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Automated Smart Attendance System with Face Recognition

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Abstract: ***In this paper, the development of the smart attendance system with face recognition technology is presented. The proposed system is fully automated and does not require. The system has been implemented on a Raspberry Pi 4 Model B board using a USB webcam automatically detects and recognizes people in real-time and records their presence in a centralized database. The proposed system utilizes OpenCV and the concept of face recognition models like CNNs to guarantee proper recognition regardless of changes lighting conditions. When compared with the traditional method, this contactless technology has been found to result in a lower increase in errors and prohibits proxy attendance. Results for the experimental evaluation of the hardware prototype justify the following conclusions on the desirability and functionality an average face recognition accuracy of over 90% (95% in well-lit conditions, around 90% in low-lighting conditions) and average processing latency of approximately 1-2 seconds per recognition. The power consumption is restricted to a standard *5V/3A USB Power Supply, for continuous use*. The paper describes the hardware and software components "Software design, methods of software testing, including unit and black box tests, and performance measurement." Lastly, the benefits of the system are highlighted, and future enhancements are touched upon.***

Keywords: Smart Attendance System, Face recognition, Raspberry Pi, OpenCV, real-time image processing.

I. INTRODUCTION

Managing attendance effectively has long been a concern and challenge in educational institutions and organizations. manual attendance methods using roll call systems or punch cards and RFID systems are extremely time-consuming and inaccurate. This has been pointed out in research with the comment that ‘traditional systems are often beset with inefficiency and inaccuracies [1], which are even prone to proxy attendance. However, modern developments in the use of computer vision technology may soon make attendance monitoring possible through face recognition systems that automatically identify individuals as they enter a class or office. Face recognition systems are non-contact biometric systems that are cleaner and more convenient to users compared to fingerprint or smart card systems [2]. Especially using CNN deep learning technology, face identification using video technology has already achieved a high level of accuracy.

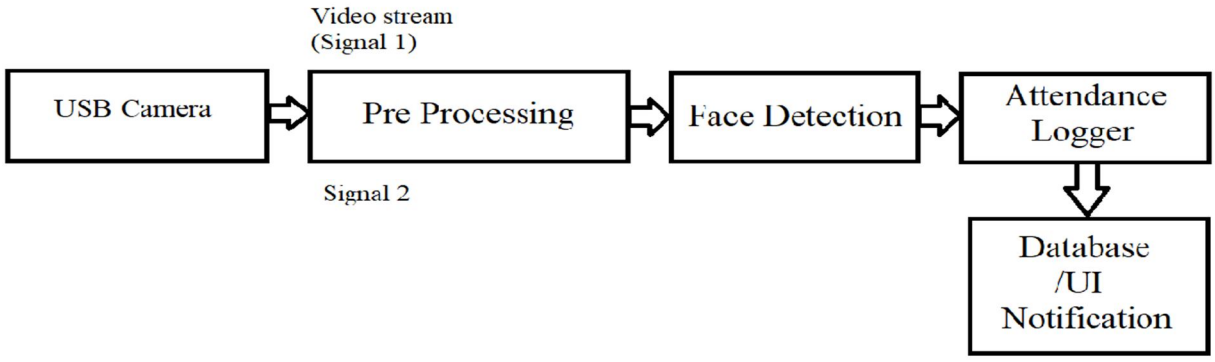

Fig. 1 Main block diagram of the system

The proposed system utilizes a Raspberry Pi-4 Model B computer, along with a USB camera and open-source software (Python/OpenCV), in a cost-effective manner to establish a fully automatic attendance mechanism. The camera is always operating, capturing frames of videos, and those frames are utilized to detect faces and compare them to a database of registered personnel. When a match is found, the faces are automatically timestamped and logged into a SQLite database, either local or online [3]. A friendly interface is utilized to show the status of attendance in real-time.

