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"Smart Parking Systems: Enhancing Efficiency and Sustainability in Urban Areas"

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Abstract: ***Smart Parking systems are innovative solutions designed to address the challenges faced by drivers when searching for parking spaces, especially in busy urban areas during peak hours. These systems utilize IoT technology deployed on-site to monitor and indicate the availability status of individual parking spaces. Additionally, a mobile application is provided to enable users to conveniently check the availability of parking spaces and easily locate vacant slots.***

By implementing a Smart Parking system, drivers can save valuable time and avoid the frustrations associated with the daunting task of finding suitable parking spots. Moreover, these systems play a crucial role in alleviating traffic congestion and reducing air pollution in densely populated urban areas.

However, it is important to consider the costs associated with the installation of Smart Parking systems. The implementation process requires the use of camera sensors and costly infrastructure such as line or cabling. The core circuitry involves the integration of NodeMCU, which is connected to infrared (IR) sensors. These IR sensors effectively detect the presence of a parked car and transmit a signal to the NodeMCU. Subsequently, the mobile application is notified, and the corresponding parking slot is accurately displayed as "occupied."

In conclusion, the adoption of Smart Parking systems offers numerous benefits, including time savings, reduced frustration, traffic alleviation, and environmental advantages. Although there are cost considerations involved, the implementation of these systems has the potential to greatly enhance the overall parking experience and contribute to the development of smarter and more efficient cities.

Keywords: smart parking, IoT, mobile application, traffic congestion, air pollution, efficiency, sustainability.

I. INTRODUCTION

With the exponential growth in the number of vehicles on the roads, traffic congestion has become unavoidable. The existing transportation infrastructure and parking facilities are struggling to keep up with the increasing influx of vehicles. To address these challenges, the smart parking system has been developed as an innovative solution. This system allows drivers to conveniently locate and secure vacant parking spaces at their preferred car parking slots. It relies on a computerized system that utilizes the Internet of Things (IoT) technology to provide a reliable and efficient parking service.

In the smart parking system, IoT technology is employed, connecting sensors with physical parking infrastructure and information and communication technologies. A mobile application is a key component of this concept, empowering end users to check the availability of parking spaces and reserve a specific parking lot accordingly. Each parking lot is equipped with a control system that continuously monitors the number of free and occupied parking spaces, providing users with real-time updates on the status of parking lots. This enables users to conveniently check for available parking spaces online from anywhere, facilitating a hassle-free parking experience. Consequently, the implementation of this system effectively resolves parking-related issues.

The basic procedure of this concept is as follows:

The car enters the parking area.

The driver checks the mobile application for information on available parking slots.

Sensors installed in each parking slot maintain a cloud-based database of free slots, which is then updated in the mobile application. The application suggests an appropriate parking slot based on various factors such as proximity and accessibility, ensuring an optimal parking solution. By leveraging IoT technology, the smart parking system enables wireless connectivity, allowing seamless tracking of available parking locations. In conclusion, the smart parking system is a much-needed solution in the face of increasing traffic congestion and parking challenges. Utilizing IoT technology and a mobile application, it empowers drivers to easily find and secure parking spaces, leading to smoother traffic flow and reduced frustration. The implementation of this system will significantly enhance the overall parking experience and contribute to the development of smarter and more efficient cities.

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II. LITERATURE REVIEW

In the field of smart parking, various related works have been explored. These systems utilize sensors, technologies, and interfaces to gather and present real-time information, often requiring costly private infrastructure. They aim to provide users with information about parking slot availability and accessibility. Typically, smart parking systems are categorized as off-road or on-road solutions.

One example of a smart parking system involves an Android application that displays a map indicating the availability of empty parking spaces to users. Each parking slot is equipped with an LED to assist users in locating and booking a space. Infrared sensors are employed to detect free parking spots and control the entry and exit gates. Additionally, an Arduino-based system utilizes an internet server and GPS for detecting and booking available slots. The associated Android application captures customer details such as area, state, car number, and entry and exit time and provides information on vacant parking slots through a MySQL database.

