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iot - enabled digital vehicle parking systems using Machine Learning

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Abstract: In large cities, parking availability is a major problem. Car owners are confused by crowded reserved parking spaces during rush hour. To overcome this obstacle, modernizing the parking system is crucial. This research will conduct an in-depth and thorough literature review of past studies and project implementations to identify best practices and gaps in the existing research.

The goal is to analyze previous work comprehensively, highlighting successful approaches and areas where further investigation is needed.In this study aims to perform a detailed and comprehensive examinations of previous research and research executions to precise effective strategies and deficiencies in the current body of research.The objective is to thoroughly evaluate prior efforts,emphasizing successful methodologies and areas requiring additional investigation.A prototype of the digital vehicle Parking System is implemented via an Android application leveraging Firebase and IoT based on AI . This makes it easy for drivers to find parking spaces with assigned spaces.

It is recommended to use the Smart Parking Management System to handle the high volume of arrivals and departures. By monitoring and managing vehicle occupancy in real time, this system reduces pollution and energy. Additionally, it maximizes parking space usage and reduces consumption of time.

Keywords: IOT, Firebase, Parking, Vechile Occupancy, Obstacle, Rushhour.

I. INTRODUCTION

When machine learning algorithms are integrated with Internet of Things (IoT) technology, an IoT-based parking system yields a smart and efficient parking management solution. The system uses Internet of Things sensors, such as cameras, magnetic sensors, and ultrasonic sensors, to detect if automobiles are in parking slots. Real-time data on parking space occupancy is gathered by these sensors.

The Internet of Things sensors collect information about parking space availability, vehicle types, and entry/exit times. Subsequently, the information is routed to a central server or cloud platform for processing. For analysis and decision-making, machine learning algorithms are used to the collected data. These algorithms can include clustering, predictive models to forecast future parking demand, or anomaly detection algorithms to identify unusual parking habits.

Based on machine learning algorithm analysis, the system can efficiently lead drivers to available parking spaces in real-time. This can be accomplished using mobile applications, digital signs, or automated voice messaging. Machine learning algorithms can optimize parking spot allocation, forecast peak parking hours, and automate operations such as ticketing and reservation. This leads to better parking management, less congestion, and a better customer experience. The system provides useful information and reports to parking operators, city planners, and companies. These insights can help you make informed decisions about infrastructure upgrades, pricing strategies, and resource allocation.

II. RELATED WORKS

Distance and image sensors are used in parking space detection for autonomous and assistance systems. A distance sensor-based parking assistance system uses ultrasonic and lidar sensors to detect available space. The algorithm recognizes a parking spot as one that is equal to the width of the car, even if it is not a parking space. A parking assistance system uses distance-sensor-based parking slot identification to help users find a parking space.

However, it is challenging to implement in a fully automated parking system that determines a parking space and moves the vehicle accordingly.

Image sensors, such Around View Monitoring (AVM), can overcome the limitations of distance-based sensors by detecting parking spaces based on slot markers.

Image-based feature extraction can produce false positives due to other objects like shadows, automobiles, and guidance cones. AVM's false-positive features can lead to incorrectly identifying parking spaces. An AVM system recognizes a 3D object, such as a parked automobile, and distorts its shape to fit in a parking slot. If a parking slot marker detects a false positive, it may be incorrectly identified as an occupied or no-parking space, even if it is unoccupied.