The objectives that this project aims to achieve are:

1) Automating the marking of attendance by using face detection and recognition software.
2) Accuracy improvement: Reduce manual mistakes and proxy check-ins by assigning each recognized face to a distinct individual.
3) Improve safety and hygiene: Offer a non-contact system (in contrast to the fingerprint scanner) that helps reduce the spread of germs.
4) Centralize attendance records to make them accessible and easily retrievable.
5) Through the fulfillment of these objectives, the system is expected to provide an efficient and optimal solution for schools, colleges, offices, and other institutions.

II. LITERATURE REVIEW

In the human body, the face is the most crucial factor in identifying each person as it contains many vital details. There are different prevailing methods to capture person's presence like biometrics to take attendance which is a time-consuming process. This paper develops a model to classify each character's face from a captured image using a collection of rules i.e., LBP algorithm to record the student attendance. LBP (Local Binary Pattern) is one among the methods and is popular as well as effective technique used for the image representation and classification and it was chosen for its robustness to pose and illumination shifts. The proposed ASAS (Automated Smart Attendance System) will capture the image and will be compared to the image stored in the database. The database is updated upon the enrolment of the student using an automation process that also includes name and rolls number. ASAS marks individual attendance, if the captured image matches the image in the database i.e., if both images are identical.[1]

Attendance tracking in educational institutions is critical, the manual methods are very difficult, in particularly for large numbers of student populations. In this research novelty new methodology proposed work a face recognition-based attendance monitoring system that employs deep learning prediction system and computer vision. This system aims to streamline processes, reduce fraud, and improve accuracy. This study has used robust face detection algorithms, combined with Histograms of Oriented Gradients (HOG) feature extraction to yield a comprehensive database of authorized students. Deep Learning (DL)-based face detection, when combined with Principal Component Analysis (PCA), Support Vector Machine (SVM), K-Nearest Neighbor (KNN) classification enhances system performance and accuracy. Enrollment generates unique identifiers, and regular updates to a centric dataset in order to make attendance tracking easier. This research promises to manage attendance in educational institutions in an efficient and accurate manner.[2]

In this paper, a touch less automated face recognition system for smart attendance application was designed using convolutional neural network (CNN). The presented touch less smart attendance system is useful for offices and college's attendance applications with this the spread of covid-19 type viruses can be restrict. The CNN was trained with dedicated database of 1890 faces with different illumination levels and rotate angles of total 30 targeted classes. A CNN performance analysis was done with 9-layer and 11-layer with different activation functions i.e., Step, Sigmoid, Tanh, softmax, and ReLu. [3]

The management of the attendance can be a great burden on the teachers if it is done by hand. To resolve this problem, smart and auto attendance management system is being utilized. But authentication is an important issue in this system. The smart attendance system is generally executed with the help of biometrics. Face recognition is one of the biometric methods to improve this system. Being a prime feature of biometric verification, facial recognition is being used enormously in several such applications, like video monitoring and CCTV footage system, an interaction between computer & humans and access systems present indoors and network security. By utilizing this framework, the problem of proxies and students being marked present even though they are not physically present can easily be solved. The main implementation steps used in this type of system are face detection and recognizing the detected face.This paper proposes a model for implementing an automated attendance management system for students of a class by making use of face recognition technique, by using Eigenface values, Principle Component Analysis (PCA) and Convolutional Neural Network (CNN). After these, the connection of recognized faces ought to be conceivable by comparing with the database containing student's faces. [4]

Attendance is a compulsory requirement of every organization. Maintaining attendance register daily is a difficult and time-consuming task. There are many automated methods for the same available like Biometric, RFID, eye detection, voice recognition, and many more. This paper provides an efficient and smart method for marking attendance. As it is known that primary identification for any human is its face, face recognition provides an accurate system which overcomes the ambiguities like fake attendance, high cost, and time consumption. This system uses face recognizer library for facial recognition and storing attendance. The absentee's supervisor or parents are informed through email regarding the absence of their employees or wards respectively.

