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Smart Parking using Image Processing and Deep Learning

G Basanthi[1], Dr. D. Sivaraj[2]
[1]*B.E , ECE PSG college of Technology (Final Year)*
[2]*Assistant professo; ECE Dept; PSG college of Technology*

Abstract: ***In the modern world proportion to the technological growth the problems caused by them are also increasing. With the increase in the number of cities, people have started to struggle with traffic congestion and inadequate parking availability. In this study, a more adaptable and affordable smart parking system using distributed cameras, edge computing, data analytics, and advanced deep learning algorithms is designed. Cameras with motorized head and zoom lenses are deployed to capture registered numbers by tracking the vehicles when they enter or leave the parking lot.***
Keywords: Deep learning, Data analytics, Neural networks, Image processing.

I. INTRODUCTION

Nowadays urban areas are in great need of smart parking solutions. According to recent studies on parking, a motorist spends an average of 17 hours per year searching for a place to park his vehicle. This is the reason for the great demand for parking solutions. To balance the cost and service quality, a system that helps in monitoring the parking lot using a distributed network of cameras is designed. One camera can cover a large area instead of covering an individual parking spot. In order to provide services like allocation of a free parking lot to a vehicle, continuous vehicle tracking and feature extraction via the camera network are performed. Specifically, cameras with zoom-lens and motorized head are deployed to capture license plate numbers by tracking the vehicles when they enter or leave the parking lot.

Other cameras with wide-angle fish-eye lens will cover large parking spaces, and detect the parked areas using artificial intelligence. Deep learning algorithms will be used to identify occupied, vacant, and special parking spots, for example, disabled parking signs, carpool signs. Through the intelligent algorithm, one can significantly reduce the number of sensors and cameras of existing systems, while achieving a higher level of service quality. To further reduce the computational complexity of the deep learning algorithms, the proposed system consists of a custom convolutional neural network that can be run on top of edge devices in real-time. When compared with existing state-of-the-art approaches, our solution can achieve the same level of detection accuracy with lower computational complexity.

Along with the detected license plate numbers of vehicles, our system performs data fusion and object association from multiple cameras and enables applications such as keeping track of the duration of a vehicle's stay in a particular parking spot. The overall system will help motorists in navigating to a vacant spot with ease and will also help in charging them based on the exact amount of time the vehicle has been parked in the parking lot.

II. EXISTING WORK

An Edge-based Smart Parking Solution Using camera Networks and Deep Learning(1) uses distributed cameras, edge computing, data analytics and advanced deep learning. They deploy cameras with a zoom lens to capture license plate numbers and wide-angle fish-eye cameras to monitor the large parking area. The algorithms are optimized by deep learning to provide a more adaptable and intelligent solution. Smart Parking Reservation using Short Message Services(2)is developed in such a way that users book their parking spots through SMS. The SMS sent will be processed by micro-RTU. The micro-RTU will reply to the confirmation of booking by giving the details of reservation like password and lot number. Should they exceed the time, the password will expire and they will be notified through SMS. Zigbee and GSM based Secure Vehicle Parking Management and Reservation System(3) is developed in such a way that users book their parking spots through SMS. The SMS sent will be processed by micro-RTU. The micro-RTU will reply to the confirmation of booking by giving the details of reservation like password and lot number. Should they exceed the time, the password will expire and they will be notified through SMS. Smart Parking Service based on Wireless Sensor Networks(4) scheme consists of wireless sensor networks, embedded web-server central web-server and mobile phone applications. In the system, low-cost wireless sensor networks modules are deployed into each parking slot equipped with the sensor node. The

state of the parking slot is detected by the sensor node and is reported periodically to embedded web-server. This information is sent to the central web-server using Wi-Fi networks and so the vehicle driver can find vacant spots using a mobile application. An Intelligent Parking Guidance and Information System by using Image Processing Technique(5) objective is to design parking guidance and information system is using S3C2440 which is a 32-bit microcontroller which has features of image and video processing.

