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Energy Efficacious IoT Based Nifty Parking Information System

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Abstract: ***Urbanization has inflated populace. This has upsurged traffic and pollution turning traffic management into a tangible reality. Gazillions of people around the globe prefer ownership of private vehicles over public mode of transportation. There is an imbalance between the available parking space and demand. The proposed Internet-of-Things (IoT) based nifty parking information system (IPIS) module is deployed on-site to monitor vehicles, signal the availability of parking space to the user, facilitate reservation of the parking slot and thereby reduce the time in finding the parking slot. MIT App Inventor creates applications on Android operating system to facilitate slot reservation for authenticated users. IPIS integrates IoT based Raspberry Pi module with the mobile Application to design an eased parking system operable with minimal energy. The user details are recorded in a server database. Based on this, an RFID tag permits user entry and exit into the parking slot. A Raspberry-Pi(R-Pi) camera module captures the license plate image and uses image recognition algorithm to match the license plate of the vehicle with the database, authenticates and then allows the member to park his vehicle in the respective slot. IPIS provides highly secured, double verified user vehicle authentication. The Raspberry- Pi also adjusts the intensity of the lights using machine learning based on the density of the traffic recorded by the camera module. This research focuses on slot reservation for authenticated users, providing map guidance to the booked slot, maximizing slot utilization, facilitating with vehicle and user timestamp transit details in real time for surveillance, conserving parking slot light energy utilization while regulating the cars through parking spaces and also performs predictive analysis on evaluating the optimum distance between the camera and number plate for recognition and power dissipation.***

Keywords: ***App Inventor, Dual Authentication, Energy, Power, Parking.***

I. INTRODUCTION

Approximately 40% of the road space is taken up for car parking resulting in traffic congestion. With proliferating vehicles, the bottom-line crux is exacerbated due to pollution, enormity of economic crisis, dynamic parking tariffs, traffic congestion and inadequate parking space. Parking System is categorized as Transit Information System, Parking guidance system and Automated E-Parking System. Public and commercial spots license should be validated based on their parking space accessibility.

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A network of seamlessly connected physical devices, navigation system, display module, user device, software, Raspberry Pi(R-Pi), image capture and centralized server form the IoT based nifty parking information system. (IPIS). This focuses on manual and resource optimization. Currently, finding a parking slot is a stressful experience [1]. Drivers resort to trial and error method and waste lot of fuel and time in finding a parking space. Even if the driver knows the availability of slots, all the vehicles clutter around the empty slot leading to traffic congestion and frustration [5]. In substantial parking zones, a driver leaves the parking area without a glimpse of the recently cleared slots. The after effect of not finding place is parking in crime prone areas, leading to robbery and traffic congestion. Mobile App based IPIS provides an update of the status of the slot to the driver before reaching the parking lot. This saves the tiring driver from travelling through filled in parking slots. This in turn reduces fuel, time and money for the stressed drivers. Using the customized secured app, a parking slot could be procured for use before reaching the campus during busy hours. This app permits only authenticated personnel to enter the parking area, thereby avoiding overcrowding.

The proposed IPIS model has hardware with application software using client server algorithm. The user registers his details in the master database in the Server maintained in a laptop and he is provided with an RFID Tag [11]. Client comprises of the RFID Tag reader [9] and the Raspberry-Pi. Raspberry Pi is a microprocessor based on-board computer with Linux operating system that is mainly used for home automation.

The Client communicates with the Server within the same Local Area Network using Client Server Socket Programming in Python. On detecting the RFID tag and the vehicle license plate, R-Pi verifies the authenticity of the person and the vehicle. License plate is validated using image capture, image segmentation and character recognition.

Pervasive mobile kindles mobile based solutions for parking space. Android is a Linux based open source for touch screen mobile devices [2]. This parking app is created by App Inventor. MIT App Inventor is an application builder that develops applications for Android Operating systems. This is developed by Google Labs and is managed by Massachusetts Institute of Technology. These apps do not require coding and are executed using Visual Programming.

IoT processes and shares large amount of data to track and control the devices remotely. Cloud provides unlimited storage capacity for this data. IPIS is connected to the cloud. The system uses real time video stream through surveillance cameras and uses machine learning approach to detect cars.