III. PROJECT OBJECTIVE

A. *Personal Parking Recommendations*

1) *Data Collection:* Gather information about individual drivers' parking preferences, such as preferred parking spots, times of day, and days of the week they generally park. Data Analysis with Machine Learning: Analyze collected data using machine learning methods such as collaborative filtering or content-based filtering to identify patterns in drivers' parking preferences. Personalized Recommendation System: Create a recommendation system that uses machine learning insights to offer parking spaces based on each driver's preferences as they approach a parking facility.
2) *Dynamic Pricing Based on Demand Predictions:* Real-time Data Collection: Constantly gather real-time data on parking space occupancy, historical demand patterns, and external factors (e.g., events, weather) that may affect parking demand. Machine Learning Demand Prediction: Using historical data, train machine learning models, such as time series forecasting or regression models, to anticipate parking demand across various time periods. Dynamic Pricing Algorithm: Create an algorithm that adjusts parking pricing dynamically in response to expected demand, with the goal of balancing supply and demand and incentivizing behavior that optimizes parking use.
3) *Environmental Impact Monitoring:* Sensor Deployment: Install sensors in parking lots to monitor environmental elements like air quality (e.g., particulate matter, contaminants), noise levels, temperature, and humidity. Data Integration and Analysis: Link sensor data to the parking system and use machine learning methods like anomaly detection or regression to evaluate environmental data and uncover patterns, correlations, and anomalies. Optimization Strategies: Create optimization measures, such as modifying ventilation systems depending on air quality, optimizing lighting based on occupancy, or introducing green infrastructure solutions, to reduce environmental effect.
4) *Integration with Public Transportation Systems:* Data Integration: Combine parking availability data with public transportation system data, such as real-time schedules, routes, and service disruptions. Machine Learning for Integration: Use machine learning techniques like clustering or classification to identify the best parking-transit connections and promote smooth transitions between parking and public transportation. User Interface and Experience: Create a user-friendly interface, such as a mobile app or web platform, that gives drivers detailed information about parking availability, transportation options, and integrated navigation guidance.
5) *Predictive Maintenance of Parking Infrastructure Sensor Data Collection:* Install sensors in parking infrastructure such as meters, sensors, gates, and payment systems to capture operational data like usage patterns, performance metrics, and maintenance indicators. Predictive Maintenance Models: Train machine learning models, such as predictive maintenance models or anomaly detection algorithms, on past maintenance data to identify possible failures or maintenance requirements. Maintenance Alerts and Schedules: Implement a system for generating maintenance alerts, prioritizing maintenance jobs based on criticality and resource availability, and scheduling preventive maintenance to reduce downtime and interruption.
6) *Accessibility Improvements:* Accessibility Data Collection: Collect information about accessible parking spaces, such as their locations, features (e.g., width, signs), usage trends by drivers with impairments, and real-time availability. Machine learning for prioritization: Prioritize accessible parking spaces using machine learning techniques like classification or regression, taking into account previous usage patterns, demand trends, and real-time accessibility requirements. User Interface Enhancements: Improve the user interface of parking guidance systems so that drivers with disabilities may receive clear information and direction, including real-time updates on accessible parking availability and navigation help.
7) *Community Engagement and Feedback Loops:* Implement systems to collect input from community participants, such as drivers, local residents, businesses, and parking operators, on their parking experiences, issues, and suggestions for improvement. Sentiment Analysis: Using natural language processing (NLP) and machine learning, evaluate feedback data to uncover common themes, sentiment patterns, and areas of worry or pleasure. Actionable insights and improvements: Transform feedback findings into concrete improvements, including optimizing parking policies, addressing infrastructure issues, improving communication channels, or providing new services/features depending on community needs and preferences.

IV. OVERVIEW OF USED MACHINE LEARNING ALGORITHMS

Machine learning Algorithm	IoT, Smart City use cases	Metric to Optimize
Classification	Smart Traffic	Traffic Prediction, Increase Data Abbreviation
Clustering	Smart Traffic, Smart Health	Traffic Prediction, Increase Data Abbreviation
Anomaly Detection	Smart Traffic, Smart Environment	Traffic Prediction, Increase Data Abbreviation, Finding Anomalies in Power Dataset
Support Vector Regression	Smart Weather Prediction	Forecasting
Linear Regression	Economics, Market analysis, Energy usage	Real Time Prediction, Reducing Amount of Data
Classification and Regression Trees	Smart Citizens	Real Time Prediction, Passengers Travel Pattern
Support Vector Machine	All Use Cases	Classify Data, Real Time Prediction
K-Nearest Neighbors	Smart Citizen	Passengers' Travel Pattern, Efficiency of the Learned Metric
Naive Bayes	Smart Agriculture, Smart Citizen	Food Safety, Passengers Travel Pattern, Estimate the Numbers of Nodes
K- -Means	Smart City, Smart Home, Smart Citizen, Controlling Air and Traffic	Outlier Detection, fraud detection, Analyze Small Data set, Forecasting Energy Consumption, Passengers Travel Pattern, Stream Data Analyze
Density-Based Clustering	Smart Citizen	Labeling Data, Fraud Detection, Passengers Travel Pattern
Feed Forward Neural Network	Smart Health	Reducing Energy Consumption, Forecast the States of Elements, Overcome the Redundant Data and Information
Principal Component Analysis	Monitoring Public Places	Fault Detection
Canonical Correlation Analysis	Monitoring Public Places	Fault Detection
One-class Support Vector Machines	Smart Human Activity Control	Fraud Detection, Emerging Anomalies in the data

