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A Review Paper on Facial Recognition for Automated Attendance System

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Abstract: ***Taking attendance in the traditional manner, i.e. calling out the names of each student present in the class, and maintaining these records can be very tiresome and time consuming. There are also high chances of false attendance being marked, or a student unable to mark themselves present despite being present in the class. Numerous biometric techniques have been proposed for finding an easier method to mark attendance, to improve the system and enable it to automatically store the attendance database. In this work, the authors have focused on facial recognition. The facial recognition system takes the faces of the people as objects and uses them to identify with the images present in the database to mark whether or not they were present. The emphasis of this work was to analyze, summarise and discuss the accuracies and limitations of the various techniques proposed by different authors. This work also highlights the previous research and future scope of face recognition systems.***

Keywords: Facial Recognition, Facial Recognition techniques, Face Detection, Face Detection techniques, Biometrics, Attendance management system

I. INTRODUCTION

Facial recognition is a biometric technique that compares photographs or videos of people's faces to databases of faces. It is commonly used in many formats to verify or classify an individual's identity. Facial recognition identifies the fiducial or nodal points of a person's facial features and compares them to a database image. Facial recognition can be used in a variety of situations. One of the many applications of facial recognition is an automatic attendance system.

In facial recognition, people are supposed to use a camera to click pictures of their faces. The faces will be detected from these pictures, and the background and noise will be removed. The facial features are extracted from these detected faces which will then be processed by different algorithms and compared to images present in the database. After all these processes are completed and the students' faces have been matched, their attendance will be registered. Fig. 1 shows the process of face recognition for automated attendance systems.

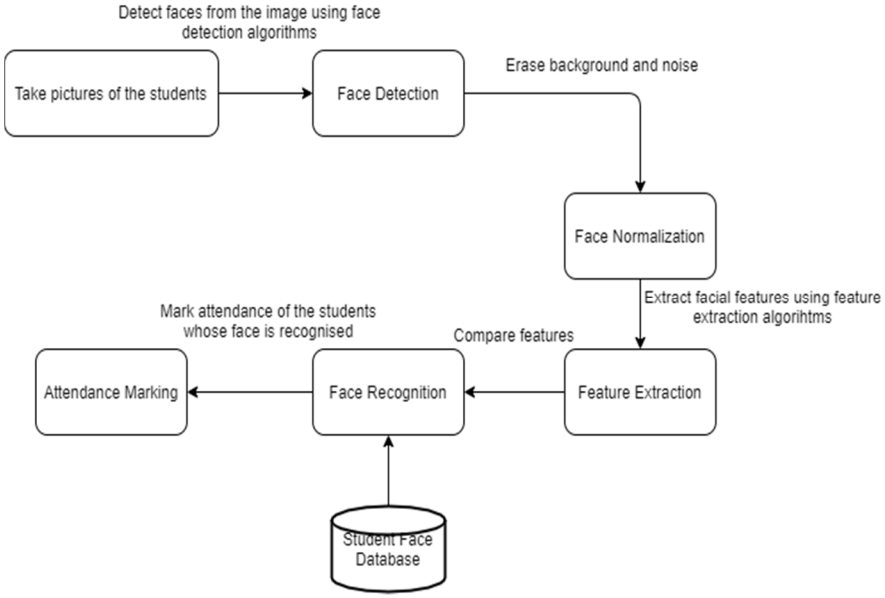

Fig. 1 Face Recognition Process for Automated Attendance System

Such an application of facial recognition for the attendance system is highly used nowadays, as it is a comfortable approach for both the students and the teachers. It takes off the load of physically taking and maintaining records of so many people in an institution. It also enables the students to keep a constant check of their attendance system.

A. *Problem Statement*

The long established method to take student's attendance is to call out their names one by one and mark their attendance manually, which can be very tiresome and a tedious job.

The chances of false attendance is very high in this method. Moreover, it is very difficult to make sure that each student is present in a classroom when students in big numbers are present.