Based on the number of cars, the intensity of the parking lot lights are conservatively controlled.

The predictive analysis about the optimum distance of the camera module and car. Also, the calculations, regarding the power dissipation helps to determine the effectiveness of the energy efficacious algorithm for the number plate detection determines the minimum distance required between the peers for efficient energy conservation. This helps in time and energy conservation.

II. LITERATURE REVIEW

Individuals have utilized unique personalized attributes such as password and signature, for user authentication. Chirag et.al, has researched on license plate number recognition systems for vehicle authentication. But user authentication was left unearthed [5]. Jagadish et.al, has proposed a secured remote access RFID based networked gate entry control system [9]. This allows the management to monitor their employees transit related activity without any additional gated security infrastructure. ODBC based secured gate entry system is used to observe the timestamp entry. These transit records are utilized for post analysis and security related research. Amin Kianpisheh et.al, [2] has proposed an ultrasonic sensor based smart parking system for parking space detection. Ultrasonic sensor for object detection is not very much reliable, as it could be triggered by any kind of object blocking its path. In a recent survey done by Abhirup Khanna et al. [1], proposed a mobile app for slot reservation and slot payment. In their proposal, they have allocated a certain time period for slot reservation. If the user's parking time runs out, a timed out notification message is sent to his phone. However, they have not taken measures against the probable chance of the driver, ignoring the message alert and not vacating the slot. Also, there is no backlog, for the authorized personnel to look back and trace a vehicle in case of security breach. Aniruddh et.al, [3] used number plate recognition to maximize security. The camera module recognizes the number plate using image processing and then confirms the recognized number plate data with the database available. It involved localization, segmentation and recognition procedures. However, the system allowed only registered vehicles to access the parking lot. There was no provision for non-member users. Ashwini [4] et al., proposed automated car parking system using sensor based path tracing. But this had limited constraints like number plate extraction. Yusnita et.al, [14] designed automated free slot identification using image processing. Hongwei et.al, [8] proposed reservation based parking system and tested using simulation. Gyanendra et.al, [7] has proposed a digital security system using RFID.

III. PROPOSED MODEL

Smart Parking systems are based on space optimization and energy optimization. This includes parking facilities, low energy utilities and traffic management systems in urban areas. User friendly mobile apps, IoT and Cloud deployment meets the need of the hour [1]. IoT shares huge amount of data. IoT- Cloud integration permits dynamic storage space, meets power constraints, allows scalability and facilitates interoperability between devices [5]. Internet-of-Things (IoT) integrates smart phones, sensors, GSM and web services like Google Firebase to facilitate smart parking system.

The proposed module involves authentication of the user and the vehicle. This involves reservation of parking slot using end user mobile application and facilitates seamless parking slot status availability to the end users with energy efficiency. Data generated by the sensors is uploaded to the cloud and accessed by the mobile application. This ensures data availability and seamless operation. Data flow involves login, registration and reservation.

The Client Server module establishes a communication link which sends the RFID Tag details to the TCPClient. The Client side consist of the Raspberry Pi along with the R-Pi camera which responds based on the response from the Server as shown in Figure 1.

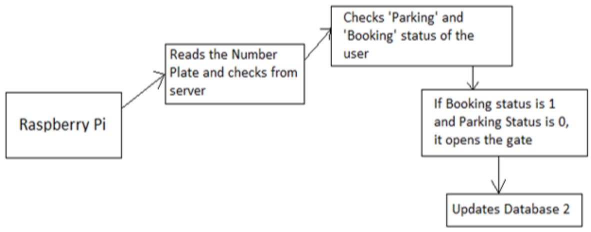

Fig.1.R-Pi for Vehicle Authentication and Control

The Server side laptop maintains a database of the clients. A Mobile App created using MIT App Inventor permits user registration as shown in Figure .2 for user authentication.

