iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** VI **Month of publication:** June 2026

DOI: https://doi.org/10.22214/ijraset.2026.83426

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

AI-Based Smart Attendance System with Face Recognition and QR Code

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Abstract: ***Attendance management is an essential task in educational institutions and organizations for monitoring participation and maintaining records. Traditional attendance systems are often manual, time-consuming, and prone to errors such as proxy attendance and inaccurate record keeping. To address these challenges, this paper presents an AI-Based Smart Attendance System with Face Recognition and QR Code Technology that automates the attendance process while improving accuracy, efficiency, and security. The proposed system integrates Artificial Intelligence (AI), computer vision, and QR code technology to provide a reliable attendance management solution. Face recognition is implemented using deep learning and image processing techniques to identify individuals in real time through a camera. The system captures facial features, compares them with stored datasets, and automatically marks attendance for authenticated users. In addition, a QR code-based attendance module is incorporated as an alternative verification method, enabling users to scan unique QR codes for attendance registration when facial recognition is unavailable or affected by environmental conditions.***

Keywords: ***Artificial Intelligence, Smart Attendance System, Face Recognition, QR Code Authentication, Computer Vision, Deep Learning, Attendance Automation, Biometric Identification, Real-Time Monitoring, Machine Learning.***

I. INTRODUCTION

Attendance management is an essential task in educational institutions, organizations, and workplaces. Traditional attendance methods, such as manual registers and paper-based records, are time-consuming, prone to errors, and vulnerable to proxy attendance. These limitations create the need for a more efficient, secure, and automated attendance monitoring system.

Recent advancements in Artificial Intelligence (AI), Computer Vision, and Machine Learning have enabled the development of intelligent attendance systems capable of identifying individuals automatically. Face recognition technology has emerged as one of the most reliable biometric methods due to its accuracy, non-contact nature, and ease of implementation. By analyzing facial features, the system can accurately verify the identity of individuals and record their attendance without manual intervention.

In addition to face recognition, QR code technology provides an extra layer of authentication and flexibility. QR codes can be generated uniquely for students or employees and scanned for quick verification. The integration of face recognition and QR code authentication improves system reliability, reduces fraudulent attendance practices, and enhances overall security.

The proposed AI-Based Smart Attendance System combines face recognition and QR code technologies to automate attendance tracking in real time. The system captures facial images through a camera, verifies identities using AI algorithms, and records attendance in a centralized database. Simultaneously, QR code authentication serves as an alternative or supplementary verification mechanism. This dual-authentication approach ensures greater accuracy, minimizes proxy attendance, and streamlines attendance management processes. The system is designed to provide an efficient, secure, and user-friendly solution for educational institutions and organizations, reducing administrative workload while improving attendance monitoring and record maintenance.

II. LITERATURE SURVEY

Attendance management systems have evolved significantly with the advancement of Artificial Intelligence, Computer Vision, and biometric technologies. Researchers have proposed various methods to automate attendance recording and eliminate the limitations of traditional manual systems.

Early attendance systems relied on RFID (Radio Frequency Identification) technology, where students or employees carried RFID cards that were scanned to mark attendance. Although RFID-based systems reduced manual effort, they were vulnerable to card sharing and proxy attendance, affecting overall reliability.

Biometric attendance systems based on fingerprint recognition were later introduced to improve accuracy and security. These systems successfully eliminated proxy attendance; however, they required physical contact with scanning devices, leading to hygiene concerns, hardware maintenance issues, and increased implementation costs.

With the rapid growth of Computer Vision and Machine Learning, face recognition-based attendance systems became a popular research area. Researchers utilized image processing techniques and facial feature extraction algorithms to automatically identify individuals from live camera feeds. Studies have shown that face recognition systems provide high accuracy, reduce manual intervention, and offer a contactless attendance solution suitable for classrooms and workplaces.

Recent developments in Deep Learning have further enhanced facial recognition performance. Convolutional Neural Networks (CNNs) and advanced facial embedding techniques have improved recognition accuracy under varying lighting conditions, facial expressions, and head orientations. These improvements have enabled real-time attendance monitoring with minimal human supervision.

Several researchers have also explored QR code-based attendance systems. In these systems, unique QR codes are generated for registered users and scanned during attendance marking. QR code systems are simple, cost-effective, and easy to deploy. However, when used alone, they may still be susceptible to code sharing and unauthorized usage.