Another system employs a camera to capture car number plates and verify if the vehicle is certified as used or not. Communication between the system and the driver occurs through Vehicle-to-Infrastructure (V21) technology, facilitating parking requests and providing useful information regarding reservation status. A parking reservation application is used, which also provides directional guidance. To ensure safety, QR codes are employed, and a webcam is used to scan these codes, authorizing access to the designated parking zone.

In terms of payment methods, a privacy-preserving pay-by-phone parking system has been proposed, allowing users to book parking slots and make payments using their mobile phones. The system utilizes credit card payment methods and assigns e-coins to new users upon registration. Each e-coin corresponds to a specific parking duration for a slot. Parking officers can query onboard devices using RFID technology. Real-time availability of parking facilities and the ability for users to book spaces and make payments in advance are offered by another system. It incorporates a communication system and a cloud-based database. An ultrasonic sensor, connected via Ethernet, is placed on the ground to detect parking space availability. Wireless communication and GPS are utilized to provide information on the nearest available parking spaces every two minutes. If no parking spaces are available, no actions are taken. However, if spaces are available, users can reserve a parking spot within a 2-kilometer radius of their current location.

Lastly, a system has been developed that calculates the optimal car parking neighborhood based on trajectory and time without offering a booking service. This system relies on the real-time availability of parking spaces.

These various approaches to smart parking systems demonstrate the use of different technologies and features to improve parking efficiency, user experience, and payment methods.

III. OVERVIEW

In today's urban environments, finding an available parking space has become a common challenge, leading to increased congestion and frustration for drivers. To address this issue, I propose the development of a Smart Parking System that leverages modern technology to help drivers make informed decisions and optimize the utilization of parking spaces. By utilizing smartphones and advanced sensors capable of detecting object presence, this system aims to equip parking spaces with ultrasonic sensors. These sensors will provide real-time information about the occupancy status of each parking spot. To enhance accessibility, a centralized management system will be implemented to gather and update the occupancy data. This data will then be made available through a user-friendly web application, assisting drivers in locating vacant parking slots efficiently.

IV. MOTIVATION

1) *Optimal Parking:* Users can easily find the most suitable available parking spot, saving time, resources, and effort. This efficient utilization of parking space benefits both commercial and corporate entities.
2) *Reduced Traffic Congestion:* With fewer cars driving around in search of an open parking space, traffic flow improves, leading to reduced congestion on the roads.
3) *Environmental Benefits:* Searching for parking consumes a significant amount of fuel, contributing to pollution. An optimal parking solution minimizes driving time, resulting in lower vehicle emissions and a reduced environmental footprint.
4) *Improved User Experience:* A smart parking solution integrates all aspects of the user experience seamlessly. This includes features like easy payment options, spot identification, location search, and timely notifications, enhancing the overall convenience of reaching the intended destination.
5) *Additional Revenue Opportunities:* Smart parking technology opens up new revenue streams. For instance, parking lot owners can implement tiered payment options based on the location of parking spaces. Additionally, reward programs can be integrated to incentivize repeat users.

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6) *Integrated Payments and Point-of-Sale:* Returning users can replace manual cash payments with convenient account invoicing and application-based payments on their smartphones. This integration also enables the implementation of customer loyalty programs and facilitates valuable user feedback.
7) *Increased Safety:* Real-time data provided by a smart parking system can aid parking lot employees and security guards in preventing parking violations and identifying suspicious activities. License plate recognition cameras can capture relevant footage, while reduced traffic caused by parking search can help minimize accidents and distractions.
8) *Real-Time Data Analysis:* A smart parking solution generates valuable data over time, allowing lot owners to identify correlations and trends among users and parking lots. These insights enable adjustments and improvements to enhance the overall parking experience.
9) *Reduced Management Costs:* Automation and decreased manual activities result in cost savings for parking lot management, reducing labor costs and resource exhaustion

V. GOALS AND OBJECTIVES

The smart car parking system is a comprehensive solution designed to identify the closest available parking area. Its primary objective is to address the challenges associated with parking by minimizing the time spent searching for parking spaces and eliminating unnecessary vehicle travel.

