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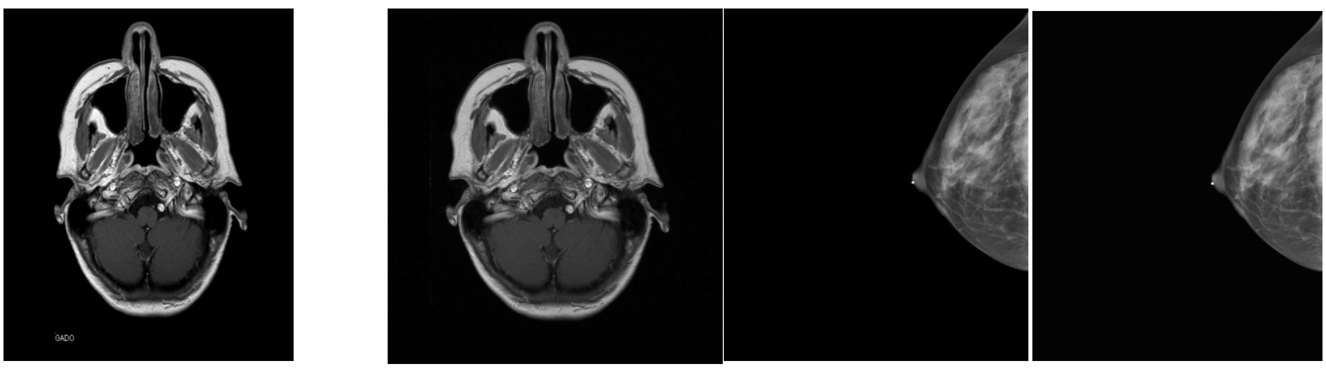
III. PERFORMANCE

Error Metrics: - Two error metrics are used to compare the various image compression techniques are: -. The Mean Square Error (MSE) and the peak Signal to Noise Ratio (PSNR). The MSE is the cumulative squared error between the compressed and the original image, whereas PSNR is a measure of the peak error. The mathematical formulae for the two are:

Where f (x,y) is the original image, f'(x,y) is the approximated version (which is actually the decompressed image) , M, N are the dimensions of the images where L is the number of gray level. A lower value for MSE means lesser error, and as seen from the inverse relation between the MSE and PSNR, this translates to a high value of PSNR. Logically, a higher value of PSNR is good because it means that the ratio of Signal to Noise is higher. Here, the 'signal' is the original image, and the 'noise' is the error in reconstruction. So, if you find a compression scheme having a lower MSE (and a high PSNR), you can recognize that it is a better one.

IV. PRACTICAL STUDY



a b c d

Fig. 3Compression using hybrid method: (a) Original Brain image, (b) Reconstructed image at CR 17.3422,(c) Original Breastimage and (d)Reconstructed image at CR71.237

a b c d

Fig. 4Compression using hybrid method: (a) Original Body image, (b) Reconstructed image at CR 18.1187, (c) Original Knee image and (d) Reconstructed image at CR 11.5614

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a b c d

Fig. 5. Compression using hybrid method: (a) Original Liver image, (b) Reconstructed image at CR 18.6869, (c) Original Shoulder image, (d) Reconstructed image at CR 14.6379

V. RESULTS

TABLE I: PROPOSED METHOD COMPRESSION PARAMETERS

Main Image	Image size (KB)	Compressed File Size (KB)	Compression Ratio	PSNR	MSE	Entropy
Brain	548	30	17.3422	28.5443	90.92	4.6891
Breast	7929	112	71.237	35.0567	20.296	2.8598
Body side view	1705	95	18.1187	25.4231	186.54	5.9943
Knee	317	45	11.5614	30.2039	62.043	7.518
Liver	459	25	18.6869	33.1445	31.523	4.5822
Shoulder	704	140	14.6379	32.6844	35.0461	5.9671
Hip	257	35	7.4268	30.9788	51.904	6.6314
Ort	514	22	23.4612	29.0306	81.287	4.1178

