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# Coin Recognition and Classification: A Review

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***Abstract:*** ***Coins are a primary need of human life. They are used in everyone's daily routine, like banks, transport, market and these spare changes also has various other uses than realization traded in for cash similar to measurement purpose, in games (toss), in organizations for research point, etc. So, it holds a vast significance that coins can be detected with high accuracy. Main aim of a coin recognition system is to classify high volumes of coins with high accuracy within short time duration. In this paper we discussed a various techniques of coin recognition systems in respective terms of their accuracy. Also focused on different coin recognition approaches have been planned by different researchers based on image recognition method. Categorization is based on images from both sides as well as a radius of the coin.***
***Keywords: Image Processing, Artificial Neural Networks, Edge detection, Features extraction***

## I. INTRODUCTION

Nowadays, antique coins [1] are becoming subject to a very large illegitimate trade. Thus, the interest in reliable automatic coin recognition systems in cultural heritage as well as law enforcement institutions rises rapidly. Usual methods to fight the illicit traffic of ancient coins comprise manual, periodical search in auctions catalogues, field search by authority forces and the periodical controls at expert dealers, also a unwieldy and unrewarding internet search, followed by human investigation. Applied pattern recognition algorithms are various ranging from neural networks to eigen spaces, decision trees, edge detection as well as gradient directions, and contour with texture features. Tests performed on image collections both of medieval with indian modern coins show that algorithms performing good quality on Indian modern coins do not necessarily meet the wants for classification of medieval ones. Major difference between ancient and Indian modern coins is that the indian ancient coins [1] have no rotating symmetry and subsequently their diameter is unknown. Since ancient coins are all too often in very unfortunate conditions, common recognition algorithms can effortlessly fail. The description that most influence the quality of recognition process are yet unexplored. The COINS project addresses this investigation gap and aims to give an efficient image based algorithms for coin categorization as well as identification. There is a basic need of highly perfect and efficient automatic coin recognition systems in our everyday life. Coin recognition systems as well as the coin sorting machines have become an essential part of our life. They are used in banks, vending machines, grocery stores, supermarkets etc. In-spite of daily uses coin recognition systems can also be used for the investigate purpose by the institutes or organizations that deal with the ancient coins. There are three types of coin recognition systems based on dissimilar methods used by them accessible in the market:

*A.* Mechanical method based systems
*B.* Electromagnetic method based systems
*C.* Image processing based systems

The mechanical method based systems employ parameters similar to diameter or radius, thickness, weight as well as magnetism of the coin to distinguish between the coins. But these parameters cannot be used to make different between the dissimilar materials of the coins. It means if we provide two coins one original and other false having same diameter, thickness, weight as well as magnetism but through dissimilar materials to mechanical method based coin recognition system then it will treat both the coins as original coin so these systems can be fooled simply. The electromagnetic method based systems can distinguish between different materials because in these systems the coins are passed through an oscillating coil at a sure frequency as well as different materials bring dissimilar changes in the amplitude as well as direction of frequency. So these changes and the other parameters like diameter, thickness, weight as well as magnetism can be used to differentiate between coins. The accuracy of recognition obtained better in electromagnetic based coin recognition systems except still they can be fooled by some game coins. In the modern years coin recognition systems based on images have also approach into picture. In these systems first of all the image of the coin to be recognized is taken whichever by camera or by some scanning. Then these images are processed by using different techniques of image processing such as FFT, segmentation, DCT, edge detection etc. and further different features are extracted from the images. Based on these features unlike coins are recognized. There is extremely less work done on recognition of ancient coins. The major

reason for this is that the ancient coins do not have symmetrical boundaries like indian modern coins since ancient coins were hammered or casted during manufacturing while Indian modern coins are minted. Also earliest coins are usually found in poor conditions due to wear or fouling. So due to unequal shape as well as poor condition, the common approaches of coin recognition simply fail for ancient coins.

