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Robust Wavelet based Watermarking Using Particle Swarm Optimization

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Abstract: From the 13th century we are using watermarking techniques and first time watermarking used by paper industry because the benefit of watermarking in this industry to unique identify of papers. Thus we can use this technique for authentication and copyright purpose. Watermarking is a pattern which is used to insert in a entity. When we insert any watermark then it will not change any functionality or structure of an entity. We can say digital entities like audio, video, computer programs, software, hardware like chips. Main purpose of watermark is to provide authenticity and illegal distribution of work attacks.

Keywords: Image processing Technique, imperceptible, algorithm, DCT, DWT, BPNN, Genetic Algorithm, PSO.

I. INTRODUCTION

From the 13th century we are usingwatermarking techniques and first time watermarking used by paper industry because the benefit of watermarking in this industry to unique identify of papers. Thus we can use this technique for authentication and copyright purpose. Watermarking is a pattern which is used to insert in a entity. When we insert any watermark then it will not change any functionality or structure of an entity. We can say digital entities like audio, video, computer programs, software, hardware like chips. Main purpose of watermark is to provideauthenticity and illegal distribution of work attacks. The purpose is to detect a strong method that find such type of illegal work. Digital watermarking can be defined as the way to store data we can say watermark in to digital multimedia files like images such that we can extract this information later. We can explain the process of watermark with the help of fig.1.3. Here a signal is embedded with the markwith function value ..The watermark is robust against various attacks.

A. *Objective And Scope*

1) To create imperceptibility and high PSNR in HSV color space in frequency domain.
2) To improve the robustness and remove the false positveness using DWT and SVD methods.
3) To optimize the results by using embedding and extraction process whichwill improve the quality and robustness of watermark.

In this paper three technique are used for watermarking. All these techniques belongs to transform domain'. The watermark information embedded in frequency domain coefficients of HSV color space representation of the images. This helps to preserve the chromatically information resulting in good imperceptibility and high PSNR value. The frequency domain transform uses the discrete wavelet domain(DWT) method and singular wavelet transform(SWT) method. (SVD)singular value decomposition gives high robustness against compression and noice.The main problem with SVD(singular value decomposition) is false positiveproblem and the methods which we are using here to remove the limitations of SVD based on watermarking techniques. Here we are using the embedding method and extraction method. PSNR value used as the criteria for optimization. The new robust algorithm have improved the quality and robustness of watermark. This is the main purpose in this paper. And it also improve the authentication. In paper here use new color space, new algorithm' and new transform methods.

II. DESCRIPTION OF WORK

In Spatial domain watermarking method: This is one of the good method for watermarking. And it takes less time and computational complexity. This techniqueis not robust against outside attacks.

1) *LSB:* (Least Significant bit insertion technique)- In this technique random pixelsare selected from the host image and then the watermark is embedded on the leastsignificant position.
2) *Predictive Coding Scheme:* This technique is more robust than previous technique. In this first set of pixels need to be embedded with watermark which we taken and the difference between adjacent pixels are used to replace alternate pixels inthe image.
3) *Correlation Based Technique:* In this pseudo random noise is added and during decoding a correlation between them is found. Here is the equation:

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Iwm2(m,n) = Im(m,n) + K*R(m,n) Iwm is the watermark image. R(m,n) is the pseudo random noise is added to host image Im(m,n).K is gain factor , if we increase the k value then quality of the image decrease but robustness of image increases. In this method robustness also depends upon the gain factor.

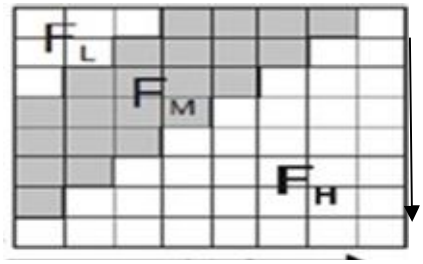
4) *Patchwork Technique:* In this method the image is divide in to two parts. Some operations are applied in these parts in opposite direction. If one part is decreased by y factor then another part is also increased by same amount . This technique is more robust against many type of attacks.

