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Smart Automated Parking System using IoT

G.SUSEELAMMA[1], M.JOSHNALAKSHMI[2], K.BINDHUPRIYA[3], M.SESHANJANEYULU[4], SK.SADHIK[5]

1, Associate Professor, Dept Of Electronics And Communication Engineering, Tirumala Engineering College, 2,3,4,5, Ug Students, Dept Of Electronics And Communication Engineering, Tirumala Engineering College

Abstract—

In response to the escalating challenges posed by urbanization and the exponential rise in metropolitan vehicle numbers, the necessity for secure parking facilities has become increasingly paramount, particularly around institutions like schools and shopping malls. Addressing thisneed, a revolutionary autonomous infrared (IR) sensor- based parking system is proposed in this paper. Byharnessing cutting-edge technologies and affordable smart devices, this system operates seamlessly without human intervention, aligning perfectly with the overarching objectives of smart city initiatives: bolstering economic growth and enhancing residents' quality of life. The suggested architecture integrates an array of components including RFID readers and labels, servomotors for entrance control, personal computers, programmable operating systems, and light-emitting diodes (LEDs). This comprehensive framework not only ensures operational efficiency but also offers versatility across various applications. Crucially, the system grants parking accessexclusively to authorized members, enhancing security measures and mitigating the risk of vehicle theft or intrusion. At the heart of this innovation lies the Node MCU, an open-source Internet-of-Things (IoT) platform,which plays a pivotal role in data transmission. Upon scanning a vehicle's RFID tag, the Node MCU communicates slot availability to the Arduino microcontroller, which then allocates parking spaces and displays pertinent information on an LCD screen. By adopting this architecture, institutions like schools can significantly reduce the vulnerability of vehicles to theft or vandalism, instilling a sense of assurance among members, particularly students, regarding the safety of their automobiles. Moreover, the system's ability to autonomously manage vehicle access and egress ensures individual users' vehicles remain securely parked at all times, further enhancing overall security and peace of mind.

Keywords— Pull up lot, LCD Display, IR sensorbased detection, NodeMCU, Servo Motor, Check-in.

I. INTRODUCTION

The Radio Frequency Identification Device (RFID)stands as an innovative apparatus which, through the transmission of radio frequencies, serves the purpose of identifying or signaling its user. At present, the RFID system

(1) stands as the most advanced inventory management system available, facilitating wireless data transfer via radiofrequencies. The utilization of RFID technology has demonstrated favorable outcomes and benefits, notably reducing manual interactions and enhancing automation levels within operational processes (2).

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RFID technology boasts a diverse range of applications and proves highly effective. Its invention has significantly broadened its applicability, offering a heightened level of security compared to alternative technologies. The incorporation of RFID tags plays a pivotal role in advancing tracking technologies.
The progression of RFID (3) could potentially provide a framework for the unequivocal proof of car ownership, whether through automated or manual means. Parking lots can be efficiently managed, with vehicles being easily identified. RFID technology grants authorization for vehicles to enter and exit parking lots at predetermined, convenient, and secure times. The functionality of theentrance and exit module is substantially regulated by frameworks, with design considerations encompassing barriers.

The implementation of planned processing of entrance routesand detectors enables a first-come, first-serve parking allocation system, facilitating proactive planning for multiple segments or exits simultaneously. RFID readers play a crucial role in circumventing check-in and check-out bottlenecks, enabling real- time inventory management. The primary impetus behind this development is the utilization of RFID technology to resolve issues encountered in parking lots, ultimately leading to their resolution. Key components of RFID innovation include RFID trackers, RFID tags, and servo motors (4). Additionally, computer software has been tailored to manage administrative, operational, and reporting tasks for parking components within institutions.

Pull-up lot passage and exit-way management can be effectively facilitated through a framework incorporating Radio Frequency Identification for users, entryways, and RFID labels, all tailored to specific requirements. A non-manual framework has been devised to potentially replace manual pull-up lot administration operations. In instances of insufficient parking space, systematic safety measures have been implemented (5). As aresult, vehicles on the brink of entering the gate will be denied access, eliminating the need for additional time to park.