## II. RELATED WORK

There are different approaches proposed by various researchers for image based coin recognition. In this section a brief explanation of these approaches as well as a comparison between them is given. We can broadly categorize these approaches based on the coins on which they can be applied:

Approaches for Indian modern coins

Approaches for Indian ancient coins

Approaches for both Indian ancient and indian modern coins

### *A. Approaches for Indian Modern Coins*

In Minoru Fukumi et al.[2] offered a rotational invariant neural pattern recognition system for coin recognition. And for that they had used 500 yen coin as well as 500 won coin to perform the experiment. In this effort they had created a multilayered neural network along with a preprocessor consists of various slabs of neurons. The results demonstrate that 25 slabs by 72 neurons in every slab give the most excellent recognition.

Minoru Fukumi et al.[3] tried to achieve 100% accuracy for coins and to perform this experiment, they used 500 yen coin as well as 500 won coin. In this work they used BP (Back Propagation) and GA (Genetic Algorithm) to design neural network for coin recognition. BP used to train the network. Paul Davidsson [4] in 1996 offered an approach for coin classification using learning characteristic decision trees by controlling the degree of generalization. Decision trees constructed by ID3-like algorithms were incapable to detect instances of categories not present in the set of training examples. Experiments performed on Canadian and Hong-Kong coins and the accuracy of 99.7% for Canadian and 98.3% for Hong-Kong coins was achieved. Michael Nolle et al. [5] in 2003 at the ARC Seibersdorf research centre in 2003 developed a coin recognition as well as sorting system called Dagobert. This system was calculated for fast classification of huge number of modern coins from 30 different countries. They performed experiments on 12,949 coins were performed and 99.24% recognition rate was achieved. A coin recognition system to know US coins using vector quantization and histogram modeling was presented by Seth McNeill et al. [6] in 2004. Based on different image texture, they performed the experiments which show that out of 200 coin images 188 were correctly classified. Thus, 94% recognition accuracy rate was achieved. In 2005 a multistage approach for coin classification using Eigenspace as well as Bayesian fusion was offered by Reinhold Huber et al. [7]. The coin class probabilities for both coin sides are combined through Bayesian fusion including a rejection mechanism. Their experiments show that 93.23% of 11,949 coins from 30 different countries were correctly classified. In 2005,authors R. Bremananth et al.[8] presented an approach using neural network for coin recognition, To achieve rotation invariance Gabor filters and Back Propagation neural network are used. The experiments are performed on 1-rupee, 2-rupee as well as 5-rupee coin. The experiments show 92.43% recognition accuracy rate. L.J.P. van der Maaten et al. [9] in 2006 developed a fast system for reliable coin categorization called COIN-O-MATIC. In this scheme, the coin classification is done based on edge-based statistical features. Adnan Khashman et al. [10, 11] presented an Intelligent Coin Identification System (ICIS) in 2006. ICIS uses neural network as well as pattern averaging for recognizing rotated coins at various degrees. ICIS shows very encouraging results. It shows 96.3% correct identification i.e. 77 out of 80 variably rotated coin images were correctly identified. In 2006 [12] P.Thumwarin et al. presented a robust method for coin recognition among rotation invariance. In this paper the variations on surface of coin such as light reflection effect are also considered. At last coins are recognized with calculating distance between the absolute value of Fourier coefficients obtained from the reference coin as well as the coin to be recognized. A fast and reliable coin recognition system based on registration approach was presented by Marco Reisert et al. [13] in 2007; the system presented was also reliable to illumination and contrast changes. The experiments were performed on CIS benchmark dataset. Linlin Shen et al. presented in 2009 [14] an image based approach used for coin recognition. In this paper Gabor wavelets are used to extract features. For experiments public MUSCLE database consisting of over 10,000 images is used. The algorithms used in this paper show the recognition accuracy rate of 74.27%. Vaibhav Gupta et al. presented in 2011[15] an approach based on image subtraction method for recognition of Indian modern coins. In this approach scheme performs 3 checks (radius, coarse as well as fine) on the input coin image.