III. TRANSFORM DOMAIN WATERMARKINGTECHNIQUE

Spatial domain watermarking techniques are very easy to understand but they are less robust and we can't do any further processing in this technique. Other than transform domain watermarking technique gives more robustness. In this technique host image first change in to transform domain and then watermark is embedded.

A. Discrete Cosine Transform Method

By using this method we can divide image in tolow, medium and high frequency coefficients. Fig 1.1 shows the coefficients after applying discrete cosine transform of an image.



Low frequency

Fig. 1.3 Discrete Cosine

Transform Area

$$[\mathbf{C}]_{i,j} =$$

$$\begin{cases} \sqrt{\frac{1}{N}} \cos \frac{(2j+1)i\pi}{2N} & i = 0, j = 0, 1, \ldots, N-1 \\ \sqrt{\frac{2}{N}} \cos \frac{(2j+1)i\pi}{2N} & i = 1, 2, \ldots, N-1, j = 0, 1, \end{cases}$$

B. Discrete Wavelet Transforms Method

DWTis a transform method that decomposes a signal in to different number of sets. It divides an image in to four quadrants, first quadrant is LL1, Second is LH1, third is HL1, fourth is HH1 with different frequencies.

Fig. 1.4 Two level DWT composition of host image

C. SVD (Singular Value Decomposition Method)

It break host image in to rectangular matrix.Let A is the square matrix and it can berepresented as:

$$A=DSV^T$$

The singular values are obtained by takingsquare root of Eigen values. D and V are square matrix and they calculated as Eigen vectors .S is the diagonal matrix Who takes the singular values. If A is real then U and Vis real and S is also real.

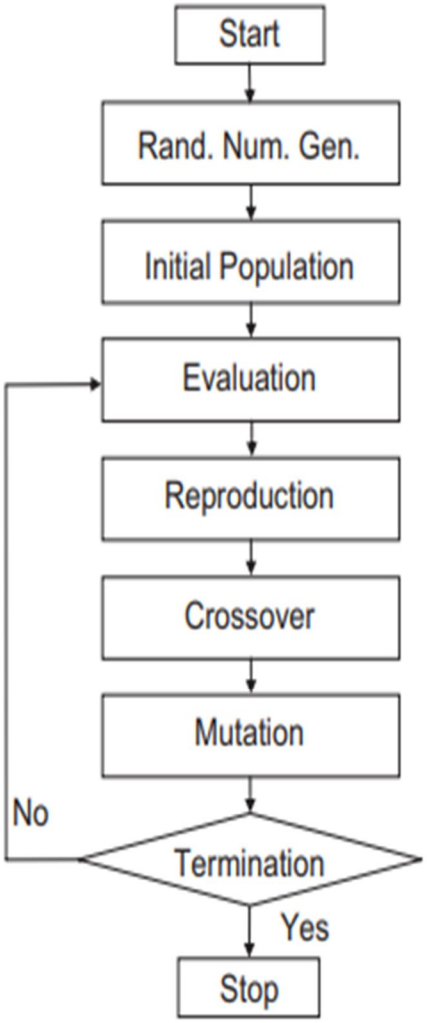


Figure 4.1 process of Genetic algorithm

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In this figure four attacks are there to calculate the robustness of watermark.