To overcome the limitations of individual approaches, recent studies have focused on integrating multiple authentication methods. Hybrid attendance systems combining face recognition and QR code verification provide enhanced security, higher accuracy, and better resistance to fraudulent attendance practices. Such systems verify both the physical presence and identity of the user before recording attendance.

Based on the findings of existing research, the integration of Artificial Intelligence-based face recognition with QR code authentication offers a reliable, secure, and efficient solution for attendance management. The proposed system builds upon these advancements by providing automated attendance tracking, real-time verification, improved security, and centralized record management.

III. PROPOSED METHODOLOGY / SYSTEM DESIGN

The proposed AI-Based Smart Attendance System combines Face Recognition and QR Code Authentication technologies to create an automated, secure, and efficient attendance management solution. The system is designed to eliminate the drawbacks of traditional attendance methods, such as manual effort, human errors, and proxy attendance. By utilizing Artificial Intelligence and Computer Vision techniques, the system can accurately identify individuals and record their attendance in real time.

The system begins with the student registration process. During registration, student information such as Student ID, Name, Department, Email Address, and Photograph is collected and stored in the database. Multiple facial images of each student are captured through a camera to create a facial dataset. Simultaneously, a unique QR code is generated and associated with the student's profile, providing an additional authentication mechanism.

After data collection, the captured images undergo preprocessing to improve recognition performance. Image processing operations such as resizing, grayscale conversion, normalization, and noise reduction are applied to the images. The processed dataset is then used to train the face recognition model. Facial features are extracted and stored so that the system can accurately recognize registered students during attendance marking.

When attendance is being recorded, the camera continuously captures live video frames. The face recognition module detects faces present in the frame and compares them with the stored facial database. If a match is found, the identity of the student is verified. The use of Artificial Intelligence-based face recognition ensures high accuracy and enables contactless attendance monitoring.

To strengthen security and prevent unauthorized attendance marking, the system incorporates QR code authentication. Each student is provided with a unique QR code that contains identification information. During attendance marking, the QR code is scanned and decoded.

The decoded information is verified against the student database to confirm authenticity. This dual-verification approach significantly reduces the possibility of proxy attendance and fraudulent activities.

Once both face recognition and QR code verification are successfully completed, the attendance management module automatically records the attendance details. Information such as Student ID, Date, Time, and Attendance Status is stored in the database. The system also checks for duplicate entries to ensure that attendance is marked only once during a specific session.

All student records, facial datasets, QR code information, and attendance logs are maintained in a centralized database. The database facilitates efficient storage, retrieval, updating, and management of attendance-related information. Faculty members and administrators can access attendance records whenever required, improving transparency and operational efficiency.

Workflow Diagram

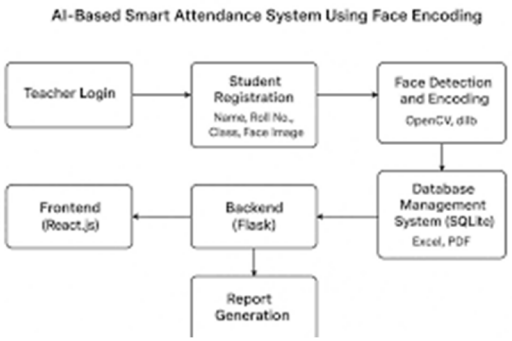

Fig.1. Workflow Diagram

IV. IMPLEMENTATION OF THE PROPOSED SYSTEM

The implementation of the AI-Based Smart Attendance System with Face Recognition and QR Code Authentication was carried out using modern software technologies and machine learning techniques. The system was developed to automate attendance management while ensuring accuracy, security, and ease of use. The implementation process consists of student registration, dataset creation, face recognition model training, QR code generation, attendance marking, database management, and report generation.

The first stage of implementation involves the student registration module. A graphical user interface was developed to collect student information such as Student ID, Name, Department, Email Address, and Photograph. During registration, multiple facial images of each student are captured using a webcam and stored in a dataset folder. These images serve as training data for the face recognition model. At the same time, a unique QR code is generated for every registered student and stored in the system database.