*B. Approaches for Indian Ancient Coins*

Very less work has been done on recognition of Indian ancient coins. The main reason for this is that the Indian ancient coins do not have symmetrical boundaries like indian ancient coins because ancient coins were hammered or else casted through the manufacturing but indian ancient coins are minted. Also Indian ancient coins are generally found in poor conditions due to wear or fouling. So due to irregular shape and poor condition, the general approaches of coin recognition easily fail for recognition of Indian ancient coins. A brief description about an approach for recognition of Indian ancient coins is given in the following paragraph: Kaiping Wei et al. [16] in 2007 presented a novel approach for classification of ancient coins based on image textual information. For extracting textual information Tree-Structured Wavelet Transform (TWT) as well as Ant Colony Optimization (ACO) algorithm is used. The multi-resolution character of the texture is extracted by TWT, and information can be accessed in various scale rather than low frequency. In calculation, segmentation algorithm based on ACO is implemented by TWT to obtain textural information with the absence of noise. The results illustrate that this hybrid move towards provides extremely accurate recognition results for Indian ancient coins.

*C. Approaches for both Indian Modern Coins and Indian Ancient Coins*

In 2006 [17] Laurens J.P. van der Maaten et al. presented algorithms used for automatic coin classification. The algorithms obtain digital images of coins as input as well as generate a class as output i.e. to which class the coin belongs. To perform this experiment, author used two datasets in this paper. The main dataset is the MUSCLE CIS dataset, which is used for evaluating the efficiency of the characteristic types. The second dataset is the Merovingen coin dataset which is working to evaluate to what extent our feature types are suitable for ancient coin classification. The results exposed that a combination of Contour as well as Texture features acquiesce the best presentation. Abdolah Chalechale [18] offered a novel approach for coin image recognition using image abstraction as well as spiral decomposition in 2007. The approach SDAI (Spiral Decomposition of Abstract Image) enables measuring the comparison between full color multi- component coin images as well as need no cost intensive image segmentation. The planned approach is compared with three other approaches i.e. QVE, PFD (Polar Fourier Descriptor) with EHD (Edge Histogram Distribution). The results demonstrate that the future approach is much better than last three approaches since it shows major improvement in recall ratio using proposed description. The compared the results from both Edge based segmentation plus GHT as well as clearly the previous performed better than the latter.

| Sr. No. | Year | Author Name | Technique Used | Coins Used | Accuracy Achieved |
|---|---|---|---|---|---|
| 1 | 2005 | R. Bremananth et al. | Gabor filter, Statistical color threshold | Rs.1, Rs.2, Rs.5 Indian coin | 92.43% |
| 2 | 2006 | Adnan Khashman et al. | Neural Network, Pattern Averaging | 2 Euro and 1 Lira coin | 96.3% |
| 3 | 2010 | Hussein Al Zoubi et al. | Statistical Approach | Jordanian coins | 97% |
| 5 | 2011 | Shatrughan Modiet al. | Artificial Neural Network | Rs.1, Rs.2, Rs.5, Rs.10 Indian coins | 97.74% |
| 6 | 2013 | Saranya das. Y. M et al. | Harris-Hessian Algorithm | Indian coins | App.100% |
| 7 | 2013 | Deepika Mehta et al. | Otsu's Algorithm, Hough Transform | Indian Coins | 40 to 50% |

Table.1 Chronological Development of Techniques for Indian modern coins and / or Indian Ancient Coins

## III. COIN RECOGNITION APPROACHES

In this section we nearby new approaches for coin recognition techniques, namely algorithms based on the eigenspace approach,

gradient features, contour as well as texture features. Finally, we examine some preliminary results of tests performed on the MUSCLE CIS coin dataset.