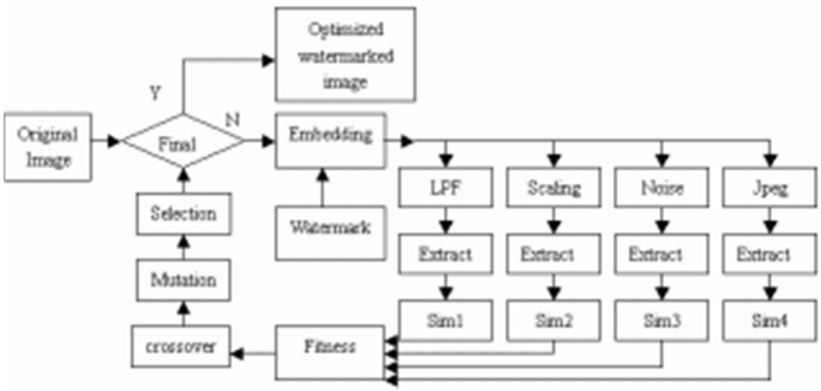

Fig. 1.6 Block Diagram ofGenetic algorithm'

D. Explanation of Embedding Process

Use discrete wavelet transform method on cover image to decompose into corresponding sub bands.

1) Use LL31 band and apply SVD on Red , Green and Blue components of Hostimage to partition in to three matrix U ,S and V

2) $A_{cm} = U \quad S \quad V^{T}$ cm

3) i = R, G & B .....(1)

4) Apply SVD on Red , Green and blue components of water mark image to obtain its corresponding matrix

$$A_{wm} = U_{wm} S_{wm} V_{wm}^{T}$$

i = R, G & B .....(2)

5) Update the values of color components LL3band of host image with Singularvalues of different components of watermarked image. Where H the scaling factor

$S_{watim} = S_{cim} + H * S_{wim}$ .....(3)

6) Obtain modified LL3' sub band usingequations:

7) $A_{watim} = U_{ci} * S_{watim} * V_{ci}$ ..... (4)

8) There arrays are concatenated to get themodified LL3' sub band.

9) Change LL31 sub band of host image with updated LL31' sub band at third level and apply inverse discrete wavelet transform toget the watermarked image.

10) Use different attacks like rotation, scaling and noise to the final image to find the robustness of applied algorithm.

E. Explanation of Extractionprocess

1) Use third level DWT (Discrete wavelet transform)on Host image to decomposeinto corresponding sub bands.

2) Use LL31 band and then SVD on Red, Greenand blue components on of cover image to partition in to three matrices.

$A_{ci} = U_{ci} S_{ci} V_{c}$ ..... (1)

i = R, G & B ..... (2)

3) Apply SVD on red, green and blue components of watermark Image to find its corresponding matrices.

$$A_{wim} = U_{wim} S_{wim} V_{wim}^{T}$$

4) Use step 1 or step 2 on watermarked image to obtain its corresponding SVD matrics on LL3 sub band.

$$A_{watim} = U_{watim} S_{watim} V_{watim}^{T}$$

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5) Obtain singular values of watermarkedimage from the LL3 subband of watermark and cover image.

$S = (S - S)/k$

6) Obtain extracted watermark :$Aewim = Uwim * Swim^{*} * Vwim^{T}$

7) Use third level DWT (Discrete wavelet transform)on Host image to decomposeinto corresponding sub bands.

8) Use LL31 band and then SVD on Red, Greenand blue components on of cover image to partition in to three matrices.

$Aci = UciSciVc$ ..... (1)

$i = R, G \& B$ ..... (2)

9) Apply SVD on red, green and blue components of watermark Image to find its corresponding matrices.

$Awim = UwimSwimVwim^{T}$

10) Use step 1 or step 2 on watermarked image to obtain its corresponding SVD matrics on LL3 sub band.

$Awatim = UwatimSwatimVwatim^{T}$

11) Obtain singular values of watermarkedimage from the LL3 subband of watermark and cover image.