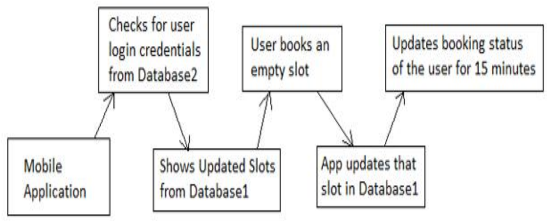

Fig.2. Mobile App for user authentication

Based on registration of the users, the database is created in the Server. For authentication, based on the details of the Client, the Server responds. While working in realtime, the raspberry pi always communicates with the server to verify the authentication details and then performs the necessary tasks.

IV. HARDWARE IMPLEMENTATION

The campus has two parking areas, one for members (client) and the other for guests. At the member parking area, the gate is operated using a servo motor [6].

A. CLIENT-SERVER

At the client end, the Raspberry Pi (R-Pi) authenticates the user using RFID module. RFID is linked with the central database maintained by the server. The client credentials are stored in the laptop which forms the server.

The client downloads the Mobile App and registers his login credentials such as his Name, RFID etc., with the server. He is provided with an RFID Tag.

Passive RFID Tag is connected via USB to the system.

The server maintains a database of the registered users. Once registered ,he logs into the android app with his username and password and views the status of the parking lot. Reserved slots are highlighted as 'Red' and the available slots are marked as 'Green'. Once the user has booked a slot , the slot will be marked as 'Occupied' and he will not be allowed to enter into the portal until the slot is Re-marked as 'Unoccupied' in the database. After booking, the user is given a time period of 15 minutes to park his car into the respective slot. If he fails in doing so, the slot will again be marked as unoccupied automatically with the help of raspberry pi and he needs to re-book his slot again. R-Pi at the client signals Arduino continuously to control the color of the LED. LED Color indicates the slot availability status.

Whenever any member produces his/her RFID near the Infrared Sensor, the R-Pi reads the tag and sends a request to the server for authenticity check. The server checks the RFID details in the database, if it matches, it permits entry else it denies entry to the client. The Raspberry Pi on getting the posive response of the client, stores the name of the member along with the timestamp of his entry in its local database, and creates a log. Once user authentication is performed the system generates a control signal through a parallel port. This controls a stepper motor which opens the gate of the parking lot to the client for a particular period of time.

Mobile App provides route guidance to the client using a map to the parking lot. Client and Server are programmed using Socket Programming.If any member wants to exit the campus, the same procedure is followed. Figure. 3 depicts the Client-Server sequence of implementation. The R-Pi camera module fixed near the gate captures images of the number plate of the car. Vehicle authentication is done by R-Pi license number plate recognition. R-Pi uses OpenALPR API to process the image of the number plate and reads it as a text. It then checks with the database if the user has booked a slot from the mobile app.

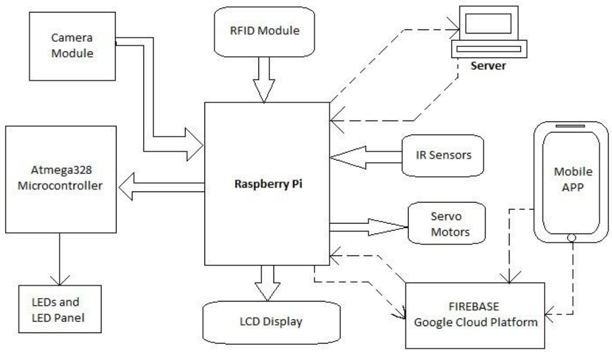

Fig.3 Client Server Implementation

Firebase (online database supported by Google Platform) is used for storing and verifying data from the Mobile Application with the R-Pi. During midnight, it is a waste of electrical energy to light up the parking lots with the same intensity as during official hours.

Parking lot lights are optimized based on the traffic intensity and also on the natural light intensity. Traffic intensity is based on the number of operable cars from entry to exit. Natural light is calibrated based on the sunrise and sunset intensity details fetched from the server. Based on these two parameters, R-Pi controls the intensity of light in the parking lot. Haar-feature based cascade classifiers are used to detect cars. User and Vehicle authentication is implemented as per the sequence depicted in Figure 4.