*A. Eigenspace Approach*

Huber et al. present in a multistage classifier based on eigenspaces that is able to discriminate between hundreds of coin classes. The first step is the preprocessing performed to obtain translationally and rotationally invariant description. Due to the controlled setup of the system presented coin detection becomes a trivial task. Rotational invariance is obtained by estimation of the rotational angle. This involves cross-correlation of the coin presented to the system with reference images. Each reference image is associated with a coin class depending on thickness (estimated from additional thickness sensor measurement) and diameter. In the second stage an appropriate eigenspace is selected. Again, based on the diameter and thickness measurements multiple eigenspaces are constructed. Thus, each eigenspace spans only a portion of the thickness/diameter plane and a moderate number of coin classes. In the last stage Bayesian fusion is applied to reach the final decision. Bayesian fusion incorporates probabilities for both obverse and reverse sides of the coin and knowledge about its orientation coherence.

*B. Contour based Algorithms*

In Maaten et al. present a coin classification system based on edge-based statistical features, called COIN-O-MATIC. It was developed for the MUSCLE CIS Coin Competition 2006 focusing on reliability and speed. The system is subdivided into five stages: in the segmentation step (1) the coin is separated from the coin photograph. Next a feature extraction process measures edge-based statistical distributions (2). In order to give a good description of the distribution of edge pixels over a coin, they combine angular and distance information: edge distance measures the distance of edge pixels from the center of the coin and angular distance measures distribution of edge pixels in a coarsely discretized polar space. In the third step (3) – preselection – area and thickness measurement are used in order to obtain a reliable decision on the class of a coin. A 3-nearest neighbor approach on the two sides of the coin is applied (4). The last step (5) – verification – is only performed for coins for which the two coin sides were classified differently. It is based on mutual information of a test sample and an average coin image that corresponds to the classification[23-25] assigned to the test sample. At the MUSCLE CIS Coin Competition the method achieved a recognition rate of 67.31% on a benchmark set of 10,000 coins. The Dagobert coin recognition system presented by N¨olle et al.[5] aims at the fast classification of a large number of indian coins from more than 30 different currencies. In their system coin classification is accomplished by correlating the edge image of the coin with a preselected subset of master coins and finding the master coin with lowest distance. For the preselection of possible master coins three rotation-invariant visual features, besides sensor information of coin diameter and thickness, are used: edge-angle and edge-distance distributions similar to and a third feature counting the occurrences of different rotation-invariant patterns on circles centered at edge pixels.

*C. Gradient based Algorithm*

The coin classification method proposed by Reisert et al.[13] presented at the MUSCLE CIS Coin competition 2006 is based on gradient information. Similar to the work of N¨olle et. al coins are classified by registering and comparing the coin with a preselected subset of all reference coins. In the preselection step the radius of the segmented coin is determined and only coins with a similar radius are taken for comparison. The registration and similarity computation of coin images is done by means of a Fast Fourier Transformation on binary images of discretized gradient directions. The final classification of a coin image is accomplished by a nearest neighbor scheme. The proposed method won the MUSCLE CIS.

*D. Neural Network*

Neural networks give effective results for solving multiple class classification problems. T. Chau [19] notes that neural network facilitate gate recognition because of their highly flexible and non-linear modeling ability. Neural network has three types of layers: input layer, output layers and hidden layers. Hidden layer does intermediate computation before directing the input to output layer. Back propagation can also be considered as a generalization of delta rule. When back propagation network is cycled, an input pattern is propagated forward to the output units through the intervening input to hidden and hidden to output weights. Neural network have been widely used in image and signal processing.