VI. MATERIALS AND METHODS

A. Problem

One common issue faced by drivers is the time-consuming process of finding suitable parking spaces. To address this problem, an automated car parking system has been developed. The objective is to provide assistive technology that offers parking information to registered customers through smartphone applications. By registering and booking in advance, users can receive details about available parking spaces, their destination, and estimated arrival time.

B. Scope

The proposed project aims to eliminate the need for human intervention in parking management, thus reducing labor requirements. The system automates the process of detecting vehicles and closing the gates by employing sensors and alarms. The project's benefits include increased efficiency and improved utilization of parking areas. Moreover, the system's versatility allows for potential applications in various domains, such as railway stations, apartment complexes, and military installations.

C. Project Goals

The primary goal of the smart car parking system is to identify the nearest available parking zone. Doing so, aims to address the parking problem by minimizing the time spent searching for parking spaces and eliminating unnecessary vehicle travel.

D. System Design and Implementation

Components Used:

1) IR Sensors: Infrared sensors are electronic devices used to detect the presence of objects. These sensors emit infrared light and analyze its reflection. If no light is detected, it indicates the absence of an object, whereas the detection of light signifies the presence of an object. In the context of the car parking system, IR sensors are employed to determine whether a vehicle is parked in a specific slot. This information is then transmitted to the user via a mobile app.
2) NodeMCU: The NodeMCU is an open-source firmware and development board designed for IoT (Internet of Things) applications. It utilizes the ESP8266 Wi-Fi module and the ESP-12 module. In this project, the NodeMCU serves as the central controller, responsible for managing all the connected peripherals.
3) 5 Volt AC Power Supply/NodeMCU 3.3V supply
4) Connecting wires, etc.

By combining these components, the automated car parking system achieves its objectives of providing real-time parking information and automating gate operations. The integration of IR sensors and the NodeMCU controller enables efficient management and utilization of parking spaces, leading to a more streamlined parking experience for users.

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E. Working

The operational process of the automated car parking system involves the utilization of IR sensors placed in front of each parking slot, facing the direction of the vehicles. These sensors are responsible for detecting the presence or absence of a car in front of them. Through the connection between the IR sensors and the NodeMCU, the collected data regarding the occupancy of each parking slot is transmitted to the NodeMCU controller.

Using the received information, the NodeMCU controller then communicates the current parking availability status to the driver via a mobile application. When a driver enters the parking area, they can conveniently access the mobile app to search for and identify the available parking slots in real time. With this knowledge, the driver can proceed to park their vehicle in an unoccupied slot, optimizing the parking space utilization.

To summarize, the IR sensors continuously monitor the presence of vehicles in front of each parking slot, relaying the data to the NodeMCU. The NodeMCU, in turn, communicates this information to the driver through the mobile application, enabling them to locate and utilize the available parking slots efficiently.