The second stage focuses on dataset preparation and image processing. The captured facial images are preprocessed using OpenCV libraries. Image preprocessing techniques such as face detection, image resizing, grayscale conversion, and normalization are applied to improve image quality and recognition accuracy. The processed images are then organized and prepared for training the face recognition model.

The face recognition model is implemented using machine learning and deep learning libraries such as OpenCV, Dlib, Face Recognition, TensorFlow, and Scikit-Learn. Facial features are extracted from the training images and converted into numerical embeddings. These embeddings are stored and used to identify students during attendance marking. The trained model enables real-time face detection and recognition with high accuracy.

The QR code authentication module is implemented using Python QR code generation libraries. Each student's unique QR code contains identification information linked to the database. During attendance marking, the QR

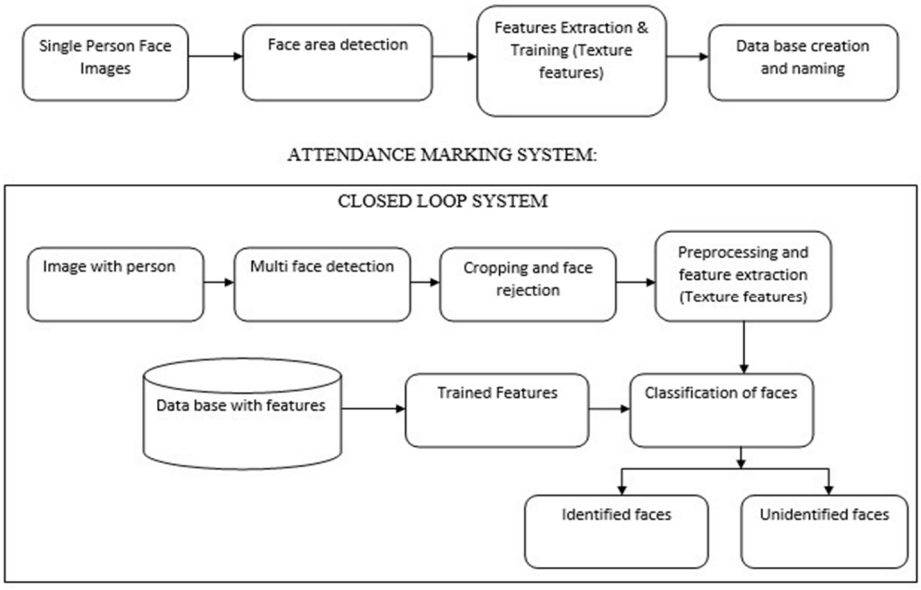

Fig.2. .Implementation Diagram

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V. CNN MODEL TRAINING AND VALIDATION PERFORMANCE ANALYSIS

The Convolutional Neural Network (CNN) model was employed to perform face recognition in the proposed AI-Based Smart Attendance System. The model was trained using a dataset containing facial images collected during the student registration process. Before training, all images were preprocessed through face detection, resizing, normalization, and data augmentation techniques to improve model performance and generalization. The dataset was divided into training and validation sets, where the training set was used to learn facial features and the validation set was used to evaluate the model's effectiveness on unseen data.

During the training phase, the CNN model learned important facial characteristics such as eye structure, nose shape, facial contours, and other distinctive features. Multiple convolutional and pooling layers were used to extract high-level features from the input images, while fully connected layers performed classification based on the extracted features. The training process was carried out over several epochs until the model achieved stable performance and minimized classification errors.