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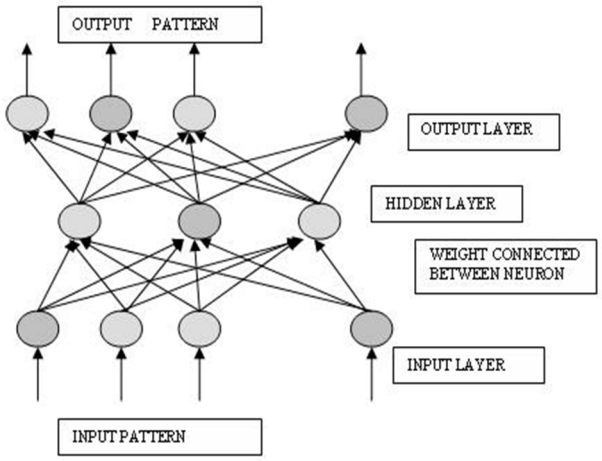


Figure 1. Neural Network system

*E. Edge Detection*

Hough transform is based on feature points extracted from the original image and usually, edges are used as the feature points. Various edge detection methods have been used for different applications. If Sobel filter[20] is used to a coin image, large number of edge points are obtained from texture of the coin can be regarded as noise, which will induce a huge overhead in the execution time of the Hough transform and most importantly will produce measurement errors, so technique to reduce the unwanted edge is sought. Result of applying Sobel filter to an image is shown in Fig. 2. The canny edge detector is very powerful tool for detecting edges in a noisy environment. Canny edge detector[21] can remove most of the edge points. Canny gives thin edge compared to the Sobel.

Figure 2. Sample Image(coins.jpg)

Hence, canny edge detector has used for eliminating the unwanted edges that can result from Sobel. Based on the smoothed image, derivatives in both the x and y direction are computed, these in turn are used to compute the gradient magnitude of the image. Once the gradient magnitude of the image has been computed, a process called non maximum suppression‟ is performed; in which pixels are suppressed if they do not constitute a local maximum.

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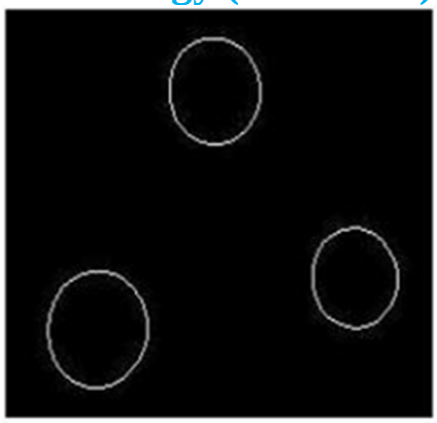

Figure 3. Result of Canny Edge Detector

The final step in the canny edge detector is to use hysteresis operator, in which pixels are marked as either edges, non-edges and in-between, this is based on threshold values. The next step is to consider each of the pixels that are in-between, if they are connected to edge pixels these are marked as edge pixels as well. The result of this edge detector is a binary image in which the white pixels closely approximate the true edges of the original image as shown in Figure 3.

In this system, CHT (Circular Hough transform) is used to detect the presence of circular shapes like coins from the input image because it has the robustness to deal with the noises in the image. CHT is a kind of HT (Hough transform) that can extract circular objects from an image. The Hough Transform was first introduced by Paul Hough in 1962[22] to detect straight lines in bubble chamber data, the transform consists of parametric description of a feature at any given location in the original images space. The HT essentially consists of two stages. In the first stage, edge map of the image is calculated then each edge point contributes a circle to an output accumulator space. In the second stage, the output accumulator space has a peak where these contributed circles overlap at the center of the original circle and then define the coordinates of the circle. The CHT has been used in several researches in detecting iris and pupil boundaries for face recognition, fingertips position detection and automatic ball recognition. The main advantage of using HT is high reliability and it gives ideal result even in the presence of noises. Also the HT provides parameters to reduce the search time for finding objects based on a set of edge points. In spite of its advantages, the HT has some disadvantages when it deals with large size image.

## IV. CONCLUSION

This paper we reviewed and studied the various systems of coins classification and different techniques. The existing techniques for coin recognition based on image processing. In this paper we basically provide various methods of recognition of the coins and studied the best accuracy occurred in the various techniques.