V. TYPES OF SENSORS

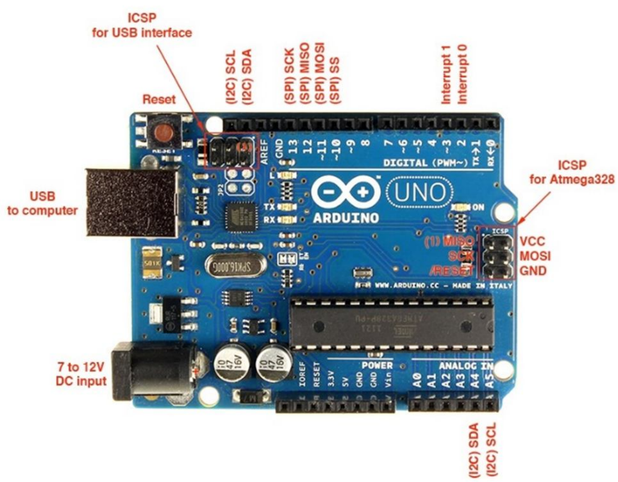

Fig.1. Arduino UNO

A programmable, open-source microcontroller board that is inexpensive, versatile, and simple to use, the Arduino UNO may be included into a wide range of electronic projects. This board has the ability to interface with additional Arduino boards, Arduino shields, and Raspberry Pi boards. Its output can be used to control relays, LEDs, servos, and motors.

Fig.2. LED Light

An orange light emitting diode and a green light emitting diode built of gallium arsenide phosphide are used to create high efficiency red and green bi-color LEDs. The uniform light output, extended lifespan, low power consumption, and solid-state dependability of this LED make it widely employed.

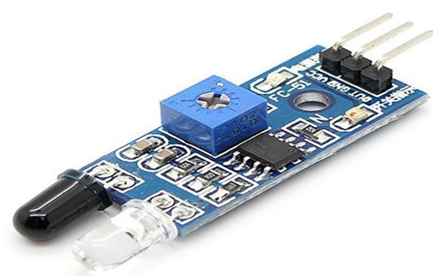

Fig.3. IR Sensor

In order to count the cars leaving, an IR sensor 2 is positioned after the DC motor. When every parking spot is taken, the sign "No space" will appear, and the gate won't open until there is still room inside the parking lot.

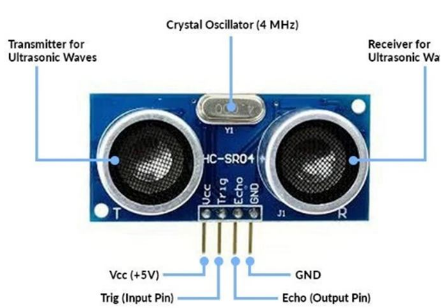

Fig.4. Ultrasonic Sensor

A device that uses ultrasonic sound waves to measure an object's distance is called an ultrasonic sensor.