II. RELATED WORK

A thorough literature review on smart parking systems spanning thepast four decades has been conducted, focusing on select topics for discussion (6). An innovative Smart Vehicle Parking System integrating Wireless Sensor Networks (WSN), Radio FrequencyIdentification (RFID), and Internet of Things (IoT) technologies is proposed by the author. The research aims to provide optimal solutions for customers, enabling them to reduce time spent searching for parking spots, save on fuel costs, and alleviate traffic congestion.

The study presented in the International Conference on Sustainable Computing and Data Communication Systems(ICSCDS-2023) delves into various reservation techniques, including cloud-based and IoT approaches, to identify availableparking zones in urban areas. Implementation of these techniques is envisioned to realize the full potential of smart city concepts while prioritizing customer security and convenience (7). Utilizing Global Positioning System (GPS) technology along with a range of sensorssuch as Infrared (IR), RFID, and GSM, the framework offers real- time information on nearby parking lots, enhancing accessibility forcustomer. Another

study introduces an IoT-based parking system designed to identify vacant parking slots through sensorsinstalled ineach spot. Signals indicating availability are communicated to a microcontroller, enabling customers to reserve parking spaces via mobile applications. Users input personal information to initialize the system and can pre-reserve parking spaces before arrival, optimizing the parking experience (8).

Additionally, a defended system combining WSN, RFID, and IoT technologies is proposed for parking autonomous vehicles. This system integrates intelligent monitoring, control, and administration features, enhancing traffic organization and safety while minimizing administration costs (9). A machine- learning-based smart parking estimation system is proposed for urban environments, featuring event-driven communication protocols to facilitate data exchange among transportation modules. This system aims to optimize parking allocation and fee calculation based on real-time and predicted occupancy data(10). Furthermore, an Internet of Things Recommender (IOTRec) is introduced for smart parking systems, offering GDPR-compliant suggestions for parking spots and routes based on IoT data. The architecture incorporates microcontroller-based Bluetooth Low Energy (BLE) boards anddurable sensors for reliable operation (11).

A study titled "Remote Detector System and RFID for Smart Parking Framework" proposes a comprehensive system comprising monitoring and control modules for vehicle detection and parking allocation. The framework utilizessensors, LED displays, and database management systems to manage parking operations efficiently. Users register via a mobile application to access available parking spaces and are monitored to ensure compliance with system procedures (12). Infrared sensors installed in parking lots accurately identifyvehicles and maintain an up-to-date database (13).

III. Proposed Method

In supporting the objective of smart cities, a pivotal challenge lies in addressing the congestion caused by manual parking. To tackle this issue, a prototype model has been proposed, enabling the entry and exit of vehicles through an RFID reader and tag system. The setup involves an RFIDReader, utilized for reading label data during registration, transmitting Radio Frequencies to a Smart card embedded withan RFID label, which corresponds to the user's affiliation with the organization (14). These cards, available in lifetime and temporary variants, are installed within vehicles to ensure readability by the RFID reader. The database serves as a repository for individual customer data, vehicle information, and real-time updates on vehicle-related developments.

User interaction with the system begins with administrator registration, followed by issuance of a unique Smart card (RFID tag) to the user. Users then register their vehicles to acquire the tag, facilitating seamless access to parking facilities(15). Additionally, guests have the option to register their vehicles and obtain temporary RFID tags during their visit, overseen by authorized organization members responsible for managing registrations.

In the event that the car has not been registered with the system, the code that is in place will not let the individual to access. When the vehicle that has already been enlisted comes in and stops for check-in, the framework will check the database at that moment. If the vehicle has been previously registered and an authorized

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person is driving it, the boundary will open up so that the vehicle may pull into the parking spot. Anytime an enrolled vehicle has to check out, the framework will check the points of interest in the database to see whether the car has already been checked out. In the event that this is not the case, the system will look for the authorized customer who is checking in with the car. In the event that the customer does not have a place to the organization, the border will not open up and the security alert will be triggered. In order to ensure the client's safety, an SMS will be sent to the portable number of an authorized user if it turns out that the client is a member of the organization but not the linked component. . If this access to the authorized user's car is in their information, thenone party may choose to reject the notification, while the other party can immediately call the security officer in charge to cease their vehicle access.