The current biometric methods being used for attendance system are:

1) Finger scan
2) Iris scan
3) Face recognition

In this work, we focus on face recognition as it is a contactless method unlike iris and finger scanning, and stores the information automatically in a database. This reduces the manual work, is faster to operate, and makes it easier for the teachers and the students to access the records.

B. *Objective*

Facial recognition is a widely used method for attendance systems. Face recognition detects the faces of the students, matches it with the one present in the database and marks their attendance based on whether or not it was able to find a match.

Using artificial intelligence and machine learning, algorithms are designed to make facial recognition systems efficient and give more accurate results.

The primary objective of our work is to offer an efficient and effective biometric based automated attendance system, and to reduce the workload for the teachers and give them more time to conduct their lectures.

The paper is organized as follows: Research Method Overview for face detection and face recognition is explained in Section 2. The algorithms used in these works are compared in Section 3. Section 4 lists out the information sources and search criteria followed by the authors. All the papers reviewed in this work are discussed in Section 5. Section 6 provides the conclusion and the future scope.

II. RESEARCH METHOD OVERVIEW

This section is classified into two parts. First part contains a brief description of the algorithms used for face detection and the second part contains the description of the face recognition algorithms.

A. *Face Detection*

Face detection is the method used to detect the faces and distinguish the faces from the background. Various algorithms are used for face detection which are discussed below.

1) *Haar cascade (Viola Jones):* Haar-like highlights calculations are used on the image after converting it from RGB to Grayscale. Every face has some common features like the area around the eyes is darker. These calculations are used for finding the area of the face. Various features like height/width of a face, colors of the face, width of nose, lips are used to train the model to recognize the face from the database. [3]

2) *Histogram of Oriented Gradients (HOG):* It is a feature descriptor which extracts useful information in order to simplify the image. First, the image is pre-processed after which gradient is calculated followed by calculation of histogram of gradients. Histograms are normalized into vectors and finally the vectors are concatenated into a single vector. [5]

3) *Multi Task Cascaded Convolutional Neural Network (MTCNN):* MTCNN is a method used for face detection. It has a cascade structure with three networks. These networks are Proposal Net (P-Net), Refine Network (R-Net) and Output Network (O-Net). The image that is captured with the camera is rescaled and sent to P-Net, which finds the bounding boxes of the facial features, saves the coordinates and forwards it to R-Net. R-Net screens the bounding boxes, and forwards it to O-Net. The images are cropped with the help of the parameters returned by the MTCNN model, removing all the redundant background, leaving only the faces present in the image.[14]

B. Face Recognition

An overview of face recognition is provided in the introduction section. This section contains various algorithms used for face recognition.

1) *Local Binary Pattern (LBP):* Local Binary Pattern is an operator used for describing local texture features. LBP labels a pixel by thresholding each pixel's neighbourhood. Face images can be represented using LBP combined with histograms.[1], [16]
2) *CNN:* It is a feedforward neural network, where the images are passed through a series of convolution layers. These layers contain filters for extracting features from the image. Dimensionality of each map is reduced in spatial pooling without affecting the important information. The feature map matrix is then converted into a vector to create a model. Finally, to classify the output as a person, an activation function is applied.[6]
3) *Principal Component Analysis (PCA):* Principal Component Analysis reduces the dimensions of the face to make it easier for recognition. It narrows out the important features, and disposes the face structure components into uncorrelated elements of the face, known as eigen faces.[7], [8]
4) *Linear Discriminant Analysis (LDA):* LDA reduces the dimensions while preserving as much class discriminatory information as possible. It works on the same principle as PCA. LDA extracts discriminating features known as fisher faces.[7]

III. COMPARISON OF ALGORITHMS

The under mentioned papers proposed various algorithms for face detection and face recognition which are mentioned in Table I. These algorithms are compared based on the accuracy achieved in the research works shown in Fig. 2.