VI. LITERATURE SURVEY

1) Short Message Service (SMS) Based Smart Parking Reservation System: This parking system uses a reservation system that allows users to reserve parking spaces via SMS services, which helps users save time. After processing the SMS, a Micro-RTU wireless communication device responds with the reservation details and booking confirmation. A PIC (Peripheral Interface Controller) microcontroller, which can store information about available parking spaces, assign passwords and grant or deny access to the reserved space, powers the entire automated system. Secure parking management and reservation system based on GSM and ZigBee. Existing solutions such as surveillance cameras and car tracking systems are too expensive and do not provide complete security.[3] It is proposed to implement an automated parking management system with two-way password security and infrared sensors to continuously detect the presence of parked cars.
2) A Wireless Sensor Network (WSN) is the proposed solution as it makes it easier for drivers to find available parking spaces. A low-cost wireless sensor network module monitors the parking lot condition and transmits real-time data to the central web server of the intelligent parking guidance system. This displays available parking spaces and uses image analysis to identify only cars. Due to the challenges of implementing this system without impacting existing facilities, not many parking spaces have used it.[4]
3) Modern Internet of Things (IoT) technology such as the proposed smart parking system is intended to solve urban infrastructure problems such as traffic congestion, lack of parking spaces and traffic safety. The deployment of the system uses Internet of Things modules that track the availability status of each parking space.[7] The Internet of Things (IoT) connects physical objects and devices and enables them to communicate with systems that process, receive, organize and analyze data through processes and services. It also allows data collection remotely.[5] The system now features Cloud of Things (CoT) technology, which allows nodes (objects) to be viewed, controlled and interacted with from any remote location via the cloud. The management of parking spaces and traffic management systems is one of the main problems of urban areas. The goal of the intelligent parking system is to reduce search times, traffic jams and collisions on the roads by using parking resources more effectively.[6] Various IoT devices have already been installed in several modern cities for testing purposes to provide users with real-time data on parking availability.'

VII. MACHINE LEARNING ALGORITHMS

ALGORITHM 1: Algorithm for Training CART

Input: labeled training data set $D = \{(x_i, y_i)\}_{i=1}^{N}$.

Output: Classification or regression tree.

FITTREE(0, D, *node*)

function FITTREE(*depth*, R, *node*)

if *the task is classification* **then**
node.prediction := most common label in R

else
node.prediction := mean of the output vector of the data points in R

end

(i^*, z^*, R_L, R_R) := SPLIT(R)

if *worth splitting and stopping criteria is not met* **then**
node.test := $x_{i^*} < z^*$

node.left := FITTREE($depth + 1$, R_L, *node*)

node.right := FITTREE($depth + 1$, R_R, *node*)

end

return node

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ALGORITHM 2: K-means Algorithm

Input: K, and unlabeled data set $\{x_1, \ldots, x_N\}$.

Output: Cluster centers $\{s_k\}$ and the assignment of the data points $\{\pi_{nk}\}$.

Randomly initialize $\{s_k\}$.

repeat

  for $n := 1$ *to* N **do**

    for $k := 1$ *to* K **do**

      if $k = \arg\min_i \|s_i - x_i\|^2$ **then**

        $\pi_{nk} := 1$

      else

        $\pi_{nk} := 0$

      end

    end

  end

  for $k := 1$ *to* K **do**

    $s_k := \frac{\sum_{n=1}^{N} x_n \pi_{nk}}{\sum_{n=1}^{N} \pi_{nk}}$

  end

until $\{\pi_{nk}\}$ *or* $\{s_k\}$ *don't change*;

ALGORITHM 3: PCA Algorithm

Input: L, and input vectors of an unlabeled or labeled data set $\{x_1, \ldots, x_N\}$.

Output: The projected data set $\{z_1, \ldots, z_N\}$, and basis vectors $\{w_j\}$ which form the principal subspace.

$\bar{x} := \frac{1}{N} \sum_n x_n$

$S := \frac{1}{N} \sum_n (x_n - \bar{x})(x_n - \bar{x})^T$

$\{w_j\}$:= the L eigenvectors of S corresponding to the L largest eigenvalues.

for $n := 1$ *to* N **do**

  for $j := 1$ *to* L **do**

    $z_{nj} := (x_n - \bar{x})^T w_j$

  end

end

VIII. COMPARATIVE ANALYSIS

Paid Parking: This arrangement allows customers to purchase a ticket from a machine and place it on the dashboard of their vehicle. Limitations: Dependence on manual ticketing; limited payment options; Inability to extend parking time. Features of smart parking meters include time-based parking fees, digital payment methods and enforcement systems. There is a lack of real-time availability information, users need to find available seats, and maintenance issues can arise. Automated vehicle identification and ticketless entry and exit are enabled by LPR (Licensing Plate Recognition) systems. - Limitations: Accurately reading license plates can be challenging, and not all parking lots have access to all technologies. Parking aggregation platforms offer the following features: real-time availability, booking options, and consolidation of parking data from multiple sources. - Limitations: Relies on data from parking managers; Coverage is patchy in places; The accuracy of real-time availability may be affected.