Classification algorithms have been proposed for detecting the only car at a particular parking slot. To design this car parking system they have used ARM9 microcontroller, Webcam and GSM module. The webcam finds the free slots for parking. If any person wants to book the slot, send a slot number through SMS. After receiving the information the controller keeps the slot free for minutes time and also sends the message as slot booked to that particular person. Wireless Sensor Network (WSN) and RFID for Smart Parking System(6) introduces the Parking Guidance Information System (PGIS) based on WSN. A sensor network that carries all information about the parking space from the sensor node of the management center via Zigbee. The sensor network and the information and management center constitute a PGIS.

This system can be conveniently installed in the parking lots. There is no need to change the existing parking system and it is compatible with the existing wired networks. New "Smart Parking" System based on Resource Allocation and Reservations(7) approach solves a mixed-integer linear programming (MILP) problem at each decision point with a guarantee that there is no resource reservation conflict and that no driver is ever assigned a resource with a cost function higher than the current cost function value. This system reduces the average time to find a parking space and the parking cost, whereas the overall parking capacity is more efficiently used. Intelligent Parking Management System Based on Image Processing(8) based method of detecting the availability of a car park was modeled.

This system consists of finding car park coordinates from an empty car park, acquiring an image with cars, converting the image to black and white for simple analysis, removing noise and determining whether parking slots are filled or vacant. The current limitation in this paper is the weather conditions and it can be improved by filtering the image in a high-quality transform, so the camera can detect the parking lots in any weather conditions. Automatic Parking Management System and Parking Fee Collection based on Number Plate Recognition(9) implements a convenient automatic parking system that can collect parking fees without hassles of using magnetic cards.

The auto parking system will able to have less interaction between humans and use no magnetic cards. In addition to that, it has a parking guidance system that can guide the user towards a parking space. This system presents the algorithm-based method for license plate extraction from car images and also develops an electronics parking fee collection system based on number plate information.Automated Parking System with Bluetooth Access(10) aims at developing a fully automated parking system for two-wheelers and cars.

For authentication and owner's identification, the parking system has an inbuilt Bluetooth reader. The users have to start their mobile's BlueTooth for identification and registration. The BlueTooth reader fetches the user's BlueTooth number and transfers it to the database. The user has to restart their BlueTooth at the time of exit. This eliminates the use of tokens or paper bills. The space management and automation are performed with the help of an ARM microcontroller which controls the mechanical motors to park the vehicles at an appropriate parking location.

III. METHODS

The entire system consists of

1) A network of ground cameras which are placed close enough to the ground to capture license plate numbers of vehicles
2) A network of top-view cameras whose view when combined will cover the entire area of the parking lot
3) A cloud server and database which will be used to hold information such as the occupancy status of all the slots, license plate numbers of vehicles that are parked in the lot along with entry and exit time-stamps for each vehicle
4) A web application that will display all the relevant and necessary information.

A. *Network Of Ground Cameras*

The ground cameras need to be appropriately focused as they are responsible for having a clear view of the license plate number of vehicles that enter and leave the parking lot. We choose the low-cost Raspberry Pi (Rpi) camera and fit with a zoom lens to achieve the required focus. The Rpi runs algorithms for the license plate