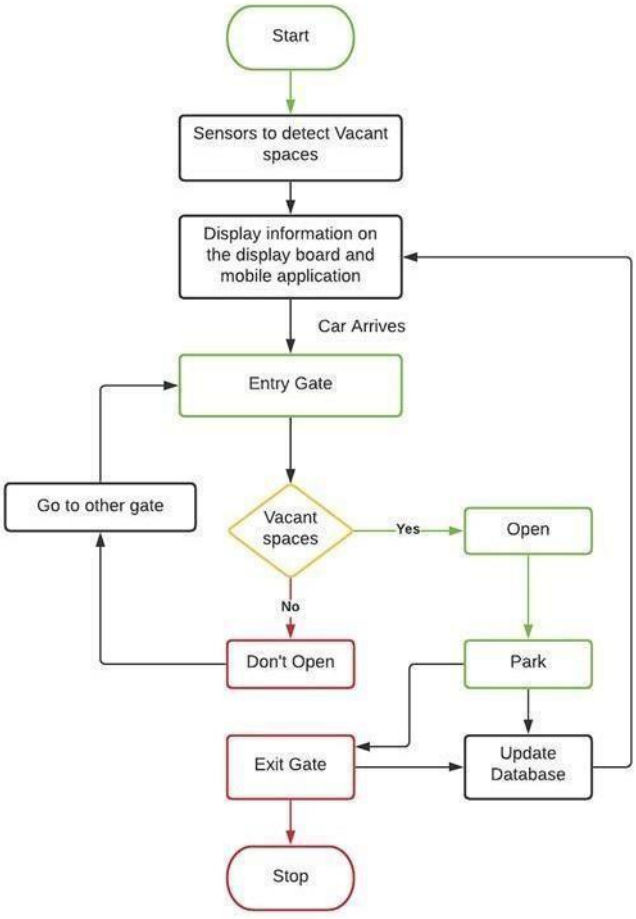

Figure 1. Flow chart of proposed System

When any enrolled vehicle requires checking out, the framework will check the points of interest in the database to see whether the car has already been checked out. In the event that this is not the case, the system will look for the authorized customer who is checking in with the car. In the event that the customer does not have a place to the organization, the border will not open up and the security alert will be triggered. In order to ensure

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A **servo motor** is a type of motor that can rotate with great precision. Normally this type of motor consists of a control circuit that provides feedback on the current position of the motor shaft, this feedback allows the servo motors to rotate with great precision. If you want to rotate an object at some specific angles or distance, then you use a servo motor. It is just made up of a simple motor which runs through a **servo mechanism**. If motor is powered by a DC power supply then it is called DC servo motor, and if it is AC-powered motor then it is called AC servo motor. For this tutorial, we will be discussing only about the **DC servo motor working**. Apart from these major classifications, there are many other types of servo motors based on the type of gear arrangement and operating characteristics. A servo motor usually comes with a gear arrangement that allows us to get a very hightorque servo motor in small and lightweight packages. Due to these
features, they are being used in many applications like toy car, RC helicopters and planes, Robotics, etc.Servo motors are rated in kg/cm (kilogram per centimeter) most hobby servo motors are rated at 3kg/cm or 6kg/cm or 12kg/cm. This kg/cm tells you how much weight your servo motor can lift at a particular distance. For example: A 6kg/cm Servo motor should be able to lift 6kg if the loadis suspended 1cm away from the motors shaft, the greaterthe distance the lesser the weight carrying capacity. The position of a servo motor is decided by electrical pulse and its circuitry is placed beside the motor.