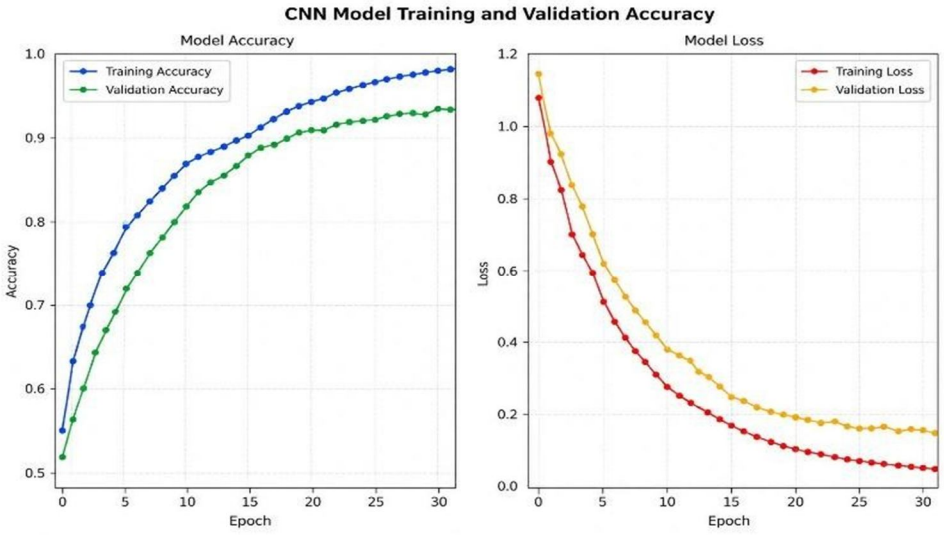

Fig.3.CNN Model Training and Validation Performance Analysis

VI. RESULTS

The AI-Based Smart Attendance System with Face Recognition and QR Code Authentication was successfully developed and tested in a controlled environment. The system effectively automated the attendance marking process by combining facial recognition technology with QR code verification. Experimental results demonstrated that the system accurately identified registered students and recorded attendance without requiring manual intervention.

The student registration module successfully stored student details, captured facial images, and generated unique QR codes for each registered user. The collected facial dataset was used to train the CNN-based face recognition model, which achieved high recognition accuracy during testing. The model was able to identify students under different lighting conditions and facial expressions, making it suitable for real-time attendance monitoring.

The face recognition module demonstrated efficient real-time performance by accurately detecting and recognizing faces from live camera feeds. The system successfully matched captured facial images with the stored dataset and identified students within a short response time. The implementation of the CNN model significantly improved recognition accuracy by extracting distinctive facial features and reducing classification errors. The model maintained consistent performance even when minor variations in facial expressions, head positions, and image quality were present.

The QR code authentication module functioned effectively as a secondary verification mechanism. Each student's QR code was generated during registration and securely linked to the database. During attendance marking, the QR code was scanned and verified within a few seconds. The combination of face recognition and QR code authentication enhanced system security and minimized the possibility of proxy attendance or unauthorized access.

The attendance management module automatically recorded attendance information, including Student ID, Name, Date, Time, and Attendance Status. All attendance records were stored in the database without duplication. The system successfully prevented multiple attendance entries from being recorded for the same student during a single session, ensuring data integrity and reliability.