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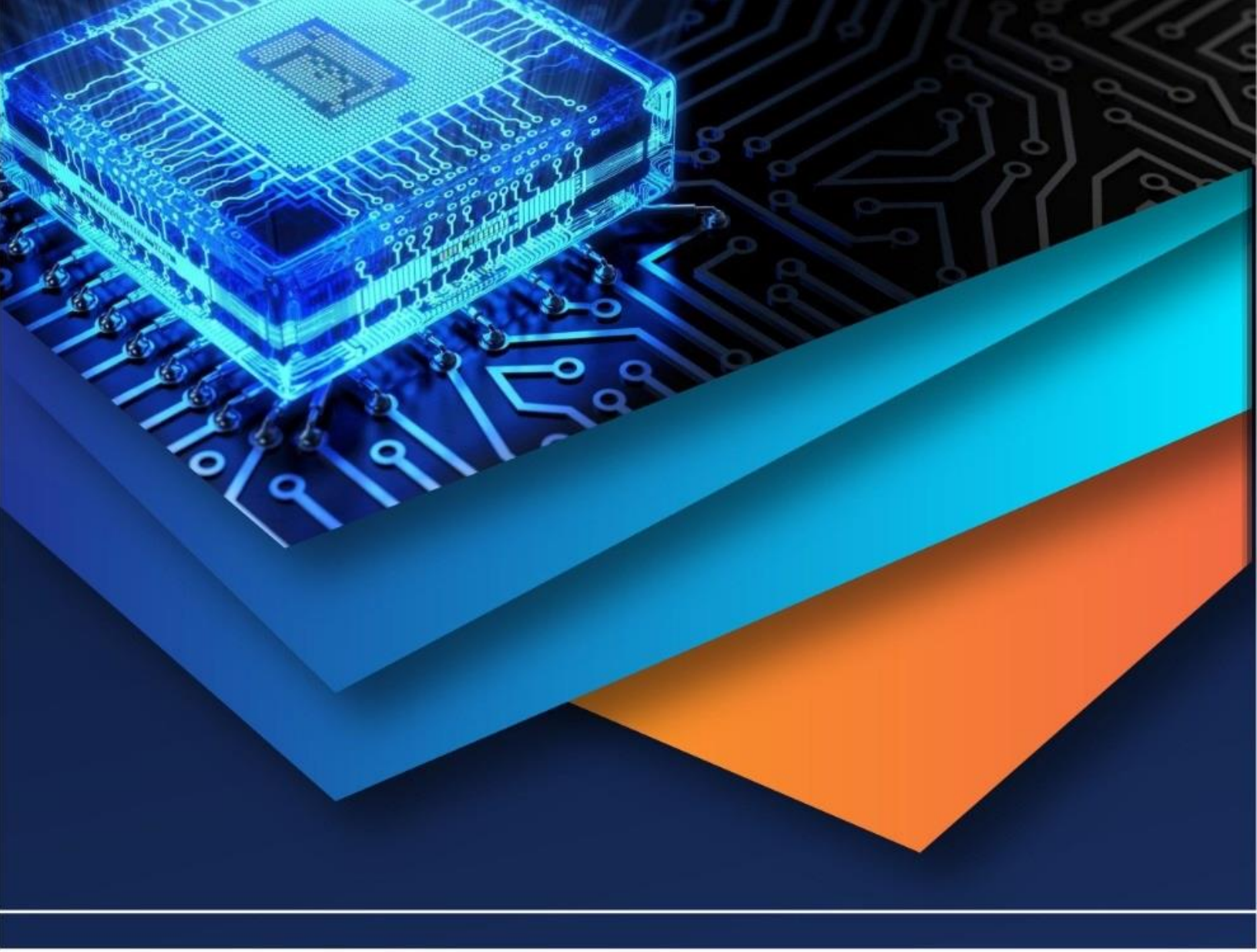

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