The objective of this project is to innovate existing projects with some added feature like large data storage and fast computing through less hardware cost. [5]

To maintain a discipline and let students grasp utmost knowledge in schools, colleges and universities the attendance system was introduced. There are two conventional techniques to mark attendance of students in a particular class. One of them is by calling the roll number and the second is to take students sign on a piece of paper against their roll number. Hence there was a need to evolve this system in such a way that it could become user friendly, less time consuming and efficient. This is an automated system to assist the faculty in taking attendance of the whole class without any disturbance or time waste. The idea can encompass a large number application one of which include face identification, it will help save time and efficiently identifies and eliminates the chances of proxy attendance. The main purpose of this project is to built automated attendance system using Raspberry pi 3B+ with OpenCV/Python libraries and recognizer algorithm have been implemented. The proposed system can be implemented in any field where attendance system is present and plays a vital role. In addition, as the project objectives and the design criteria all met, it's greatest to say this project is an engineering solution for all university and colleges to track and manage the attendance. [6]

III. SYSTEM COMPONENTS

The proposed system major components includes , Raspberry Pi ,USB Camera, Micro-SD Card, Monitor and their specifications shown in Table I and Table II.

A. Raspberry Pi (Processing Unit)

The Raspberry Pi is a powerful, low-cost, credit-card-sized computer used for a wide range of embedded and IoT applications. In this project, Raspberry Pi is shown in Fig.2., acts as the primary processing unit responsible for capturing the video feed, detecting faces, extracting facial features, matching users from the database, and recording attendance in real time. It supports Python, OpenCV, TensorFlow-Lite, and other libraries essential for face recognition operations. Raspberry Pi also supports Wi-Fi, Bluetooth, USB connectivity, HDMI output, and camera interface, making it ideal for face recognition systems used in smart attendance monitoring.

Fig 2. Raspberry Pi Board

B. USB Camera

A USB camera module (Fig.3) is used to capture real-time images or video frames. It plays a crucial role in face detection and recognition. The clarity of captured images directly influences recognition accuracy.

Fig 3. USB Camera Module

C. Micro-SD Card

The micro-SD card (Fig.4), stores the operating system, machine-learning libraries, Python scripts, datasets, and attendance logs. Higher capacity and faster read/write speed make data processing smoother.

Fig 4. Micro-SD Card

TABLE I
TECHNICAL SPECIFICATIONS

Sr.No.	Parameter	Value
1.	Resolution	720p / 1080p
2.	Interface	USB 2.0 / CSI
3.	Frame Rate	30 fps
4.	Lens Angle	60° – 120°
5.	Operating Voltage	5V
6.	Focus	Auto / Manual

TABLE II
SPECIFICATIONS OF MICRO-SD CARD

Sr.No.	Parameter	Value
1.	Capacity	16GB / 32GB
2.	Speed Class	Class 10
3.	File System	FAT32
4.	Usage	Stores OS + code + dataset

D. Monitor

A monitor is used for system setup, debugging, visualization of camera output, training dataset creation, and attendance monitoring.

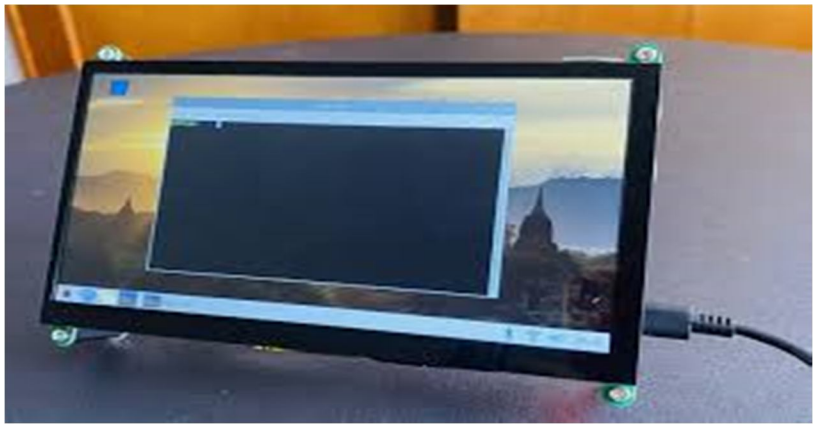

Fig 5. Monitor Interface with Raspberry Pi

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IV. METHODOLOGY

A. Hardware Implementation

The Raspberry Pi 4 Model B, with its Broadcom BCM2711 quad-core Cortex-A72 1.8 GHz processor and 4 GB LPDDR4 RAM, is actually the central hardware component of the proposed system, as it is a credit-card-sized computer.