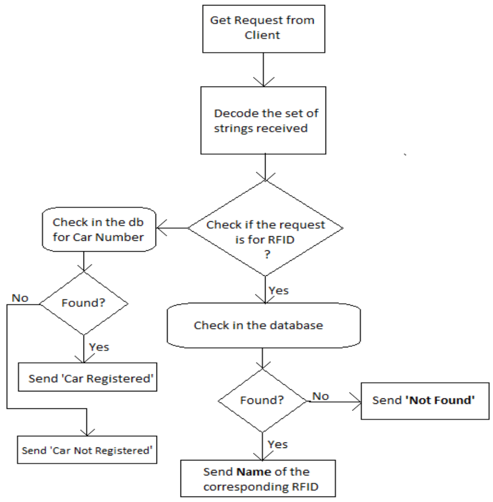

Fig. 4. User –Vehicle Authentication

V. SOFTWARE IMPLEMENTATION

A. Android Application

App Inventor proposed by Google Labs and redesigned by MIT for Android Operating Systems (OS) provides mobile based technical solutions for real time scenarios [10].Using the home design editor, blocks editor and a graphical interface, the user can create a customized application as shown in Figure. 5.

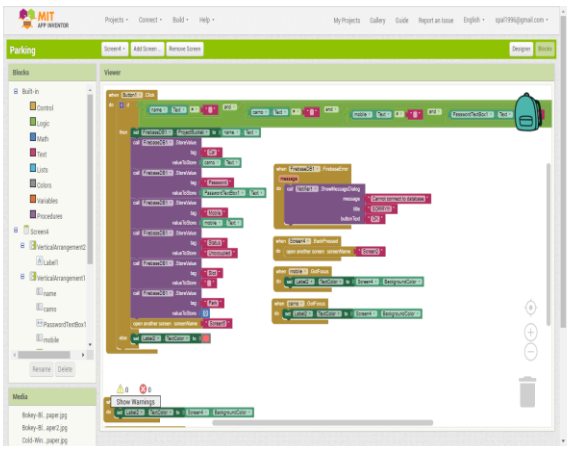

Fig. 5. Designer Part at MIT App Inventor

Two online databases are created. Database1 stores the user credentials and Database2 stores the status of the slots. Once the user logs into the Mobile App, both the databases are updated through Firebase. App Inventor's basic user interface elements like buttons, images are combined with the mobile device's features such as texting, GPS, Bluetooth, etc., Therefore, the primitive structures of the language enable the app developer to easily manipulate the functionalities of these touch enabled, portable, sensing devices. [7]

As depicted in Figure 5, the home page of the application requires the user to have proper login details registered with the database in order to proceed into the slot booking page as shown in Figure.6.

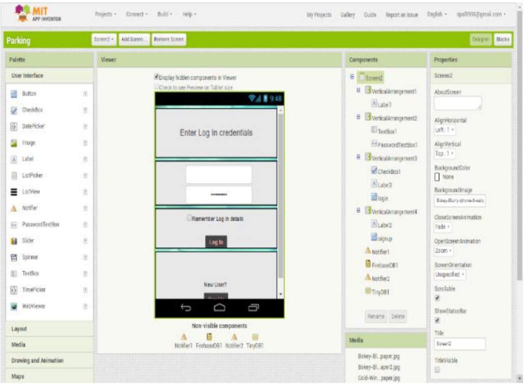

Fig. 6. Blocks editor at MIT App Inventor

As shown in Figure 7, Login details requires a username and a password. In case of unavailability of details, user can create an account and enter the details such as name, license plate number, and mobile number. Once registered the user is permitted to access slot booking. Status of the slot is displayed as shown in Figure 8.