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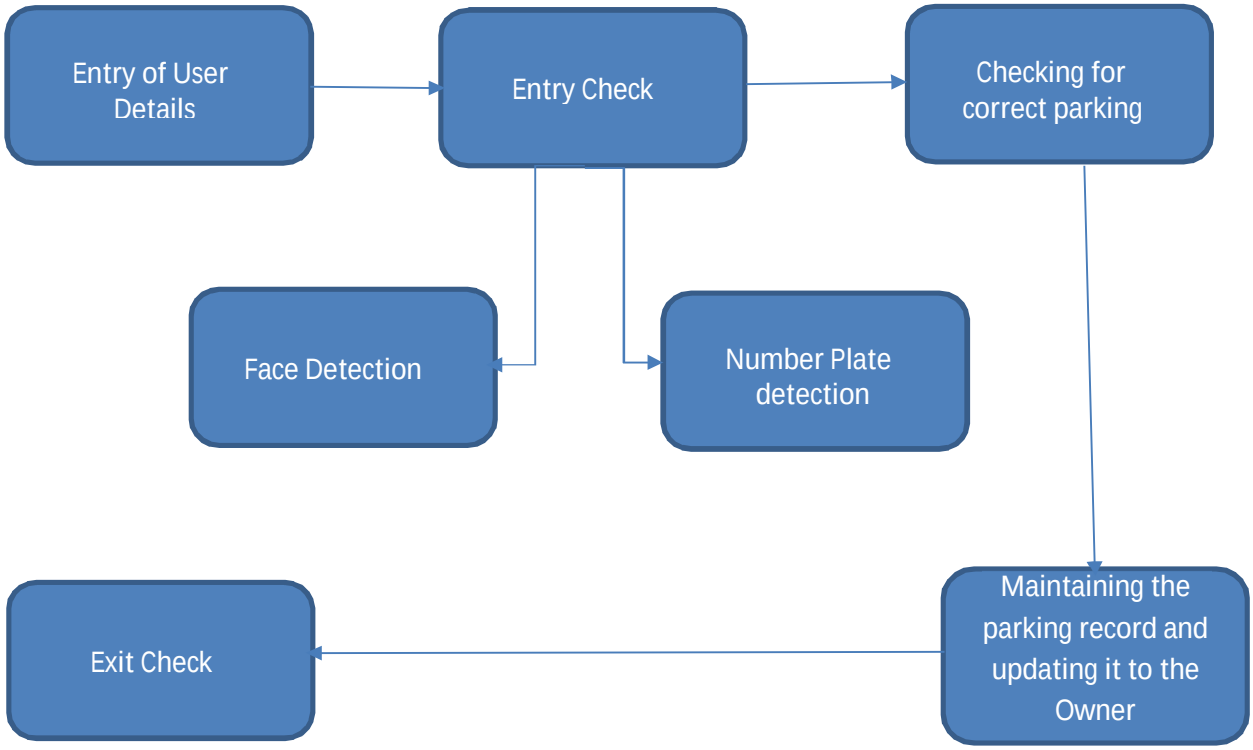

Fig 1. Block Diagram of the proposed solution

B. Network Of Top View Cameras

The top view cameras have a bird's eye view of the entire parking lot. The view of all these cameras when combined will cover the whole parking lot. Rpi cameras have been selected for the top view as well but they are fitted with wide-angle lenses. The fees from the cameras are used to identify the occupancy status of each slot, performing feature extraction from the top view and tracking vehicles until they are parked.

C. Cloud Server And Database

The data generated from the edge devices is sent to the cloud using the MQTT protocol. All the edge devices are registered to AWS IOT as "things". AWS IoT allows tracking of all the devices connected to it. The IoT certificates and policies should be added to the device. Once the device is connected to AWS, a rule should be defined which will help in communicating with the database. A dynamo dB was used for storing the license plate numbers, parking slot information and features of vehicles.

D. Web Application

The web application will display all the useful information such as the vacant and occupied slots and will be help users in navigating to vacant spots. It will contain a feature that will allow users to detect the exact location of their vehicle by entering their license plate number along with a feature that will allow users to pay their parking fare online.

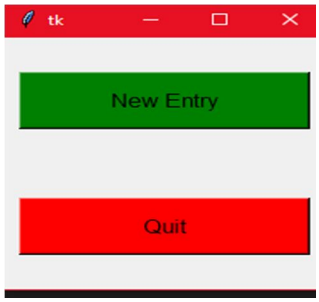

Fig 2: Main GUI

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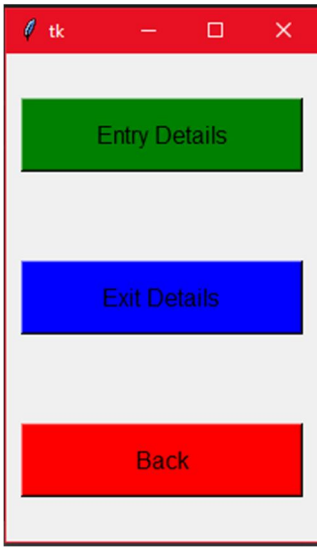

Fig 3: Entry or Exit details

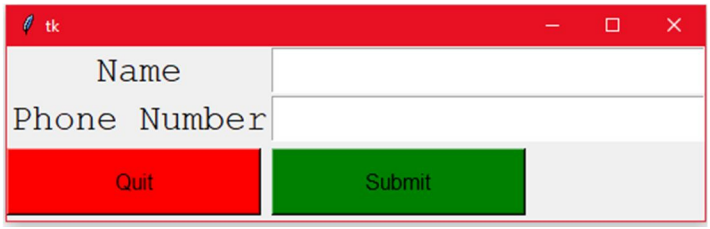

Fig 4: Entry of details

IV. RESULTS

A. Face Detection

A siamese neural network is an artificial neural network that uses the same weights while working in tandem on two different input vectors to compute comparable output vectors. Often one of the output vectors is pre-computed and is used for the comparison with the input vector.