The Raspberry Pi 4 also has the capacity for 802.11ac wireless connectivity, Bluetooth 5.0, Gigabit Ethernet, and multiple USB ports. The device draws power from the standard 5V/3A power supply for the USB-C port, and it has the capacity to power the Raspberry Pi and the connected devices. The camera interface is achieved using a USB 1080p web camera, which is connected to the USB port, and this camera will act as the RV's camera sensor.

The microSD card with a capacity of 32 GB and above has the Raspberry Pi Operating System and stores data.

It is also possible to include additional devices such as the RTC module and the indicator LED and buzzer for extra functionality, but the proposed RV system has the Raspberry Pi and the camera connected as depicted in Fig.6. The proposed Raspberry Pi 4-based RV requires only the camera, as it has its own power supply using the standard 5V/3A power supply for the USB-C port, as Raspberry Pi 4 Model B with a USB camera setup.

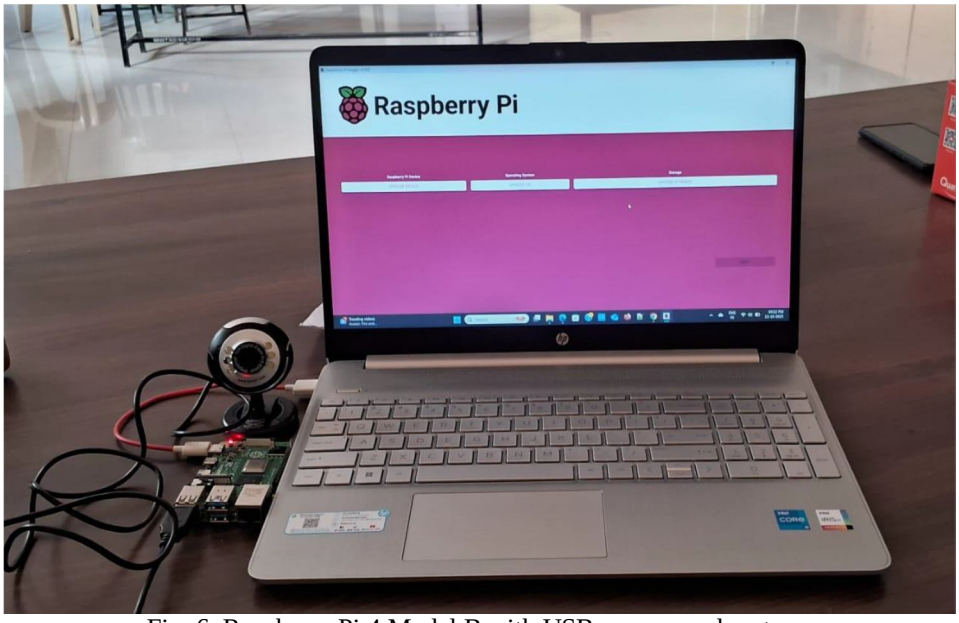

Fig. 6. Raspberry Pi 4 Model B with USB camera and system

B. Software Implementation

The System software is developed using Python programming language with the help of OpenCV library. The process followed by the software is as given below:

1) Image Acquisition: A USB camera captures video frames continuously. The video frames are acquired with the V4L2 interface. The video frames are resized and converted to

2) Face Detection: Faces are searched for within the frame using OpenCV's Cascade Classifiers or other learning-based detectors. Face regions are then used for detection and cropped for recognition.

3) Face Recognition: The obtained faces are matched with a set of predefined faces. Face recognition is performed through the use of a face recognition model, possibly a CNN, like Dlib/Face Net. If a face matches a set of predefined faces beyond a certain similarity level, the face is identified.

4) Tracking Attendance: The recognized identities are stored in the SQLite database along with time stamps in the SD card. An entry is added or updated in the attendance table for this purpose. The database is capable of multiple reads and writes per second.