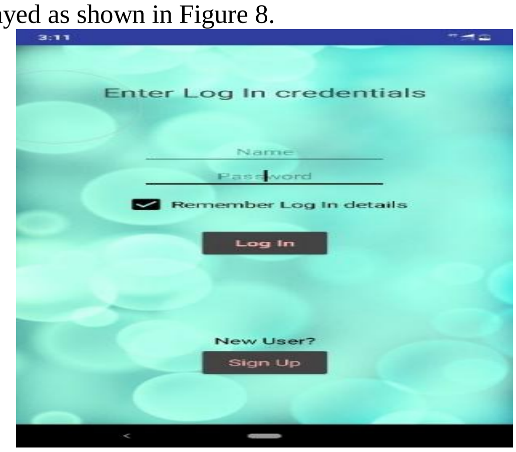

Fig. 7 .Login Page

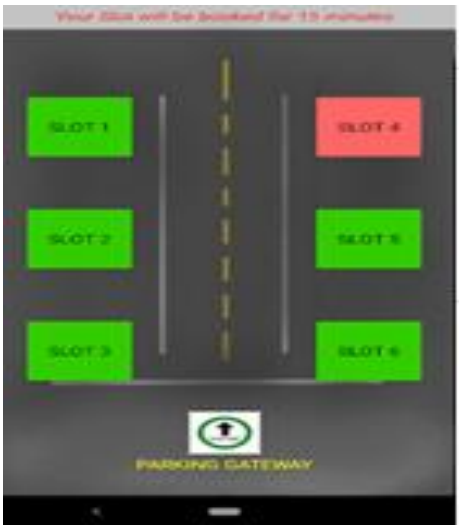

Fig. 8. Status of Slot

Firebase is the online active platform that streamlines and updates the client with the recently cleared slots.

VI. PROPOSED ALGORITHM FOR PREDICTIVE ANALYSIS

A. Optimum Distance for Number Plate Recognition

Calibrations are made using the aperture of the camera module and the rate at which data is stored in Raspberry Pi. R-Pi camera uses resolution of 640x480 pixels and an aspect ratio of 4:3. With memory split set to 64MB of RAM dedicated to GPU, 58 frames per second (fps) is achievable using R-Pi camera.

As the car moves into the parking lot, the Sensor senses the license plate. R-Pi camera module takes a short video of the car's license plate for 2seconds with resolution set to 640x480 pixels and FPS set to 10. Once done, 2*10=20 frames of the car image is obtained. More the number of frames, more is the processing time involved in plate recognition API. Each frame is processed with the help of Open ALPR license plate recognition, in which we get an array of the probable number plates that gets detected with its confidence value. The number plates are taken and stored from each frame along with its most confident value. Using bubble sorting algorithm, unique plate which has occurred most number of times, is the most probable number plate. However, the accuracy of the API is from 80 to 90% and requires much more training before it can be applied in real time.

The average size of Indian four-wheeler number is 500x120 mm. The focal length (F) of raspberry pi camera is 3.60mm which corresponds to approximately 543 in pixels [22].

$$F = (P \times D) / W \qquad (1)$$

where

W is width of known object

D is the object's distance from the camera

P the apparent width in pixels of the object in R-Pi camera

If we assume the minimum width in pixels to be 640 and W' as 500mm, then the minimum distance between camera and object (D) = (F x W) / P = (543 * 500) / 640 = 424mm = 42.4cm as in Equation 1.

So, for safe assumptions, optimum distance is 50cm. Hence the car needs to be approximately 50cm away from the camera for best detection of number plate.

B. Power Dissipation Calculation

.Power dissipation and consumption by the car detection algorithm is analyzed using an LED as a prototype for the lights in the traffic lot as shown in Fig.9. Voltage involved in applying car detection algorithm and to automate parking lot lights as per the traffic density is analyzed.