The advantages and limitations of the various methods used for face detection are given in Table II, and in Table III the advantages and limitations of face recognition are mentioned.

Table I
Algorithms in Each Paper

Reference	Face Detection Algorithms			Face Recognition Algorithms			
	Haar Cascade	HOG	MTCNN	LBPH	CNN	PCA	LDA
R. F. Olanrewaju, O. A. R. Salim & W. A. Balogun (2018)	✔	✖	✖	✔	✖	✖	✖
Serign Modou Bah & Fang Ming (2020)	✔	✖	✖	✔	✖	✖	✖
N. Gupta, P. Sharma, V. Deep & V. K. Shukla (2020)	✔	✖	✖	✔	✖	✖	✖
N. Prabhu, S. Hapani, N. Parakhiya & M.Paghdal (2018)	✔	✖	✖	✖	✖	✖	✖
H. Rathod, S. Sane, S. Raulo, Y. Ware, I. A. Rizvi &V. Pakhare (2017)	✔	✔	✖	✖	✖	✖	✖
P. Patil & S. Shinde (2020)	✔	✔	✖	✖	✔	✖	✖
S. A. Sovitkar & S. S. Kawathekar (2020)	✖	✖	✖	✖	✖	✔	✔

E. Rekha & P. Ramaprasad (2015)	✖	✖	✖	✖	✖	✔	✖
R. Thakare, P. Wagh, J. Chaudhari & S. Patil (2017)	✖	✖	✖	✖	✖	✔	✖
S. Kakarla, P. Gangula, M. S. Rahul, C. S. C. Singh & T. H. Sarma (2020)	✖	✖	✖	✖	✔	✖	✖
E. Winarno, H. Februariyanti, I. Husni Al Amin, P. W. Adi, W. Hadikurniaati & M. T. Anwar (2019)	✖	✖	✖	✖	✔	✔	✖
J. W. S. D'Souza, A. Chandrasekar & S. Jothi (2019)	✔	✖	✖	✔	✖	✖	✖
R. Hussain, M. Sajid & M.Usman (2014)	✖	✖	✖	✖	✖	✖	✖
A. Rasool, S. Roohi & A. Majumder (2020)	✖	✖	✔	✖	✖	✖	✖
T. Mantoro, M. A. Ayu & Suhendi (2018)	✔	✖	✖	✖	✖	✔	✖
H. Zhang, L. Yuan, Z, Qu & G. Li (2017)	✖	✖	✖	✔	✔	✖	✖
I. Q. Mundial,W. S. Qureshi, M. S. Ul Hassan, M. I. Tiwana & E. Alanazi (2020)	✖	✖	✖	✖	✔	✖	✖

Table II
Advantages and Limitations Of Face Detection Algorithms

Methods	Advantages	Limitations
Haar Cascade (Viola Jones)	Scales features instead of expanding image.	Light sensitive.
Histogram of Oriented Gradients(HOG)	Consistent regardless of photometric changes.	Sensitive to image rotation.
Multi Task Cascaded Convolutional Neural Network (MTCNN)	Supports real time face detection.	Slow detection and complex methodology.

Table III
Advantages and Limitations Of Face Recognition Algorithms

Methods	Advantages	Limitations
Local Binary Patterns (LBPs)	Fast Computation, simple and effective.	LBPs are light sensitive.
Convolutional Neural Network (CNN)	Multidimensional input can directly be sent to the network as an input, bypassing complex feature extraction and data reconstruction of the traditional recognition algorithms.	More training time is required due to large numbers of neurons.
Principal Component Analysis (PCA)	Simple and effective.	Recognition rate is affected by different poses and illumination.
Linear Discriminant Analysis (LDA)	Maximise the distance between the class scatter matrix and minimize the distance in the class scatter matrix to solve illumination issues.	Difficult to process high dimensional image.