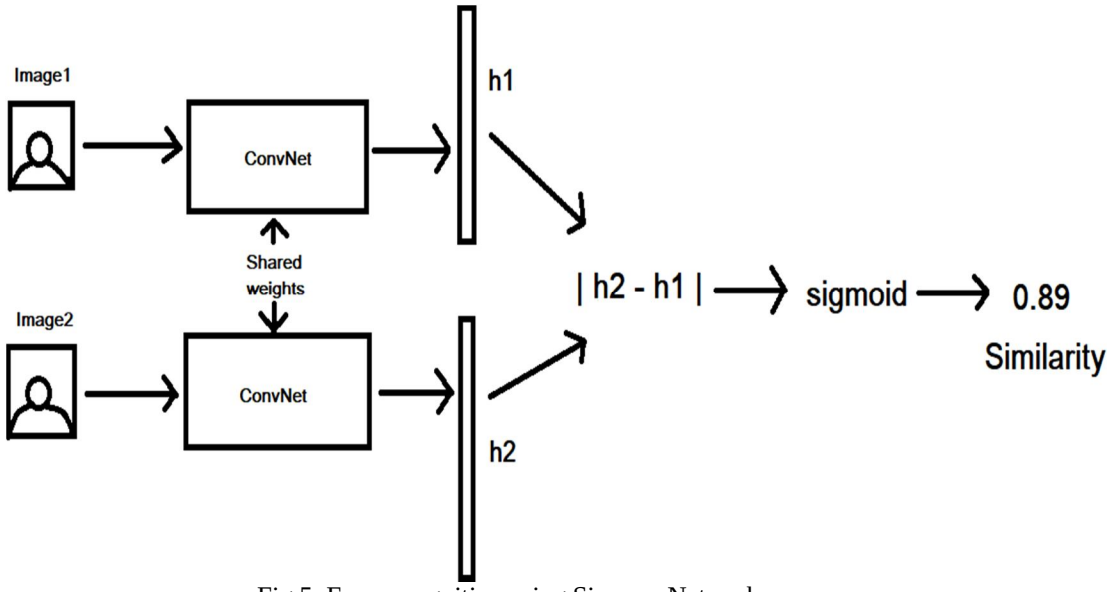

Fig 5: Face recognition using Siamese Networks

1) We take two images (*Image1* and *Image2*). Both the images are feed to a single Convolutional Neural Network (CNN).
2) The last layer of the CNN produces a fixed size vector (embedding of the image). Embeddings are obtained based on the number of images. (*h1* and *h2*).
3) The absolute distance between the vectors is calculated.
4) The values then pass through a sigmoid function and a similarity score is produced.

a) Output

Driver Face Detection

B. Parking Spot Detection

1) Algorithm Used: YOU ONLY LOOK ONCE (YOLO)

The convolution network simultaneously predicts the class probabilities and bounding boxes. YOLO trains the full images and directly optimizes detection performance. The YOLO algorithm is extremely fast and efficient. To predict the registered number of the vehicle the algorithm was run only once.

YOLO uses a totally different approach which is more efficient and significant. A single neural network was applied to the full image. Then this image is divided into regions and predicts bounding boxes and probabilities for each region.