1) *Real-time Availability:* Parking aggregators, parking guidance systems and RFID-based systems perform better than traditional systems in terms of real-time parking availability.

2) *Ease of Use:* Features such as personalized user profiles, mobile payments and reservation options are made easy to use through RFID-based systems and mobile parking applications.
3) *Compatibility and Integration:* When combined with current payment and infrastructure systems, RFID parking aggregators and systems work incredibly well.
4) *Predictive Capabilities:* Parking aggregators and RFID-based systems may be able to make predictions based on historical data and user trends.
5) *Utilization of Space:* Smart parking meters and parking guidance systems work to make optimal use of available space, while traditional parking systems usually struggle with inefficient space distribution
6) *Security:* RFID-based systems and license plate recognition systems provide enhanced security measures by combining surveillance and vehicle identification.

IX. GAP OF THE EXISTING SYSTEM (LIMITATIONS)

1) *Lack of real-time Parking Availability:* Many of today's parking systems struggle to provide accurate and timely information about parking availability. Users often rely on outdated information or encounter discrepancies between what is provided and what is actually available at the parking lot.
2) *Inefficient use of Space:* In traditional parking systems, inefficient use of space is often caused by manual ticketing or the lack of sophisticated algorithms. This results in some parking spaces being overcrowded and others being empty.
3) *Limited Prediction Capabilities:* Most parking systems are unable to predict future parking availability based on historical data, events, or user patterns. This increases the likelihood of encountering full parking spaces and makes it difficult for users to plan ahead for parking.
4) *Manual Ticket Creation and Validation:* Systems that still rely on these manual processes are more likely to experience errors, delays, and longer wait times. This could annoy users and reduce the overall efficiency of the parking process.
5) *Lack of Personalized user Experience:* Many of the systems in use today do not provide users with personalized experiences. Often, users have to go through tedious and time-consuming repetitive processes, such as providing payment details or vehicle details for each parking transaction.
6) *Limited Payment System Integration:* Some parking systems only accept m5. Lack of personalized user experience: A large number of current systems do not provide users with personalized experiences. Users are often required to complete tedious and time-consuming repetitive tasks, such as providing payment information or vehicle information for each parking transaction
7) *Inadequate Security Measures:* Some parking systems may not have strong security features such as CCTV cameras, access control systems, or vehicle authentication protocols. This can lead to concerns about car safety and illegal parking in parking lots. Mobile and contactless payments or they are only partially integrated into other payment systems. For those who prefer alternative payment methods, this might be inconvenient.
8) *Complicated Reservation Processes:* It may be difficult for users to reserve parking spaces in advance as certain reservation systems have complicated or complex reservation processes. Reservation features that are difficult to use, have limited availability, or have unclear reservation policies may result in them being less popular.
9) *Insufficient user Support:* Some parking systems lack comprehensive help, such as easily accessible help pages, customer service channels, or self-service options. This could annoy users and make it more difficult for them to resolve problems or get help when they need it.

X. PROPOSING SYSTEM

To differentiate this product from others, it includes the following:

1) *Predictive Analytics:* Leverage machine learning algorithms to predict parking availability in advance, saving drivers time.
2) *Mobile App:* An easy-to-use app that allows drivers to pay their parking fees, check their parking history and reserve spaces in advance To allow drivers to pay for parking without getting out of the car, install a smart payment system in addition to the parking system.
3) *Security Features:* Install security features such as CCTV cameras and alarms to prevent theft and vandalism.
4) *Smart Reservations:* Allow customers to reserve parking spaces in advance via an RFID-based system. Since it guarantees availability and allows users to plan their parking space in advance, this feature reduces the time wasted searching for parking.

5) *Automated Valet Parking:* Use an RFID system in conjunction with autonomous vehicle technology to offer automated valet parking services. To make the most of available space, customers can park their cars in designated areas and the system will park them automatically.

Offer users the ability to store details about their cars, parking preferences and payment methods by creating personalized user profiles in the system. The system can then provide individual recommendations and an experience tailored to each individual user based on their individual preferences.