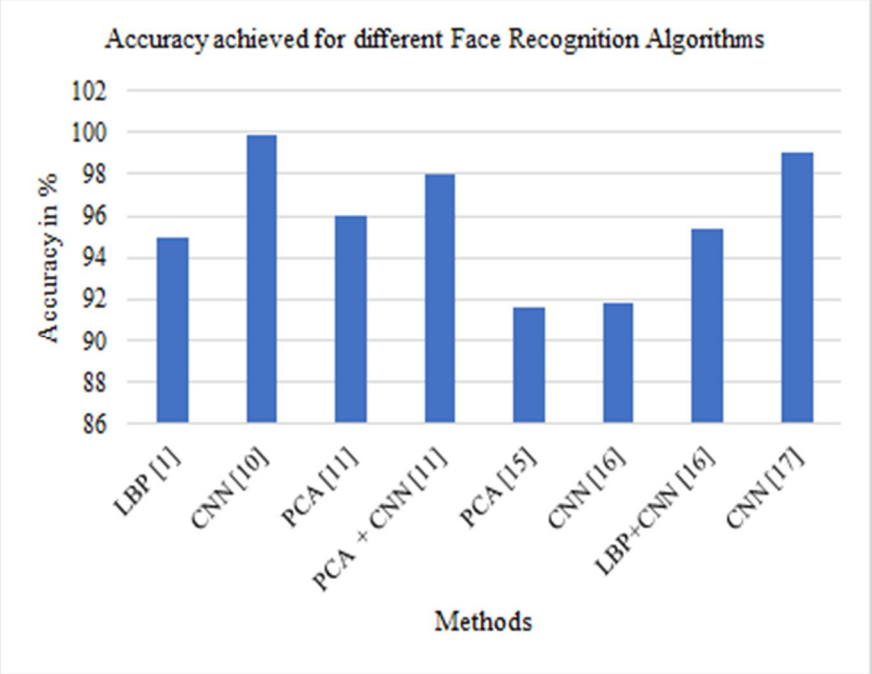

Fig. 2 Graph of the accuracy achieved for different face recognition algorithms

The above graph in Fig. 2 illustrates the accuracies achieved using various algorithms, and combinations of these algorithms. It can be observed from the graph that CNN algorithm has achieved more accuracy as compared to other algorithms. The graph also shows that the accuracies achieved by algorithms can be increased by combining it with another algorithm. Higher accuracy for PCA when combined with CNN was achieved by the authors of paper [11]. Similarly, in paper [16], authors achieved higher accuracy for CNN when combined with LBP.

IV. REVIEW TECHNIQUE

The review process started with selection of the topic and gaining the basic information about it followed by listing the questions to be reviewed, searching relevant literature, analysing the selected literature, recording the results and exploring the research challenges.

A. *Sources of information*

Literature data was collected from the following electronic database sources:

1) IEEE Xplore (https://ieeexplore.ieee.org)
2) Springer (https://www.springer.com)
3) ScienceDirect (https://www.sciencedirect.com)
4) NMIMS Library E-resources (https://ezproxy.svkm.ac.in)

B. *Search Criteria*

The keyword "Face recognition" was searched and relevant papers published between the years 2015-2021 were selected. A few questions were listed and kept in mind while selecting the paper:

1) What are the constraints faced by the face recognition systems?
2) What are the limitations of existing systems?
3) How to improve the accuracy of face recognition in real-time?
4) How to improve the efficiency of the existing systems?

V. DISCUSSION

In this section, we discuss the various papers reviewed and list out their limitations and remarks. Research gaps or constraints that we came across during reviewing the under mentioned papers are also discussed.

A. *Papers Reviewed*

The various papers selected for review purpose are summarized in the following Table IV.