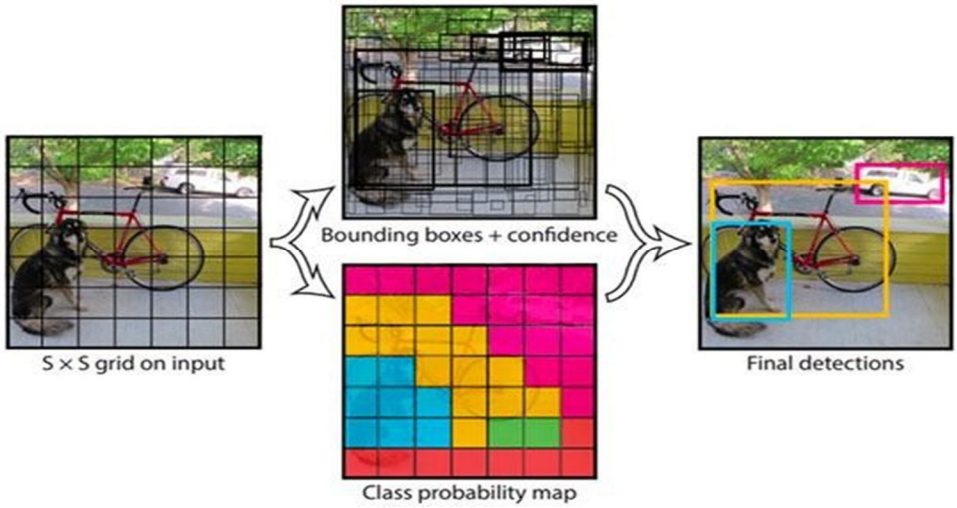

Fig 6: object detection using the one-shot algorithm

Image is converted into a grid of 13 by 13 cells: which are responsible for predicting 5 bounding boxes. The bounding box describes the object that is enclosed in the rectangle. YOLO predicts a confidence score which tells us the certainty of the predicted bounding box actually encloses some object.