XI. CONCLUSION

Humanity has always dreamed of smart cities. Significant progress has been made in the development of smart cities in recent years. The expansion of cloud computing and the Internet of Things has opened up new avenues for creating smart cities. The basis for the creation of smart cities has always been intelligent parking structures and traffic management systems. In this paper, we discuss parking and present an Internet of Things (IoT)-based cloud-integrated smart parking system. Our proposed system allows users to obtain the most up-to-date information about available parking spaces in a parking lot. Our mobile application allows users living in remote areas to reserve a parking space for themselves. The purpose of this essay is to improve a city's park system, which will benefit the quality of life of its citizens.

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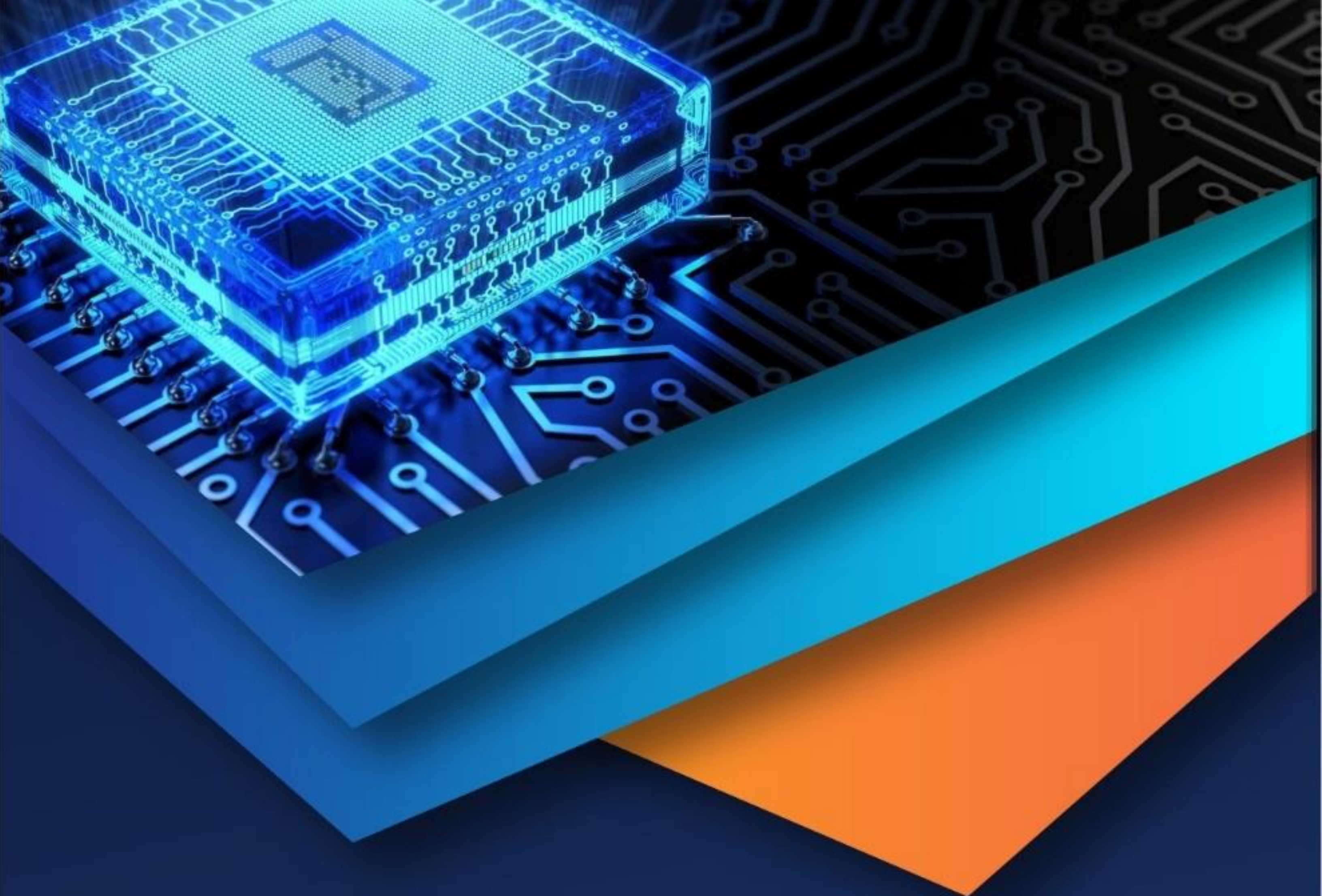

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