VI. RESULT ANALYSIS

We have applied the hybrid image compression technique on several images and the results are shown in the previous section. The results are also compared in this section in table 2 with the JPEG 2000 standard. AlthoughJPEG 2000has higher CR but, the PSNR degraded to unacceptable values. While the proposed technique meets half way between acceptable PSNR which varies from 25 to 35 and high CRAlso, in case of mammogram image the proposed technique gives goodPSNR and high CR which overrides JPEG 2000. Hence this technique operates better with mammogram images and is more appropriateto breast images which usually have large size.

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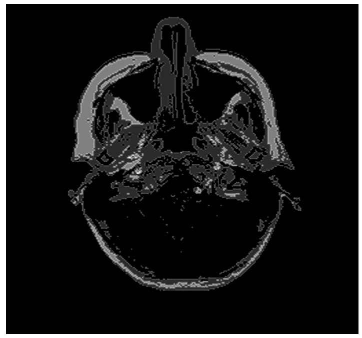
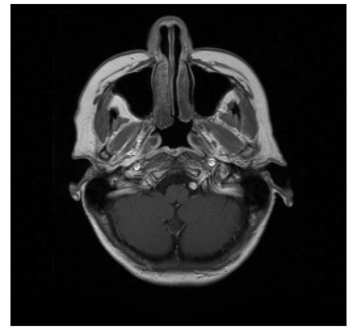
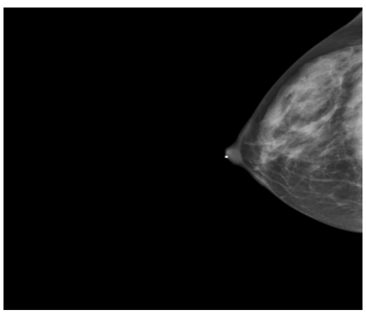
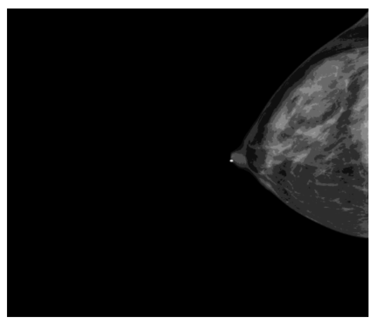
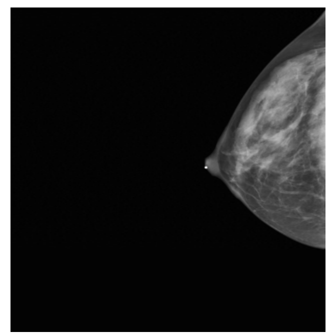
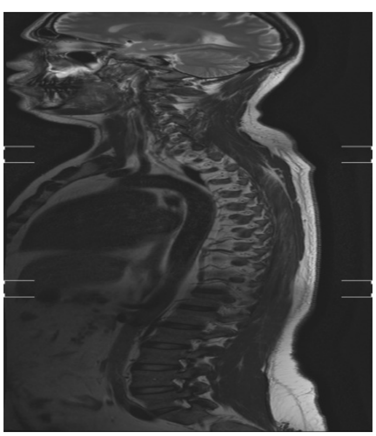
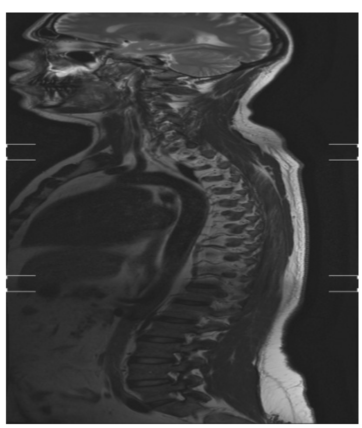
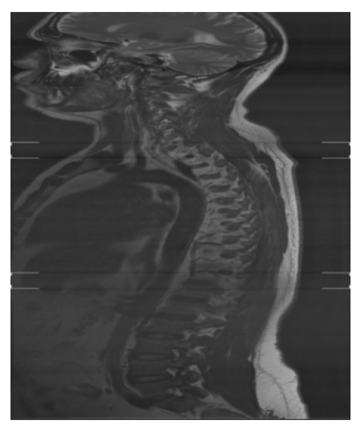
TABLE 2COMPARING PROPOSED METHOD WITH DCT IN TERMS OF PSNR AND CR.