$S^{*}_{wim} = (S_{watim} - S_{cim})/k$

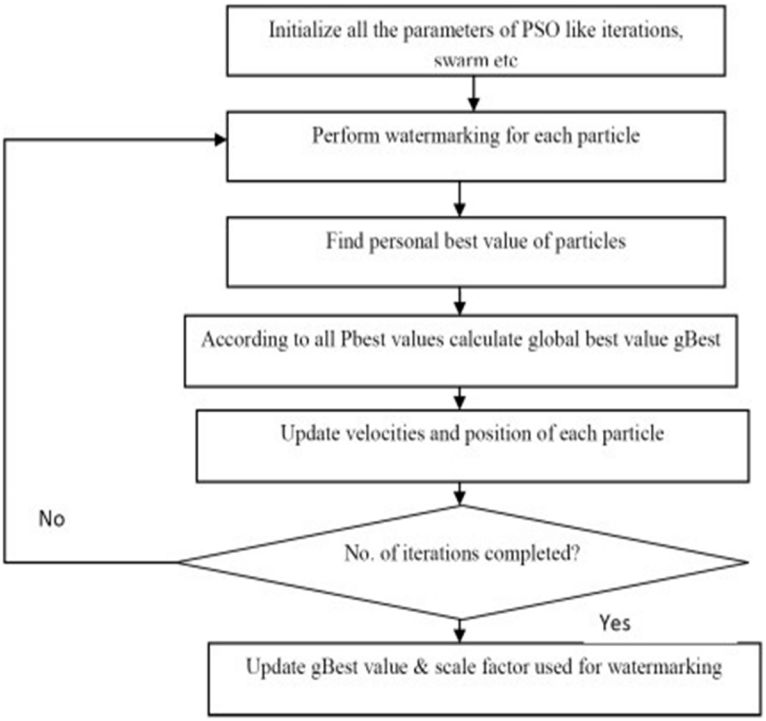
12) Obtain extracted watermark :$Aewim = Uwim * Swim^{*} * Vwim^{T}$

IV. WHAT IS PSO.

Particle Swarm Optimization (PSO) is acomputational optimization technique inspired by the social behavior of birds flocking or fish schooling. It was introduced by Eberhart and Kennedy in 1995. PSO is a population-based optimization algorithm that is commonly used to find the optimal solution for optimization problems in various domains.

The algorithm starts with a population ofpotential solutions, represented as particles, and each particle's position in the search space corresponds to a possible solution. The particles move through the search spaceby adjusting their positions based on their own experience and the experience of the best-performing particle in the population, known as the "global best."

A. How the PSO Algorithm Works



1) *Initialization:* Generate a population of particles with random positions and velocities in the search space. Each particle's position represents a potential solution, and its velocity determines how it moves through the space.
2) *Evaluation:* Evaluate the fitness or objective function value for each particle's position. This function quantifies how good the solution is for the optimization problem.
3) *Update Particle's Best Position (PBest):* Each particle records its best position (solution) found so far based on its fitness value.
4) *Update Global Best (GBest):* Determine the best-performing particle among all particles in the population (global best) based on their fitness values.
5) *Update Velocity and Position:* Update thevelocity and position of each particle using the following equations:

New Velocity(i) = (Inertia Weight * Current Velocity) + (Cognitive Coefficient *Random Number * (PBest - Current Position)) + (Social Coefficient * Random Number * (GBest - Current Position))

New Position(i) = Current Position + New Velocity

The inertia weight controls the impact of theparticle's current velocity. The cognitive coefficient and social coefficient are constants that regulate the influence of personal experience (PBest) and the experience of the best particle in the population (GBest), respectively. Random numbers are introduced to add exploration tothe algorithm.

6) *Termination:* The algorithm continues iterating through steps 2 to 5 until atermination condition is met. Common termination conditions include reaching a maximum number of iterations or achieving a satisfactory solution.

Particle Swarm Optimization is a simple andefficient optimization algorithm that can be applied to a wide range of problems, such as function optimization, engineering design, data clustering, and neural network training, among others. Its ability to explore and exploit the search space efficiently makes it popular in many optimization tasks.