Interfacing hobby Servo motors like s90 servo motor with MCU is very easy. **Servos have three wires coming out of them**. Out of which two will be used for Supply (positive and negative) and one will be used for the signal that is to be sent from the MCU. An **MG995 Metal Gear Servo Motor** which is most commonly used for RC cars humanoid bots etc. Servo motor can be rotated from 0 to 180 degrees, but it can go up to 210 degrees, dependingon the manufacturing. This degree of rotation can be controlled by applying the **Electrical Pulse** of proper width, to its Control pin. Servo checks the pulse in every 20 milliseconds. The pulse of 1 ms (1 millisecond) width can rotate the servo to 0 degrees, 1.5ms can rotate to 90 degrees (neutral position) and 2 ms pulse can rotate it to 180 degree.All servo motors work directly with your +5V supply rails but we have to be careful about the amountof current the motor would consume if you are planning to use more than two servo motors a proper servo shield should bedesigned.

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range ofapplications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters,special and even animations, etc.
The main function of the data register is to store the information which is to be exhibited on the LCD screen. Here,

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the ASCII value of the character is the information which is to be exhibited on the screen of LCD. Whenever we send the information to LCD, it transmits to the data register, and then the process will be starting there. When register set =1, then the data register will be selected. The main function of the command register is to store the instructions of command which are given to the display. So that predefined tasks can be performed such as clearing the display, initializing, set the cursor place, and display control.Here commands processing can occur within the register.

Node MCU is open-source firmware, hardware, and software development environment project developed initially for the Node MCU ESP8266 Wi-fi SoC chip based on LUA. It is a low-cost, small and powerful board. It is specifically designed for IoT applications. It is compatible with Arduino IDE and micro python making prototyping a lot faster. Because of all these features, Node MCU ESP8266 is the most popular and trending board in the electronics market. The v0.9 board is also called as 1st generation or V1 board. It is very wide and not convenient to use on a bread board. This limitation is overcome by its next generation i.e 2nd generationor v1.0 or V2 board. This ESP8266 Node MCU WiFi development board is more narrow and easy to fit on the bread board. Also, the chip in this board is upgraded i.e. from ESP-12 to ESP-12E. 3rd generation board V3 is produced by LoLin which has minor improvements over the V2 board and is believed to have a more robust USB port than its predecessor(CH340G USB-TTL chip is used instead of Silabs CP2102 from V1.0). But again this board is wide making it difficult to use .Since it can be connected to Internet it can be used in wide variety of applications like smart house, smart industrial devices, smart healthcare devices ,etc.

The Arduino Uno R3 is a popular microcontroller board widely used in electronics projects and prototyping. Developed by Arduino LLC, it is part of the Arduino ecosystem, which includes a range of compatible boards, sensors, shields, and accessories. The Uno R3 is particularly favored among hobbyists, educators, and professionals for its simplicity, versatility, and affordability. At the heart of the Arduino Uno R3 is the Atmega328P microcontroller, manufactured by Atmel (now Microchip Technology). This microcontroller features 32KB of flash memory for storing program code, 2KB of SRAM for temporary data storage, and 1KB of EEPROM for non-volatile data storage. It operates at a clock speed of 16MHz, providing sufficient processing power for a wide rangeof applications.Furthermore, the Arduino Uno R3 is supported by a vibrant and active community of users and developers. There are countless online resources, tutorials, forums, and projects available to help users get started with Arduino and explore its capabilities. This collaborative ecosystem fosters creativity, innovation, and knowledge sharing among Arduino enthusiasts worldwide.In summary, the Arduino Uno R3 is a versatile and user-friendly microcontroller board that is widely used in electronics projects and prototyping. Its simplicity, affordability, and compatibility with a wide range of peripherals make it an ideal choice for beginners and experienced developers alike. Whether you're building a simple LED blinker or a complex robotic project, the Arduino Uno R3 provides a solid foundation for bringing your ideas to life.

Another notable feature of the Arduino Uno R3 is its versatility. It can be powered via USB or an external power supply, providing flexibility in different usage scenarios. Additionally, the board supports serial communication via USB, enabling seamless interaction with a computer for debugging, data logging, and serial monitoring.One of the key features of the Arduino Uno R3 is its ease of use. It can be programmed using the

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Arduino Integrated Development Environment (IDE), a user-friendly software platform that simplifies the process of writing, compiling, and uploading code to the board. The IDE supports the Arduino programming language, which is based on C and C++, making it accessible to beginners and experienced developers alike.The Uno R3 board is equipped with a variety of input and output pins, allowing users to interface with external components such as sensors, actuators, displays, and communication modules. It features 14 digitalinput/output pins, 6 analog input pins, and a range of power and ground pins. These pins can be configured and controlled programmatically to perform a wide range of tasks, from reading sensor data to driving motors and controlling LEDs.