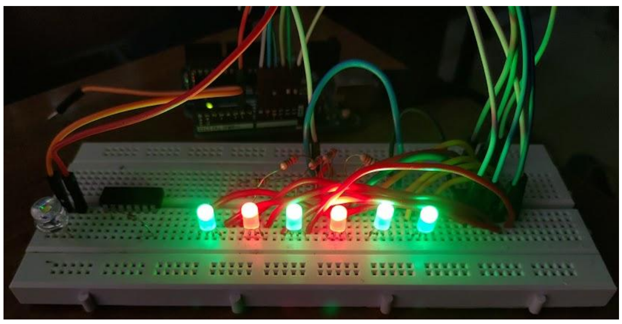

Fig.9. Slot Occupied and Slot Vacant Prototype

The current rating of the bright LEDs used for the prototype is 20mA with a maximum operating voltage of 5V. Therefore, power dissipation involved in a single LED usage is V*I which accounts to 5V * 20mA .This results in 100mW. To test the implementation, 8 LEDs were used and the total power dissipated is 800mW.
AT Mega MCU code calibrates traffic intensity varying from low to medium to high depending on the count value it gets from the raspberry pi.
As cited in Table –I, for low traffic, for an analog value of 25, it provides an output voltage of 0.5V. Corresponding Power dissipated = Duty cycle x Maximum power dissipated= 10% of 800mW = 80mW. Power Saved = (800 – 80)/800 % = 90%
Similarly, when there is medium traffic, the analog value is 127, which corresponds to 50% duty cycle. Therefore, power dissipated = 50% of 800mW = 400mW. Power Saved = 50%
When there is heavy traffic, the microcontroller [13] is set to provide the highest voltage i.e., 5V with analog value of 255.

Table- I Power Dissipation Comparison

Traffic Intensity	Power Dissipated	Power Saved %
Low	80mW	90
Medium	400mW	50

VII. RESULTS AND INFERENCES

A. Client –Server Authentication

A low frequency RFID based reader and a passive RFID Tag along with cloud based software provides transit details of the employee. This sort of secured access prevents man-in the middle attack [12].

At first, the server screen is initialized to accept new registration from the client as shown in Figure .10.

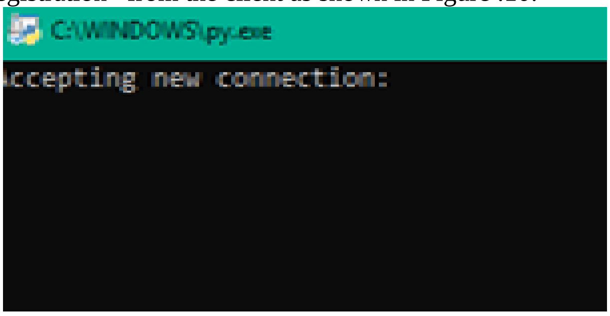

Fig. 10. Server Initialization

The RFID program at the client is made to run on the Raspberry Pi. Figure. 10 shows the R-Pi screen, and Figure.11 shows the hardware end, where the LCD display aids with the registration process.

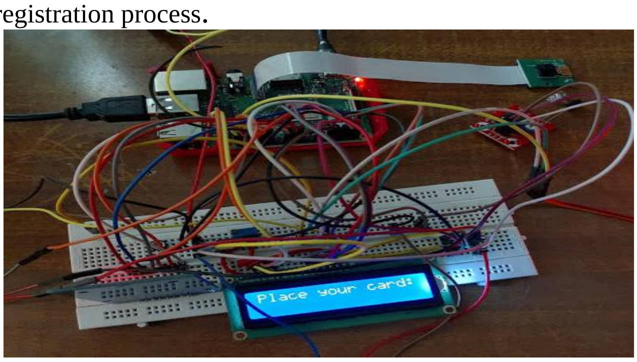

Fig. 11 Hardware Implementation

Now, whenever any user places his card on the reader, it checks with the server by sending the RFID number. The server responds by sending the name to the client. After sending the required response to the client, the server again initializes to get new response from the client. Status is displayed as shown in Figure 12.

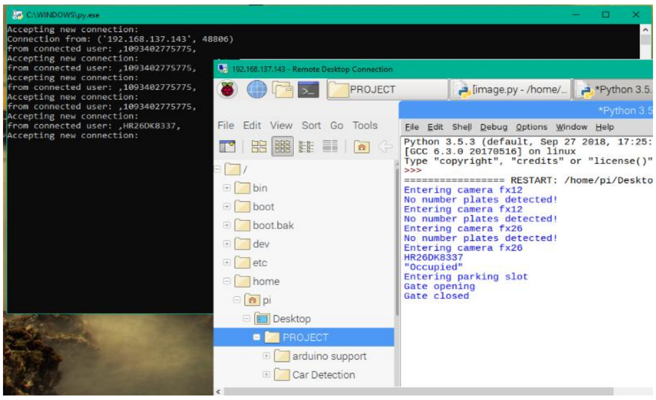

Fig. 12. Status of Parking Lot.