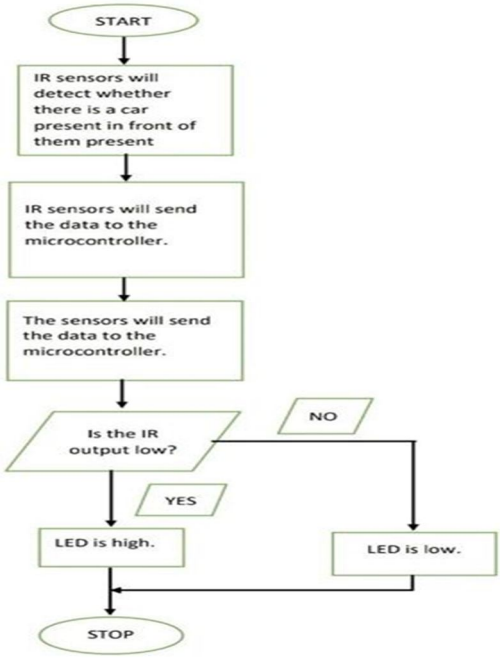

Fig 1. Flowchart of working of the circuit

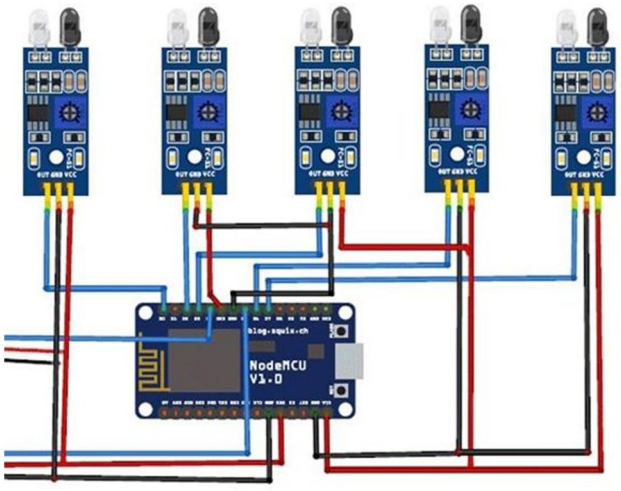

Fig 2. Circuit Diagram

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VII. RESULT AND DISCUSSION

The demand for smart parking systems is rapidly increasing due to their ability to provide real-time information about available parking spaces. However, current systems lack important features like parking reservations and real-time slot availability checks.

One existing approach uses a vision-based monitoring system that counts incoming and outgoing cars to estimate available parking slots. This method is time-consuming and requires a significant amount of effort. Another system relies on sensors that use ultrasonic sound waves to detect vehicle presence. Additionally, two-tier parking systems have been developed to maximize space utilization by parking cars on top of each other.

The objective of this research paper is to establish a connection between parking areas and the digital world, aiming to reduce time spent searching for parking and provide a cost-effective solution for users. The paper also seeks to address issues such as car theft and minimize fuel consumption associated with searching for parking spaces.

In essence, the paper emphasizes the need to enhance existing parking systems by leveraging technology to improve efficiency, reduce fuel consumption, and enhance the overall user experience.

Figure 3. Working Model

Figure 4. Working Model

VIII.LIST OF ABBREVIATIONS

ABBREVIATION	ILLUSTRATION
IR	Infrared
VPN	Virtual Private Network
IP	Internet Protocol
TCP	Transmission Control Protocol
IDS	Intrusion Detection System

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IX. CODE AND CODE OUTPUT

Define Blynk template ID, name, and authentication token.
Include necessary libraries.
Set Wi-Fi credentials.
Setup function:
Initialize serial console.
Connect to Wi-Fi and Blynk server.
Set pin modes.
Loop function:
Read the state of pin 16 and update virtual pin V0:
Read pin 16 and store the value in val0.
Update V0 with brightness value 255.
If val0 is HIGH, set the color property of V0 to green.
If val0 is LOW, set the color property of V0 to red.
Repeat the above steps for pins 5, 4, 0, and 2, updating virtual pins V1, V2, V3, and V4, respectively.
Call the setup() function once.
Enter an infinite loop and repeatedly call the loop() function