In the architecture of the system that is being ~~su~~ggested, the Arduino microcontroller board is linked to the Node MCU and theWeb application. This board is responsible for making judgments on the authorization of members and determining whether or not new entrants should be permitted. The RFID reader and the IR sensors are both linked to the Node MCU, which enables it to monitor notifications of slot occupancy as well as the results of RFID scanning. The following is a pseudo code that displays the slot occupancy:

- If user is between 1 and N, do the following code: "N:parkingspaces count in the parking area."
- Do the following for j = 1 to M / M represents thenumber of sensors present in each parking lot.

• Send the status of the parking space as occupied tothe controller so that it can be updated on the display if the sensor node in IDzi, IDpj detects the presence of a vehicle. If the sensor node does not detect the vehicle's presence, send the status of the parking space as unoccupied to the controller so that
it can be updated on the display.

• Finish if Finish for End for.

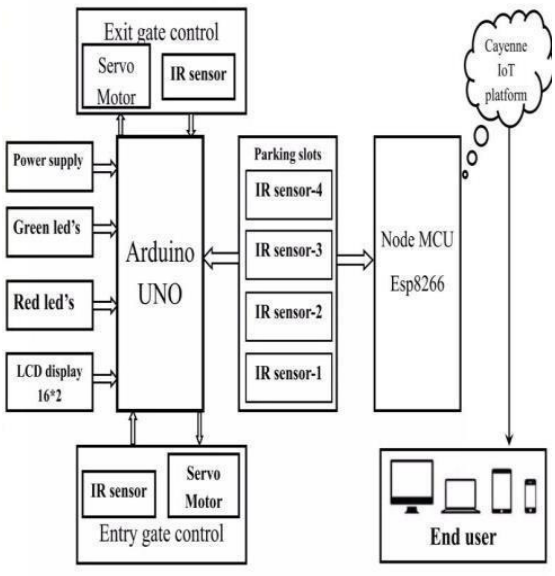

Figure 2. Architectural diagram of the proposed system

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IV. .RESULTS ANALYSIS

The user logs into the mobile application and checks for vacant parking spaces and chooses the space which isconvenient to him/her and goes directly to that particular space which saves a lot of time to him/her. If the user doesn't check the mobile application, the display board at the entry gate tells if there are vacant spaces. If vacant spaces are present the gate gets opened, otherwise it remains unopened. IR sensors are placed at each parking space to detect if the parking space is vacant or not.

A servo motor is placed to open the entry and exitgates when a car arrives at the gate. Based on the sensors data, total number of vacant parking spaces are calculated and displayedon the display board. Thevacant parking spaces information like space numberand other information will be updated in the mobile application every time a car enters and occupies a space or every time a carexits and leaves a space.

The proposed system was constructed by integrating all ofthe hardware components via the use of connecting wires,which were used throughout construction.The prototype version of the system has three parking spots, each of which is equipped with an infrared (IR) sensor. After that,there is a servo motor that is attached to the Arduino, and when the Arduino acknowledges the car's arrival, the servo motor rotates the amplifier on the Arduino depending on the angle. A reader for radio frequency identification is linked to Node MCU. This reads the data from the RFID tag and transmits it so that it may be used in subsequent procedures. After the construction of the necessary hardware, a large number of tests and adjustments have been made to the system in order to get the required results.