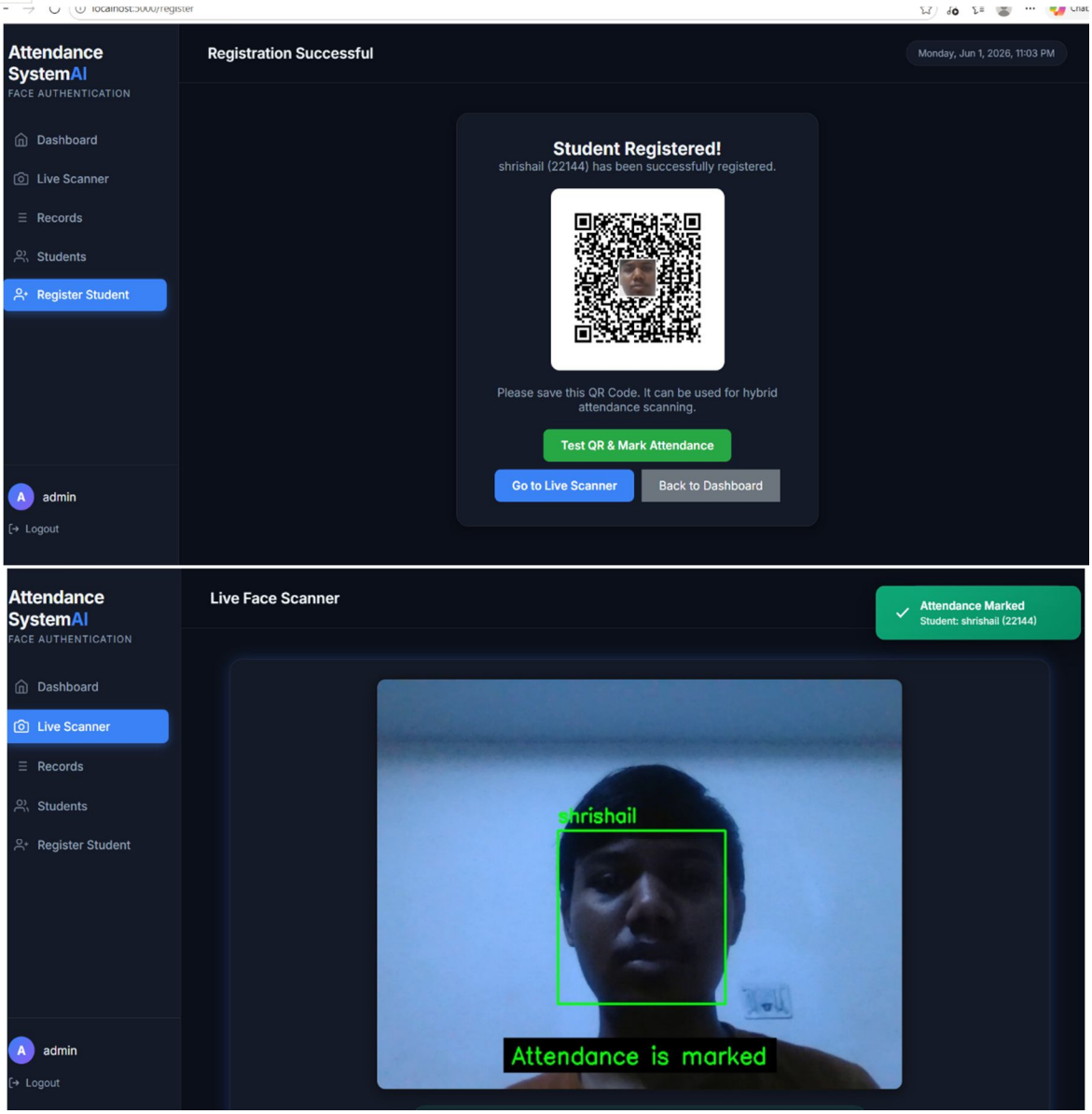

Fig.4. Output interface

The above figure illustrates the output interface of the proposed AI-Based Smart Attendance System. The system captures the user's facial image through a camera and performs real-time face recognition using the trained CNN model. Once the face is successfully recognized, the corresponding student details such as Student ID, Name, Department, and attendance status are displayed on the screen. The system also verifies the student's identity through QR code authentication to ensure secure attendance marking.

VII. CONCLUSION

The AI-Based Smart Attendance System with Face Recognition and QR Code Authentication provides an efficient, secure, and automated solution for attendance management. The system successfully integrates Artificial Intelligence, Computer Vision, Deep Learning, and QR code technology to eliminate the limitations of traditional attendance methods, such as manual effort, human errors, and proxy attendance.

The proposed system accurately identifies individuals using a CNN-based face recognition model and verifies their identity through QR code authentication. This dual-verification mechanism enhances security and ensures that attendance is recorded only for authorized users. The automated attendance marking process reduces administrative workload, saves time, and improves the overall efficiency of attendance management.

Experimental results demonstrate that the system achieves high recognition accuracy and reliable performance in real-time environments. The attendance records are stored securely in a centralized database, allowing easy retrieval, monitoring, and report generation. The system also prevents duplicate entries and provides faculty members with detailed attendance reports for effective decision-making.

Overall, the developed attendance system offers a practical and scalable solution for educational institutions and organizations seeking a modern attendance management approach. By combining face recognition and QR code technologies, the system ensures accurate attendance tracking, improved security, and enhanced operational efficiency. Future enhancements may include cloud-based deployment, mobile application integration, and advanced deep learning models to further improve system performance and accessibility.

VIII. FUTURE SCOPE

The proposed AI-Based Smart Attendance System with Face Recognition and QR Code Authentication provides a reliable and efficient attendance management solution. However, several enhancements can be incorporated in the future to further improve its functionality, scalability, and performance.

One possible enhancement is the integration of advanced deep learning models that can provide higher facial recognition accuracy under challenging conditions such as poor lighting, facial occlusions, and varying camera angles. The use of modern architectures and larger training datasets can further improve recognition performance and system robustness.