A. *Optimized Watermark Embedding Algorithm using Particle Swarm Optimization*

1) Step 1 - Read a image as color image and decompose it into different channels that are R1 G1 B1.
2) Step 2 -Read watermark image and decompose it into R1 G1 B1 channels.
3) Step 3 - Convert host image into different blocks and find their entropy value. Here size of each block is (8*8).
4) Step 4 - Sort each of the block according to entropy value in descending order.
5) Step 5 – Then apply 2D DCT on image and select DCT coefficients to embed the watermarked blocks.
6) Step 6 –Then embed the calculatedwatermark blocks into chosen main image's blocks using scale factor alpha1, which is

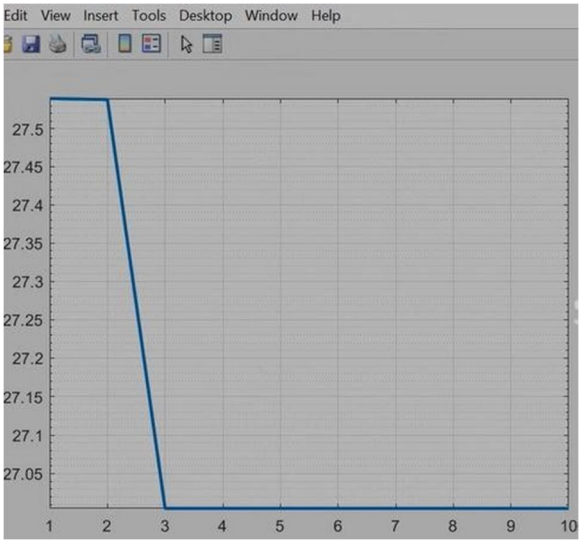
B. *Optimized Watermark Extraction Algorithm using Particle Swarm Optimization*

1) Step 1 - Read the host image and convert it into R1G1B1 channels .
2) Step 2 - Read the watermarked image and find its R1G1B1 channels used to calculate using Particle swarm optimization technique to optimize the final result so that balance between robustness and imperceptibility can be finally reached. Rather than using one scaling factors called alpha1 multiple values have been used for embedding then the best alpha1 value returned from the Particle swarm optimization algorithm has been used for embed the watermark. Embedding is performed using following equation (1)

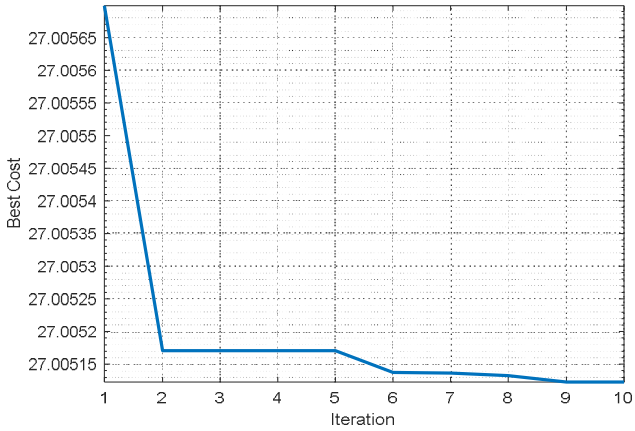
Watermarked_block1= host_block1+ alpha *watermark_block ……..(1)

3) Step 7 – Then apply inverse transform to getfinal watermark image.
4) Step 8 - Combine all channels of watermark image to get final watermarked image asoutput.
5) Step 3 -Read the alpha1 value calculated byParticle swarm optimization algorithm.
6) Step 4 – Change the host image into (8*8)block and then calculate their entropy value.
7) Step5-Then arrange all the blocksaccording to the values in descending order .
8) Step 6 – Change the signed image into (8*8) sized blocks and then apply sorting according to entropy values in descending order.
9) Step 7 – Then finally extract the watermark on the sorted block datasets in first (1028) elements using equation (2) and the alpha1 value calculated by the Particle swarm optimization algorithm. Watermarked_block_extractedi=(signed_blo ck-host_block)/alpha1… (2)
10) Step 7 – Then finally extract the watermark on the sorted block datasets in first (1028) elements using equation (2) and the alpha1

11) Step 8 - Combine all the R1G1B1 planes toget color watermarked image.