5) Interface User: There is a graphical interface that displays information through use of an HDMI display. The GUI displays names of the people who have attended, as well as the messages. The GUI gives real-time information, such as "Venugopal Karampuri: Present," and can also automatically create reports either daily or weekly.

This allows for seamless recording of presence, where the moment people appear before the camera, the software detects, recognizes, and records the presence without requiring human supervision. With the most effective algorithms, the recognition process takes approximately 1-2 seconds on the Pi 4 platform. To summarize, the entire software framework runs on the Raspberry Pi, making the entire system truly mobile. The software framework is written in Python 3.7+, OpenCV 4.x, NumPy, and SQLite.

V. RESULTS AND DISCUSSION

The system has been set up and tested on the hardware components (Raspberry Pi 4 Model B, USB camera). The system has also undergone functional, performance, and other tests:

1) *System Testing*: The entire system has been tested end to end. For instance, if a human being is placed before the camera and the intended results occur: that is, the attendance is registered. Then if an "unknown" face is placed before the camera, the "access is denied."
2) *Unit Testing*: The modules are individually tested. For example, the camera module was tested for continuous image capturing, the recognition module was tested on both known and unknown faces, and the database module was tested for proper record insertion and retrieval.

TABLE III
AUTOMATED ATTENDANCE

S.No.	Name	RollNumber	Date	Time_IN	Time_OUT	Status
1	Sanket Atanure	4	2025-11-26	10:01:24AM	nan	IN
2	Priyadarshini Birajdar	11	2025-11-26	10.02.20 AM	nan	IN
3	Omkar Dhaygude	17	2025-11-26	10.02.40 AM	nan	IN
4	Amisha Jamadar	22	2025-11-26	10.03.40 AM	nan	IN
5	Venugopal Karampuri	25	2025-11-26	10.03.55 AM	nan	IN
6	Saniya Nadaf	36	2025-11-26	10.05.10 AM	nan	IN
7	Babusha Shendage	53	2025-11-26	10.09.25 AM	nan	IN
8	Sanket Atanure	4	26-11-2025	nan	12.00.06	OUT
9	Priyadarshini Birajdar	11	26-11-2025	nan	12.00.20	OUT
10	Omkar Dhaygude	17	2025-11-26	nan	12.00.50	OUT
11	Amisha Jamadar	22	2025-11-26	nan	12.01.06	OUT
12	Venugopal Karampuri	25	2025-11-26	nan	12.01.45	OUT
13	Saniya Nadaf	36	2025-11-26	nan	12.02.06	OUT
14	Babusha Shendage	53	2025-11-26	nan	12.02.50	OUT

Key performance results include:

a) *Recognition Accuracy:* The accuracy of the system is very high in normal light conditions (around 95%) and remains constant at around 90% in low-lighting conditions. The result is comparable to current literature for face recognition attendance management systems
b) *Processing Speed:* Due to the quad-core processor and 4 GB RAM present in the Pi 4, it only takes 1-2 seconds per recognition cycle. Hence, real-time attendance can easily be captured.
c) Database Performance: The SQLite database embedded in this system performs multiple data entries per second efficiently; this satisfies classroom or office applications. The attendance records are timestamped and fetched quickly.
d) *Power Draw:* The device consumes 5V/2.5A (approximately 12.5W) power using a USB charger or external power source. This makes the device capable of running all day long without needing a recharge.
e) *Reliability:* An 8-hour continuous run of the system did not result in crashes and slowdowns, which shows its reliability for daily usage.

Testing has demonstrated the proposed attendance solution to be accurate and efficient as well. It has been ensured that the attendance solution works well for multi-face, low-light, and unknown images. The unit test has ensured the functionality of each component, such as image acquisition, logic, logging, and the GUI. The automated attendance solution has demonstrated efficient identification and logging features, ensuring its efficiency and suitability for an automated attendance solution.

VI. CONCLUSION

In this project, designed and implemented an autonomous attendance system with face recognition. The system efficiently detects and recognizes faces in real time, automatically marking attendance without any manual effort. Using OpenCV and Python-based facial recognition algorithms, the project provides an accurate, contactless, and intelligent attendance management solution. The system's performance analysis demonstrates its high accuracy, reliability, and efficiency, making it suitable for practical applications in schools, colleges, offices, and other organizations. It simplifies attendance tracking, reduces human errors, and improves data handling through automation solutions.