The system can also be extended through cloud-based deployment, enabling centralized attendance management across multiple institutions, campuses, or organizational branches. Cloud integration would facilitate secure data storage, remote access, real-time synchronization, and efficient management of attendance records from any location.

A mobile application can be developed to provide convenient access for students, faculty members, and administrators. Through the mobile platform, users can view attendance records, receive notifications, generate reports, and manage attendance-related activities directly from their smartphones.

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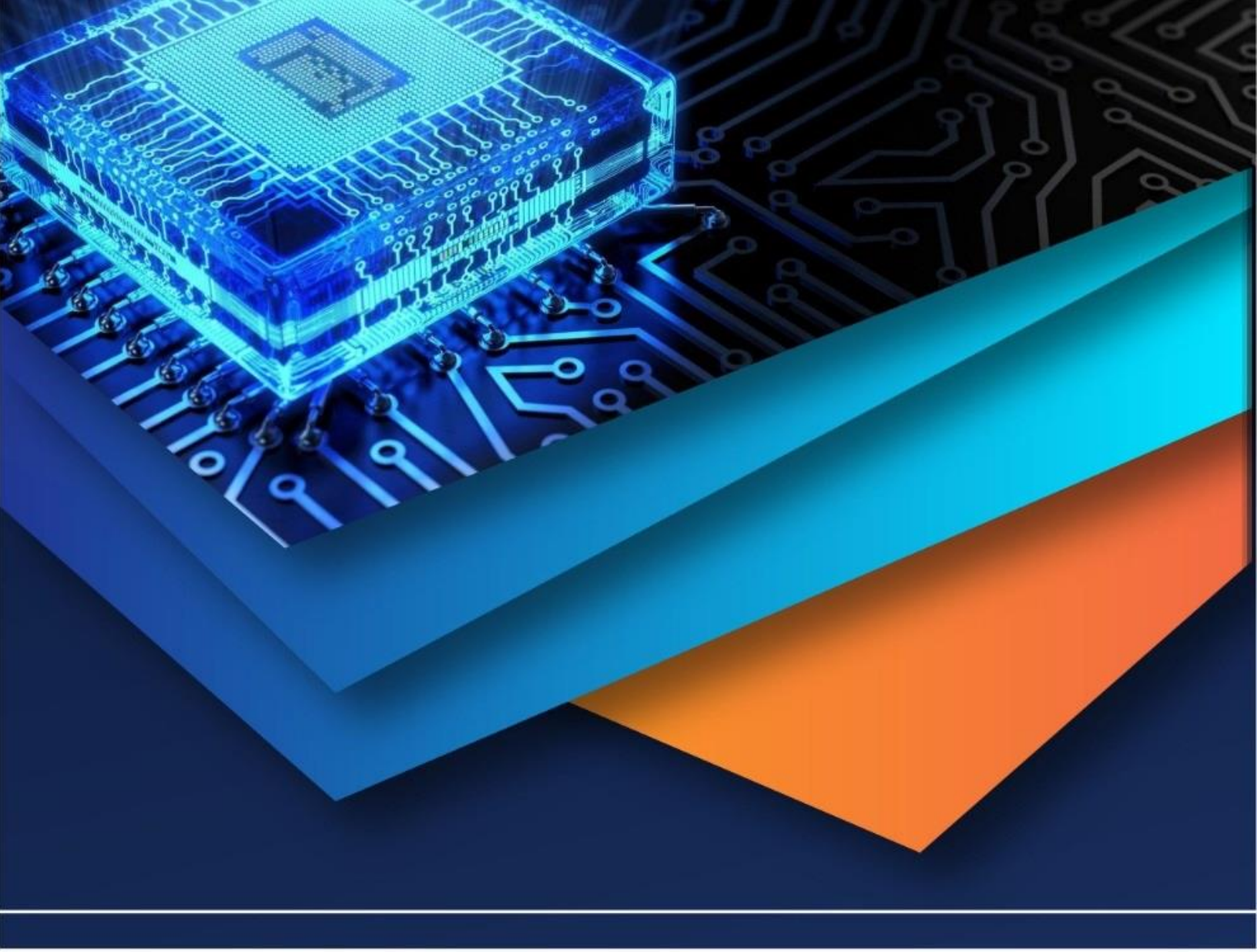

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