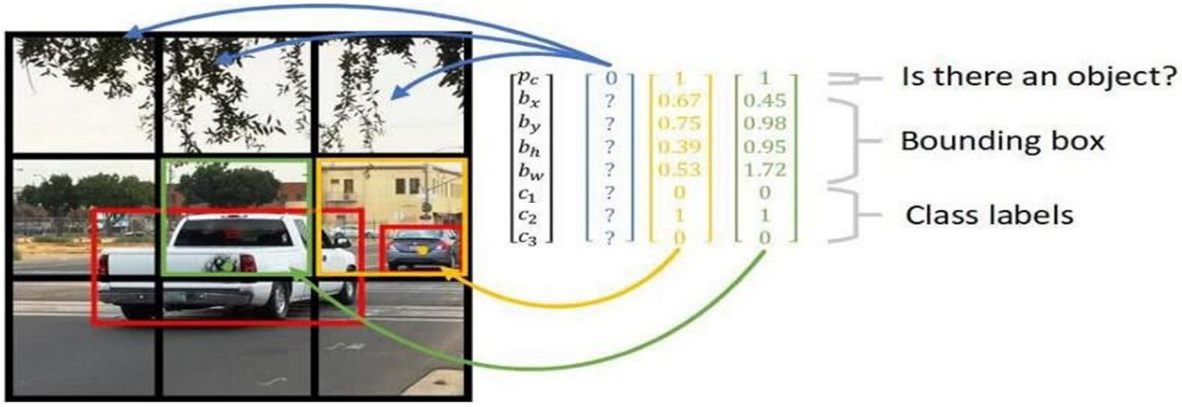

Fig 8: YOLO object detection

2) Output

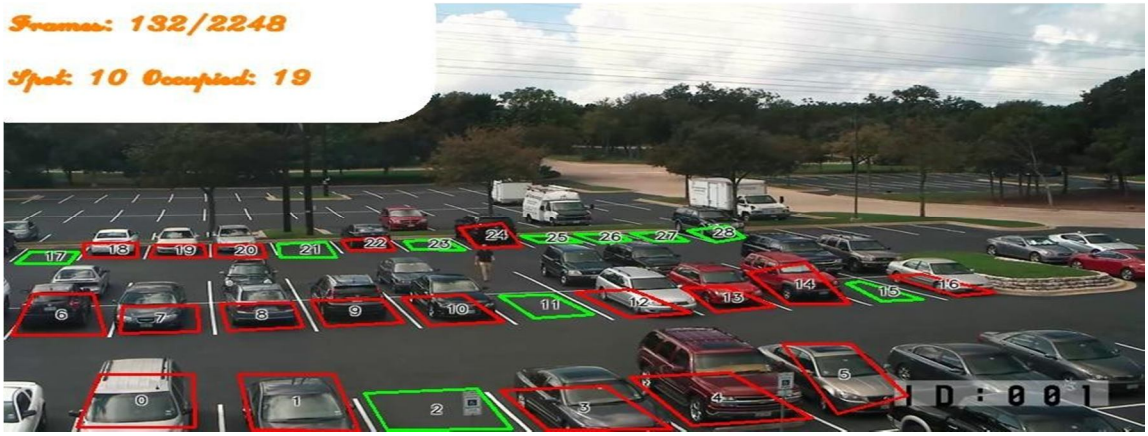

Fig 7: identification of vacant parking spots
green: vacant
red: occupied

C. Number Plate Detection

1) Algorithm Used: OPTICAL CHARACTER RECOGNITION (OCR)

Vehicle identification can be performed with the number plate detection as there is a unique identity for each vehicle. OCR is an image processing technology that identifies vehicles by their own number plates. This algorithm has wide application areas such as toll plaza, parking area, high-security areas, border areas, etc.

Automatic number plate recognition has three major parts: extraction of the number plate from the vehicle, character segmentation and displaying it in a text form.

Fig 9: Actual car image

Fig 7: a Cropped image of number plate

2) Detected Text: DL7CQ1939

V. CONCLUSIONS AND FUTURE SCOPE:

The proposed system is an economically feasible solution for solving parking problems. Our solution overcomes the disadvantages of currently existing non-vision based solutions and also adds more useful features to vision-based techniques such as license plate detection and vehicle tracking. A custom network model has been developed for identifying vacant slots in parking lots.

From the obtained results, one can observe that there is a huge reduction in the inference time for the custom network model when compared to the standard AlexNet and mAlexNet.

Our future work includes increasing the speed and accuracy of the object detection model and establishing a link between the ground cameras and top-view cameras to achieve object tracking.

A. Case Study

Fig 5: PSG Tech parking lot

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Fig 6: space allotted for car parking

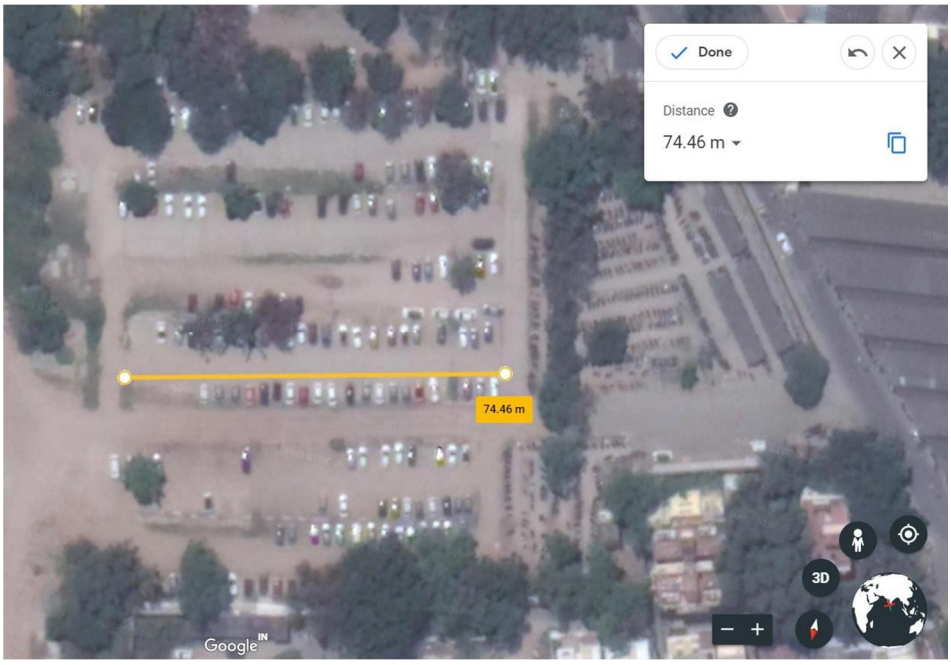

Fig 7: Calculation of row length

Total Number of Rows = 13

1) Length of One parking Row (RL) = 75 meters
2) Length of a car plus Door opening space (CL) = 2.5 meters
3) Total Number of cars that can be parked in one row = 30
4) Total Number of cars that can be parked in PSG TECH PIONEER MILL PARKING = 390.