Table IV
Papers Reviewed

Sr No.	Reference	Methods Proposed	Brief Description	Limitations	Remarks
1.	O. A. R. Salim, R. F. Olanrewaju & W. A. Balogun (2018)	Local Binary Patterns algorithms (LBPs)	The proposed system recognizes faces by implementing LBPs and the attendance was stored in MySql. The system was tested on 11 students and 21 images of each student were trained.The distance between the facial features was determined using KNN algorithm and the algorithm was analysed by the confusion matrix.	LBPs are light sensitive. Since the value of the pixels changes as the change in illumination conditions.	F1 score of 95% was achieved
2.	Serign Modou Bah & Fang Ming (2020)	Haar Cascade & Local Binary Patterns (LBPs)	This paper provides an improved method of face recognition using LBP by combining image processing techniques. This methods is designed to eliminate some issues affecting recognition rate		The proposed method achieved 99% accuracy

3.	N. Gupta, P. Sharma, V. Deep & V. K. Shukla (2020)	Haarcascade & Local Binary Pattern Histogram (LBPH)	The authors have proposed a method based on Python using open computer vision. Haarcascade is used for face detection and the model is trained using LBPH model for recognition. KNN classifier is used to find the similarity.		
4.	S. Hapani, N. Prabhu, N. Parakhiya & M. Paghdal (2018)	Viola-Jones algorithm & Fisher Face algorithm	The authors proposed a method using Viola-Jones algorithm for detection of faces from a frame captured during lecture containing multiple students. The faces were recognised using Fisher Face algorithm. Two video frames were chosen to evaluate the experiment.	Additional accessories on the face like specs, caps affected the results	The proposed method recorded accuracies of 42% and 50% for 2 frames.
5.	H. Rathod, Y. Ware, S. Sane, S. Raulo, V. Pakhare & I. A. Rizvi (2017)	Viola-Jones & Histogram of Oriented Gradients (HOG) algorithm	The authors have used Viola-Jones and Histogram of Oriented Gradients with SVM classifier for face detection in real-time. 8-10 images of each student at different angles were captured and stored. Cameras were installed in classrooms to capture video frames and detect multiple faces.		
6.	P. Patil & S. Shinde (2020)	Histogram of Oriented Gradients, Viola-Jones & Convolution Neural Network	The authors compared three face detection methods: HOG, Viola-Jones and CNN on the basis of face accuracy achieved. Haar and CNN were recommended for a real-time attendance system as it overcomes problems with illumination and angles.		Haar method achieved more as compared to HOG and CNN
7.	S. A. Sovitkar & S. S. Kawathekar (2020)	PCA, LDA and Hybrid approach	The authors have compared three feature extraction methods: PCA, LDA and Hybrid approach which is the combination of PCA and LDA. The proposed method uses Viola-Jones for face detection.		Facial recognition rate was improved in hybrid approach as compared to PCA and LDA
8.	E. Rekha & P. Ramaprasad (2015)	PCA Algorithm and eigenfaces.	The authors explain that faces have important characteristic features which are known as eigenfaces, which are extracted using PCA algorithms from the images of the face.	A full front view of the face is required in PCA, else the recognition will be unsuccessful.	