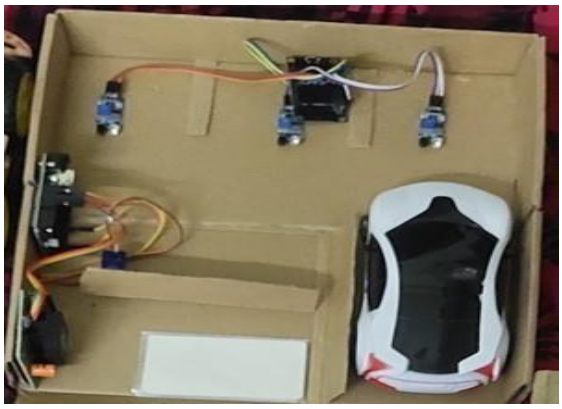

Figure 4 Prototype Model

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A variety of experiments and simulations were carried out so thata quantitative look at the effect that the suggested system would have interms of the amount of money. There are two categories of execution methods that are taken into consideration. The key category is the efficiency that is expressed in terms of the amountofenergy used by a number of different elements in order to identify aplace to stop, as well as the amount of energy used in order to receiveinformation from the sensors and send it to the source that has the most control. Due to the proximity of the sensors involved, it is possible to make use of a single control source for all of the clustered sensors, which is one of the distinguishing characteristics of this method of sensor use. This incorporates placing restraints on the cables and connections that are used for the purpose of connecting the collection of sensors with the real-time arrangement. However, rather of individually replacing each sensor device, it would make more sense to swap out the batteries for each batch of components instead of doing it individually. Energy efficacy for the information to the gathering includes selecting, from among a set of calculations, the one that caneffectively course the activity shape sensors hubs to the gateway while also being the most prudent in terms of the energy utilized.This choice is made as part of the energy efficiency for the information tothe gathering. The current plan is for the financial capability to be presented in terms of the delivery of the budgetedfetched.

After the code is loaded into Arduino in the system that is being suggested, the parking system assumes control of the parking procedures. Every procedure is broken down into steps, one of which the user or the user's vehicle will have already completed. The systembegins by having the user register with it, and after that, the system will decide whether or not to approve the user. The following actions must then be completed by the user in order for his car to be parked.

In this regard, automobiles that make use of this system arerequired to first register with the system, during which the user's automobile will be provided with an RFID tag with the user's particulars. For the purpose of providing access to the user.

Figure 5 All Slots are Available

when the setup has been turned on, the LCD display turns on andslot occupancies are displayed on the LCD display. The figure 4 indicates that the slot 1 is 0 which means slot 1is unoccupied. Whenthere is a vehicle in the slot 1 the slot 1 show 1. When there is no vacancy, the display shows parking full and system doesn't accept anew entry. This way member can access the information about slot vacancies. When the vehicle comes within the run of

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RFID reader, it reads the RFID tag which is joined within the vehicle. If the RFIDis validor registered with the system, the RFID module allows the user to enter the gate.

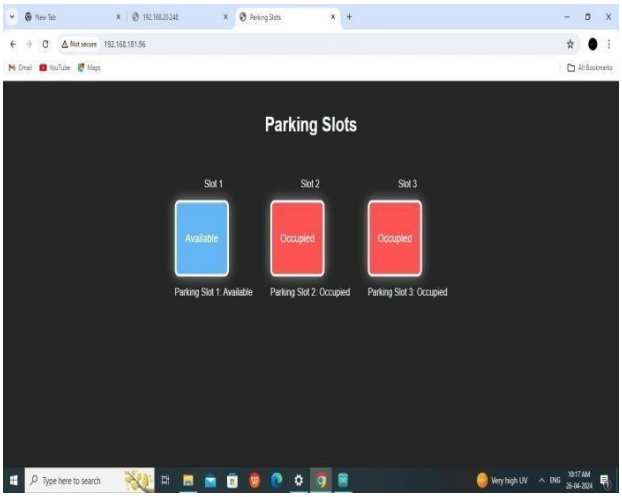

Figure. 6 :Two slots are occupied

In this location, each parking place is equipped with an IR Sensor that can detect moving vehicles. If there is a car occupying a certain space, the sensor will display green; otherwise, it will displayred.

These signals are received by Node MCU, which then transmits them to the micro controller. Once the micro controller receives thesesignals, itis able to determine whether or not to open the gate, there by allotting the user a slot, or whether or not to close the gate in the event that there is no vacancy.