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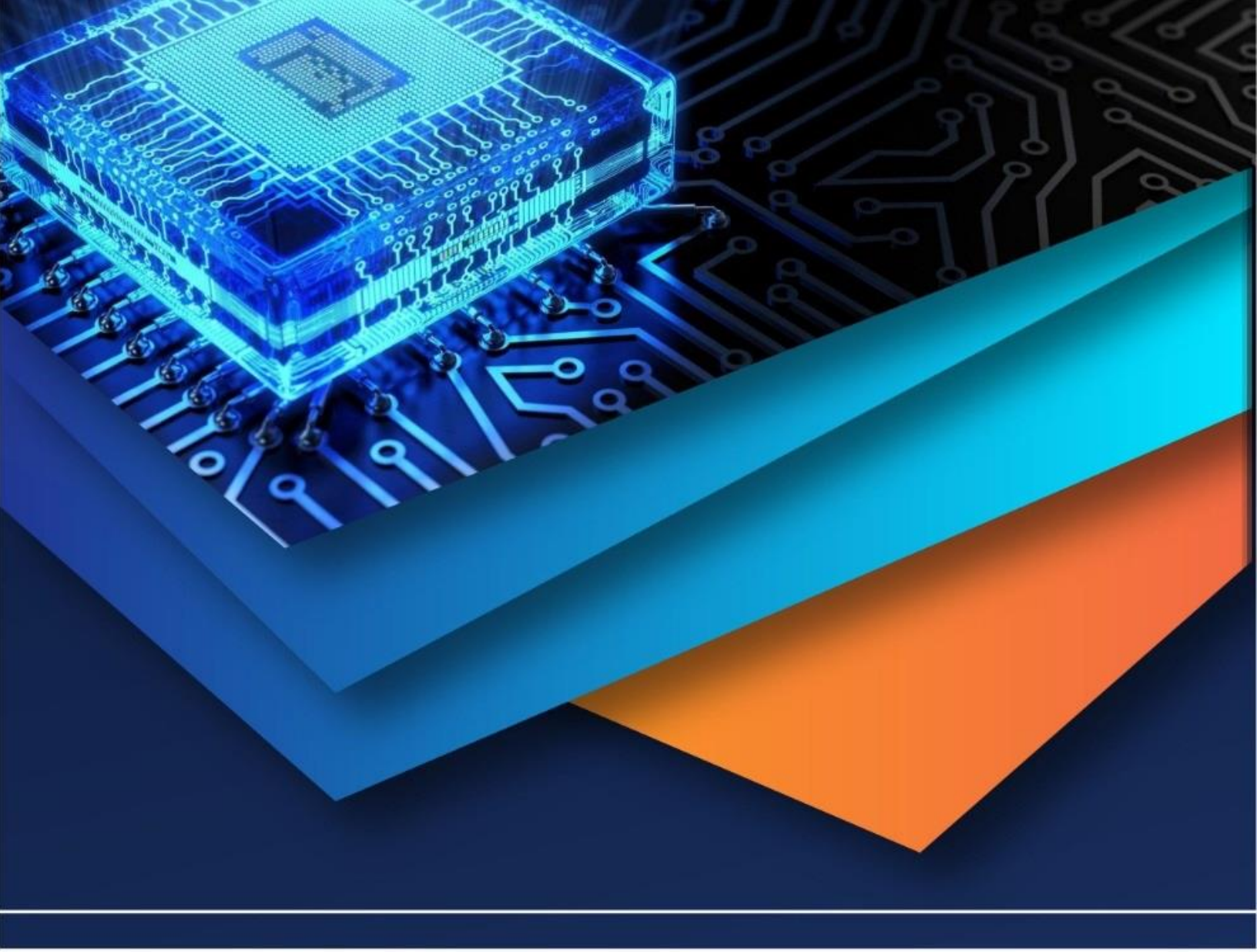

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