9.	P. Wagh, R. Thakare, J. Chaudhari & S. Patil (2017)	PCA Algorithm and eigenfaces, AdaBoost Algorithm	The authors used PCA Algorithms to extract eigenfaces, and used AdaBoost algorithm for face detection.	For detection of eigenfaces, proper illumination and camera angles are required for successful results.	
10.	S. Kakarla, P. Gangula, M. S. Rahul, C. S. C. Singh & T. H. Sarma (2020)	Convolutional Neural Networks	Authors proposed a method which used Convolutional Neural Network, which extracts the features from the images for facial recognition.		The accuracy was recorded as 99.86%
11.	E. Winarno, I. Husni Al Amin, H. Februariyanti, P. W. Adi, W. Hadikurniaati & M. T. Anwar (2019)	CNN with PCA combination	Authors used Convolutional Neural Network and PCA algorithms together for Face detection and recognition.		PCA alone gives 90%-96% accurate results and the combination method of CNN and PCA algorithms gives the result in the range of 90%-98%.
12.	J. W. S. D'Souza, S. Jothi & A. Chandrasekar (2019)	Haar cascade algorithms, Local Binary Pattern Histogram	For face detection, authors used segmentation through Haar cascade algorithm. For face recognition, they used histogram values. They compared the values of the histogram of both the images.		
13.	M. Sajid, R. Hussain & M. Usman (2014)	Gabor Filters	Authors in this work proposed a conceptual model which calculated fiducial points using Gabor Filters.		
14.	A. Rasool, S. Roohi & A. Majumder (2020)	Multi Task Cascaded Convolutional Neural Network, FaceNet, N-Shot learning algorithm	The authors in this paper used MTCNN and FaceNet for face detection. For face recognition, their focus was to reduce the training dataset, for which they used the N-Shot learning algorithm.		
15.	T. Mantoro, M. A. Ayu & Suhendi (2018)	Haar Cascade & Eigen Faces	The authors proposed a hybrid method of Haar Cascade and Eigenfaces for multiple face detection at a time.	The system fails to detect face when it is in the side facing position of 30 degrees and above	This method achieved an accuracy of 91.67% for face recognition

16.	H. Zhang, Z. Qu, L. Yuan & G. Li (2017)	Local Binary Pattern Histogram & Convolutional Neural Network	The authors proposed a method where LBP feature maps taken as the input of CNN to improve it's learning and understanding	Methods based on neural networks have limitation that the training time is increased due to large numbers of neurons	Accuracy of 91.83% was achieved for CNN and 95.33% for PCA+CNN
17.	I. Q. Mundial, M. S. Ul Hassan, M. I. Tiwana, W. S. Qureshi & E. Alanazi (2020)	Convolutional Neural Network	Authors in this work proposed a method to use CNN model for recognizing masked faces during the COVID-19 pandemic.		This method showed an accuracy of 99% on training dataset.
18.	S. Lukas, A. R. Mitra, R. I. Desanti & D. Krisnadi (2016)	Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT), Radial Basis Function (RBF)	Authors in this paper used DCT and DWT for face detection and used RBF for classification.		The success rate of this system is 82%.

B. Research Gaps

Face recognition rate may vary in different light conditions. It may go down, if there is no proper illumination, hence proper lighting is required when taking pictures of the students. The camera angle is also an important feature when taking pictures of the student, because the system might fail to recognize the faces if they are not captured at a proper angle. In the same way, camera quality is also important, and good quality cameras should be used otherwise the system may not be able to recognize cloudy images.

All these issues are also faced when the pictures of all the students are taken together, i.e. taking the picture of the entire classroom. The system sometimes is not able to recognize the faces of all the students, which may lead to their attendance not being marked, students not sitting properly will not be able to get their faces detected because of wrong camera angles. The recognition rate decreases with an increase in the number of students in the frame. Hence, the authors of this paper suggest that each student's picture should be taken individually either at the beginning of the class or the end, so as to mark the attendance properly, and help the system run efficiently.

VI. CONCLUSION AND FUTURE SCOPE

This paper reviewed 18 papers in total, and the results showed that the highest accuracy was achieved with Convolutional Neural Networks(CNN). CNN is a distinctly effective algorithm used for face recognition, and the results in the papers reviewed above show that CNN with other algorithms such as PCA and LBPH also give higher accurate results unlike when used individually. Thus, the authors of this paper believe that when CNN is used with other algorithms in hybrid mode, it gives more precise results.

Facial recognition for automated attendance systems reduces the manual work immensely and it is a vast concept and contains numerous algorithms, which can be upgraded to make them more efficient. Facial recognition is already being used in multiple fields, but if this system is improved further then it can open up a whole new advancement for us. The authors believe that these algorithms can be upgraded or used as a base, to create algorithms that can identify 3D images and objects, and can be used in large scale applications.