Therefore, after the RFID tag has been read and itsauthenticity verified, the RFID reader will transmit signals to the micro controller, which will either grant the vehicle a slot if there is one available or deny the request if there are none. The servomotor gate is opened then, allowing the user to enter the facility. And at theend, the customer will be able to park their car in the designated area[13-15].

This incorporates placing restraints on the cables and connections that are used for the purpose of connecting the collection of sensors with the real-time arrangement. However
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Figure:5.3 GrantedAccessfortheVehicle Parking

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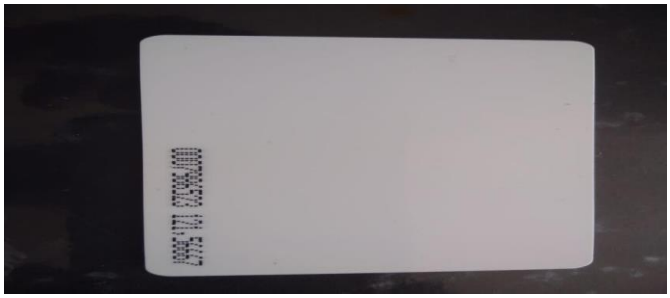

Figure: RFID ID Card

The prototype version of the system has three parking each of which is equipped with an infrared(IR)sensor. After that, there is a servo motor that is attached to the Arduino ,and when the Arduino acknowledges the car's arrival, the servomotor rotates the amplifier on the Arduino depending on the angle. A reader for radio frequency identification is linked to Node MCU. This reads the data from the RFID tag and transmit sit so that it may be used in subsequent procedures. After the construction of the necessary hardware, a large number of tests and adjustments have been made to the system to get the required results.

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V. CONCLUSION

A significant problem is the steadily increasing number of traffic collisions on the roads, which are caused by a growth in the number of cars and the carelessness of riders. Even though there have been a number of traffic laws implemented up to this point, there are stillthose who choose to disobey them. The strategy that was suggestedhas effectively represented vehicle detection, count of the cars in each class, detection of license plates and identification of plate numbers, and analysis of traffic density. This article focuses the majority of its attention on fundamental traffic monitoring and analysis of traffic density. The object detection technique, on the other hand, is effective only at closer ranges. In order to facilitate detection, the characters on the license plate must be visible. As a consequence, the ML model does not generate the intended results for license plates that are both confused and blurry. The proposed method can beexpanded to address the traffic congestion problem on a more advanced level by incorporating a mechanism for diverting commuters to lowtraffic density regions and to manage thewaiting time at the trafficsignal. Thiswill allow the method to address the problem at a moreadvanced level. The detections may be refined further to work at a greater distance, and the license plates thatare found can be utilized for incident management and the monitoring of vehicles associated with criminalactivity.

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Author's Profile:

	Mrs.G.Suseelamma received Mtech (Electronics & Communication Engineering) from Acharaya Nagarjuna University,Andhra Pradesh, India in the year 2009, Btech (Electronics & Communications)Degree from RVR&JC Engneering College,Andra Pradesh, India in the year 2005. She is currently working as Associate Professor in ECE, Tirumala Engineering College, Narasaraopet. Andhra Pradesh. She research interests are Wireless Communications & Networks, She is having 10 years of Teaching Experience. She is a life member of technical association IETE.
	Ms. M. Jyoshna Lakshmi is a student currently pursuing B. Tech in the stream of ECE in Tirumala Engineering College, Jonnalagadda, Narasaraopet, Palnadu (dt).

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	Ms. K. Bindhu Priya is astudent currently pursuing B. Tech in the stream of ECE inTirumala Engineering College, Jonnalagadda, Narasaraopet,Palnadu (dt).
	Mr. M. Seshanjaneyulu is a student currently pursuing B.Tech in the stream of ECE in Tirumala Engineering College,Jonnalagadda, Narasaraopet,Palnadu (dt).
	Mr. Sk. Sadhik is a student currently pursuing B. Tech in the stream of ECE in TirumalaEngineering College, Jonnalagadda, Narasaraopet,Palnadu(dt).