Value calculated by the Particle swarmoptimization algorithm.



Convergence Plot Of PSO

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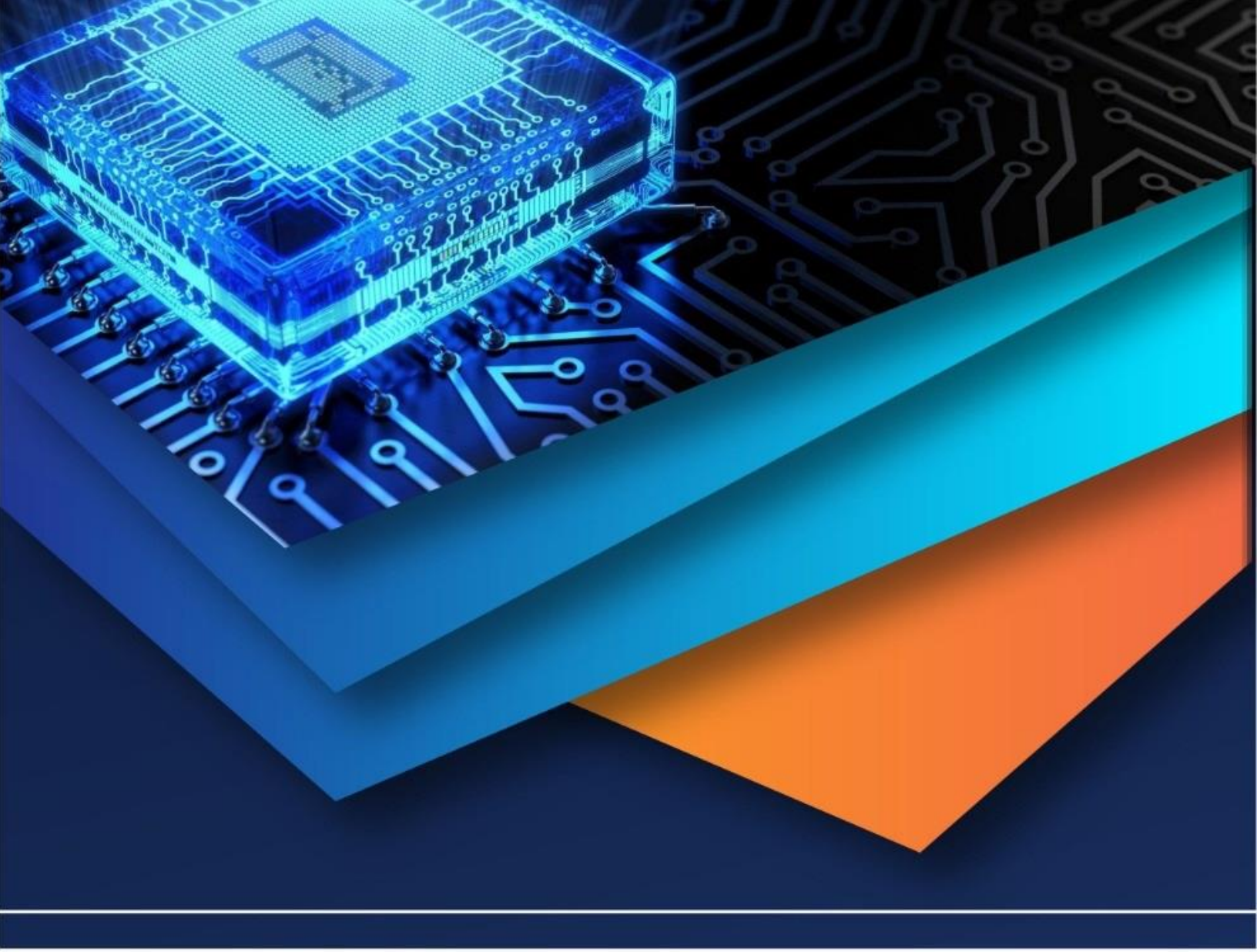

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