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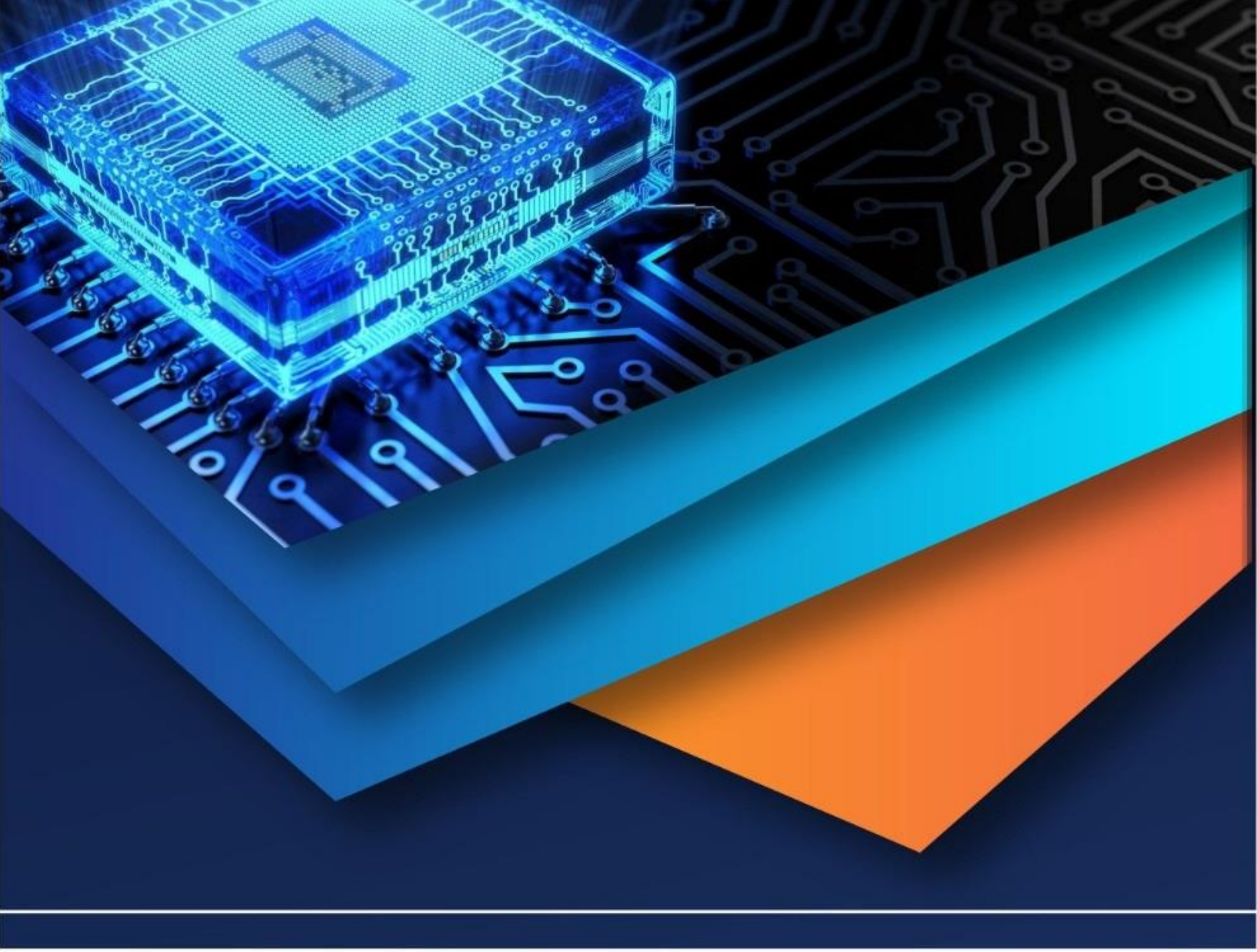

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