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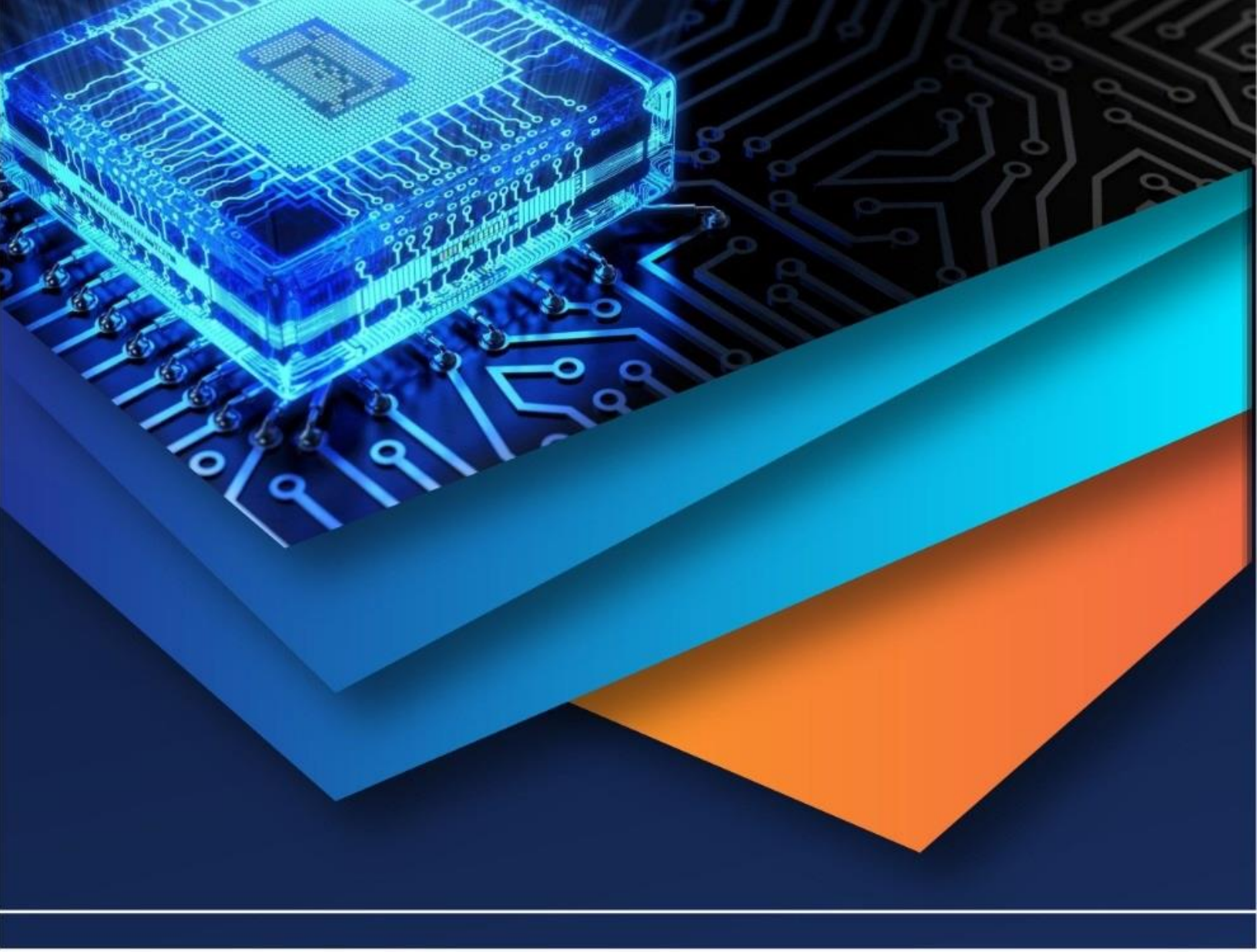

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