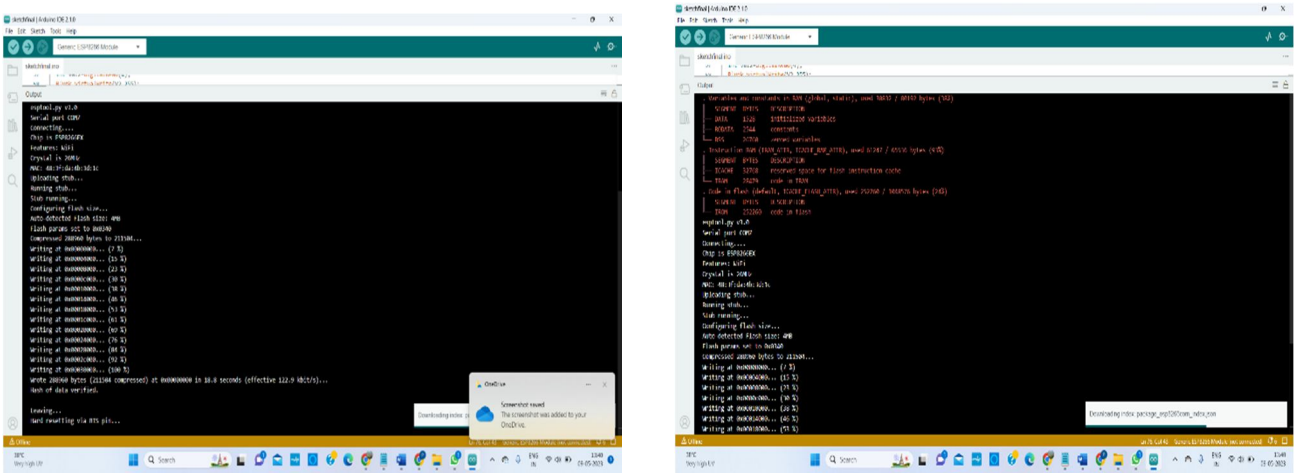

Fig 5. Screenshots of Arduino Environment

X. ADVANTAGES AND DISADVANTAGES

A. *Advantages*

Cost Savings: By driving more efficiently and locating parking spaces quickly, users can save money on fuel expenses, resulting in reduced petrol costs.
Optimized Parking: The smart parking system enables users to find the most suitable parking spot, saving time, resources, and effort.
Reduced Fuel Consumption: Directing drivers to available parking spaces minimizes unnecessary driving in search of vacant spots, leading to reduced fuel wastage and lower vehicle emissions.
Stress Reduction: The smart parking system alleviates the stress of drivers by simplifying the process of finding a parking space.
Reduced Traffic Congestion: With fewer drivers searching for parking, the smart parking system contributes to a decrease in traffic on the streets.

B. *Disadvantages*

Costly Infrastructure: Implementing the system requires an investment in expensive sensors and cables.
Maintenance Requirements: Regular maintenance of the sensors is necessary to ensure their proper functioning.
Limitations of Phone Detection: The system may not detect phones that are powered off or in airplane mode, as they are invisible to the sensor.

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XI. FUTURE WORK

The concept of smart cities has long been an aspiration, and recent advancements in Internet of Things (IoT) and cloud technologies have brought us closer to realizing this dream. Smart parking facilities play a crucial role in the development of smart cities. These facilities utilize real-time processes and provide information about available parking slots, thereby improving the efficiency of locating suitable parking spaces. By addressing the problem of traffic congestion, this paper focuses on enhancing user experience by saving time in finding parking. Looking ahead, future efforts can include features such as remote booking of parking spaces, integration with GPS systems, reservation facilities, and the utilization of license plate scanners in cars.

XII. CONCLUSION

The implementation of a smart parking system has become crucial in the development of smart cities. This presentation emphasizes the integration of a comprehensive solution for efficient parking management. The proposed system leverages the power of the Internet of Things (IoT) to accurately detect available parking spaces. Additionally, a user-friendly and visually appealing Android application was developed to enhance the overall experience. The system offers numerous advantages, such as time-saving capabilities, reduced pollution, and minimized fuel consumption.

A. Conflict of Interest

The authors declare no conflict of interest.

B. Author Contributions

Shreeya Ranwadkar and Paritosh Gogate researched about the topic in detail.
Paritosh went and bought the components required for the circuit, whereas Shreeya designed the circuit diagram and studied how to connect the components. We connected the components and built the model together. We also built an app using a cloud platform for our project.
Both of us made a report on the project and now have written this research paper.
Shamla Mantri and Uma Pujeri guided us throughout the way and are helping us with this paper.