Raspberry Pi also saves the Entry and Exit time in its local database, when a user scans his RFID card during entering or leaving the campus. Hence a time stamp is recorded in the database.

B. Vehicle Recognition

Once the car enters the parking lot, IR Sensor senses the license plate. The camera module captures a picture of the car number plate in front of it by blocking the entry IR sensor (Figure 13), then the camera module will capture a short video for 2 seconds. The R -Pi starts processing the video and finds out the number plate in text format and sends it to the server for authentication verification. The server on getting the vehicle number, verifies with the database and sends the name of the user as shown in figure 13.

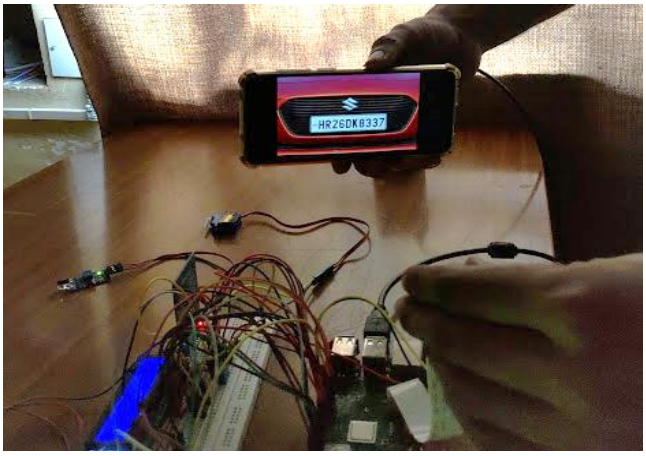

Fig. 13 Vehicle Recognition

Once the car enters the parking slot, the Raspberry Pi marks the *Parking* status of the user from '0' to '1'. A 15 minutes countdown timer running on the raspberry pi for a user who have booked a slot, checks if the *Park* status is 1. If it is 0, then it reverts back the slot status from 1 to 0 after 15 minutes.

C. Optimized light energy utilization

The lights at accident prone positions are validated and operated automatically based on the sunset and sunrise intensity details fetched from the online server. Hence, these lights are efficiently utilised and help in energy conservation and safety. With the help of Car detection algorithm, the Raspberry pi detects the car and draws a green square around it (Figure 14). The R-Pi sends the value of 'count' after 20 frames to the Atmega328 MCU, which controls the intensity of the LEDs based on the traffic intensity in the parking lot.

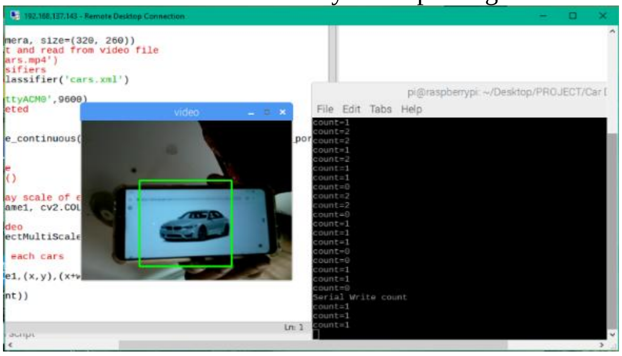

Fig. 14 Car Detection Algorithm

VIII. CONCLUSION

This mobile based automated cloud based parking system assures reliable networking, secured system maintenance, and reduced maintenance. This work researches on environmental impacts, urban transportation, and also performs predictive analysis on optimum distance between the camera and number plate for recognition and power dissipation. In this proposal, the system aids in surveillance by recording the members timestamp. RFID transit record maintains a timestamp of the transit details of the employee in a centrally distributed environment. This is user-friendly, with a customized mobile app. Smartphone is a day-to day utility. Parking Lot lighting is based on the intensity of traffic and machine learning approach. This results in energy conservation. Proposed system includes user and device authentication. However, for designing a system, which gives a faster response, we need a much more high-end hardware. IoT automation eases the parking space accessibility, reduces time consumption in identifying free space, moderates fuel consumption and carbon footprints in space. In future, applications could be developed using iOS and extended to value added services and revenue generating muti-storage parking lots.

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