Original Image	JPEG2000	Proposed Image
		
PNSR	20.4547	28.5443
CR	50.6265	17.3422
		
PNSR	27.9745	35.0567
CR	23.1018	71.237
		
PNSR	45.5649	25.4231
CR	10.7613	18.1187

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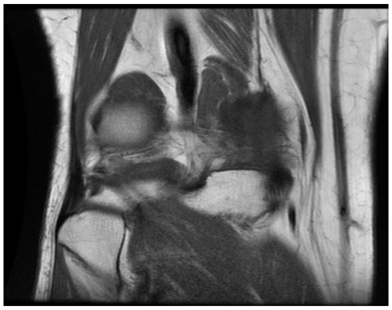
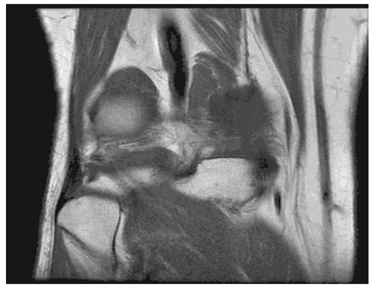
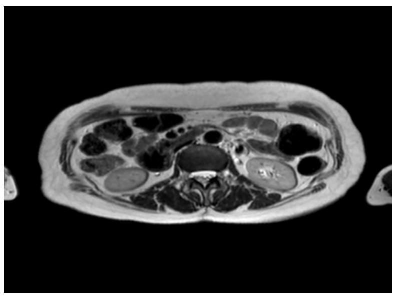
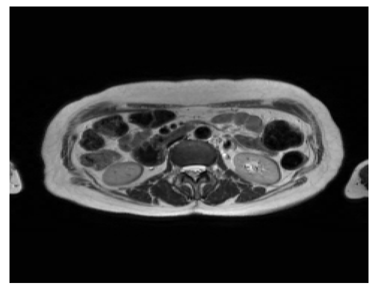
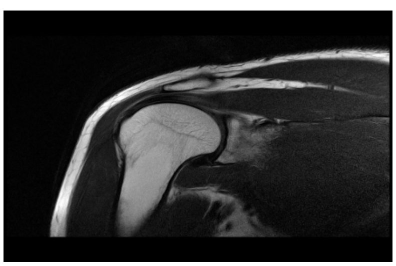
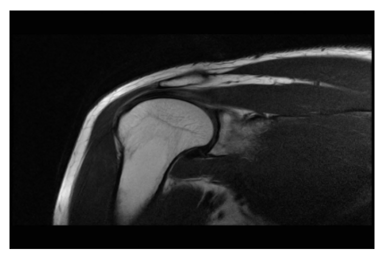
		
PSNR	22.7794	30.2039
CR	20.6657	11.5614
		
PSNR	11.1203	33.1445
CR	61.3255	18.6869
		
PSNR	14.1457	32.6844
CR	61.7609	14.6379

VII. CONCLUSIONS

In this paper we present a hybrid DWT, DCT and Arithmetictechnique for image compression. The proposed scheme helps in compressing 20DICOM imagesand gives average PSNR of 32.45which is acceptable to many areas like telemedicine and image archiving where the average compression ratio is 18.613. The performance analysis on several images shows that the hybrid compression techniquemeets half waybetween high compression ratio and acceptable PSNR. Also, the result analysis shows that the proposed image is more favorable to mammogram images which contain a lot of details that cannot been observed by the human visual system when omitted.