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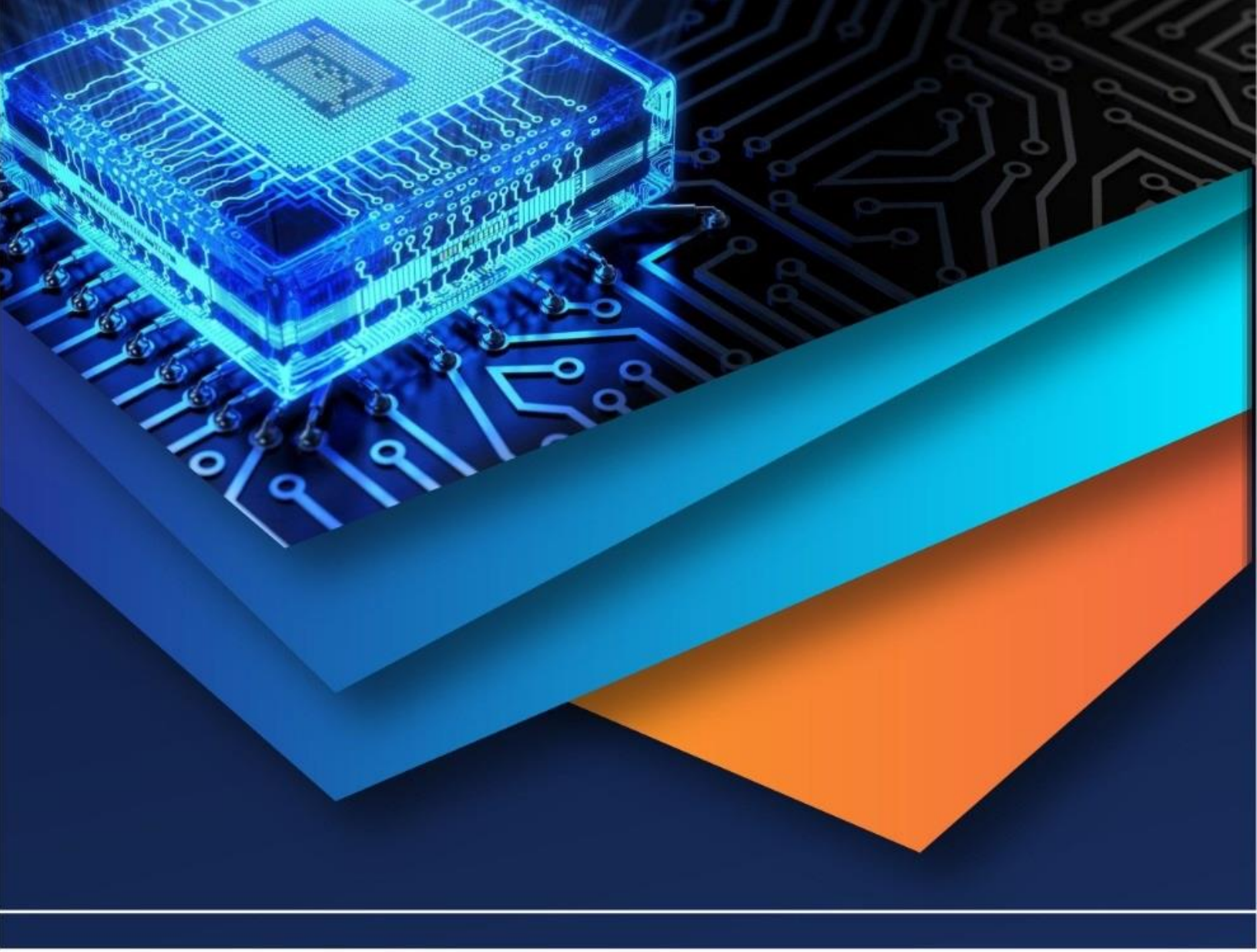

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