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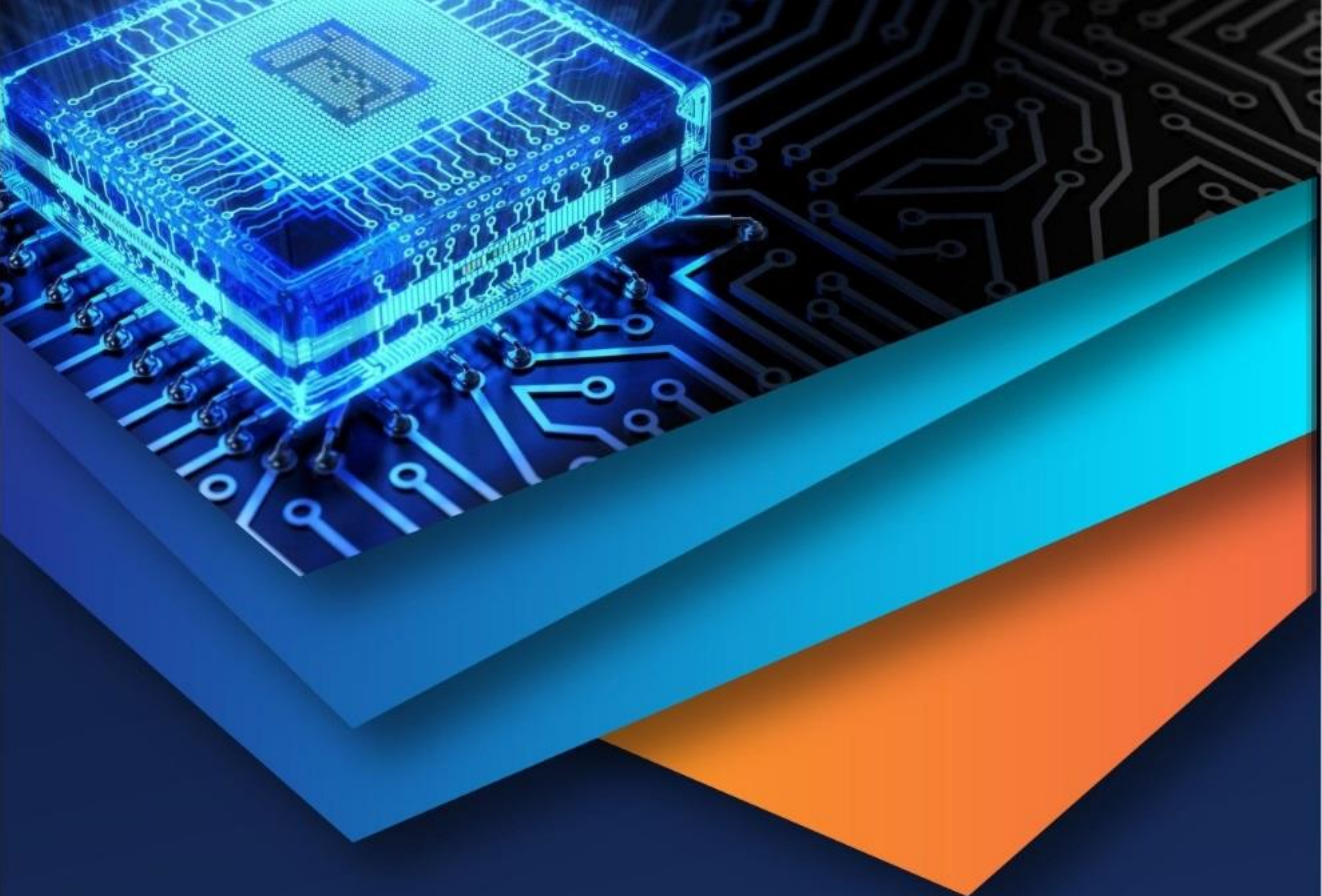

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