Smart Parking Management System

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Abstract

The demand for parking and security has increased in public areas which led us to bring this system into existence. The presented system guides the user to find a free parking slot without any effort and keeps the vehicle secure. Arduino-based systems control the movement of the toll gate to permit entry and exit vehicle to and through parking spaces. A camera in front captures the image of a vehicle passing through the toll gate and automatically stores the number plate text of a vehicle and other essential information like time and the parking slot, which is preserved in the database for security purposes. The system consists of a display that guides a user to a free parking slot. The systems also have a feature to send alerts to registered users.

Keyword: Automatic Toll; Number Plate Detection; Parking Display; Arduino; Python; Secured Parking

1. Introduction

In recent times, the increase in population and traffic congestion put forward the requirement of a smart parking system. The ongoing parking management highlighted in [1] is based on land uses and is considered an important asset to bring revenue for cities. Parking area coverage requires for large cities even more than 31% for land uses for cities. A requirement for a large parking area is a constraint in urban development and leads to a reduction in vehicle transportation [2,3]. Thanks to information and communication technology; many cities have started smart parking system helps drivers to find the free space and efficiently park the vehicle. The primary focus is given on (i) economic (ii) reduced parking search time (iii) low pollution (iv) environmentally-friendly (v) minimum fuel consumption while searching free parking slot while developing parking management system. When the driver rapidly finds a parking area, minimizes the on-street parking. It helps to regulate public transportation and generates revenue for developing smart cities [4]. Lean smart parking presented in [5] illustrates the benefit of the smart parking model deployed in Los Angeles. It is an important building for smart cities. Rapidly increase of automobiles in the cities arises issue security with parking too. As the quality of life increases and the world is moving towards digitalization, more and more people are inhabiting cities. Urban life requires centralized public facilities. Commercial centers and Educational institutions are an important point of interest both for a city's inhabitants as well as for visitors [6]. Systems like floor management techniques are in existence and other systems like the giant wheel are on the verge of completion. This also saves a lot of lands but these are difficult to bring into reality as they require heavy, and hydraulic machines, etc to implement these requires more budget. A smart and secure parking system developed in [7] based on notice framework, where the driver can view the free parking site

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Propose Model

The presented automated parking management model does not require any manual intervention. Integration of cameras and sensors simplifies the complexity. A free area of land meant for parking purpose have 100 number of parking slot available, out of which 75 for 4-wheeler and 25 for 2 wheelers. Each slot has allocated a unique number. There are two lanes, one is for entry and the other one is for an exit. A camera and infrared (IR) sensor are connected to each gate which controls the activity of the turnstile gate. When a vehicle comes near the turnstile gate to enter, the IR sensor at the entry of the gate detects the vehicle. Whenever a vehicle has detected the camera (CCTV/webcam) captures the image of the number plate and saves it on the local disk of the mainframe system as shown in figure 1.

![Block Diagram](image-url)
After saving the same image is sent to ALPR cloud for number plate recognition. A parking slot number is allotted to the particular number and reduce the number of available free slot. Then ALPR cloud returns the number plate in the sent image. The number plate received from ALPR cloud is searched in the registered users’ database of the commercial areas to check if the vehicle belongs to any of the already registered persons.

If yes then the user is the owner, who has a fixed slot so the system doesn’t allow a parking slot to the owner, therefore according to the flowchart shown in figure 2; the entry time is noted and the turnstile gate is opened for 5 seconds else if it is a non-registered user, then a vacant parking slot is given to the vehicle and the entry time, parking slot number will be noted. To exit the vehicle from, exit gate, another IR sensor placed on the exit gate detects the vehicle, camera (CCTV/Webcam) captures the image and saved it into the local mainframe computer. The same image is sent to the ALPR cloud for number plate detection. ALPR processes the image that was sent and returns the number plate in the image. The number plate thus received is searched over the registered user’s database. If it’s found then the exit time is noted and also an alert via email / SMS will be sent to that owner, else the exit time is noted and the parking slot in which the vehicle that was given will be changed to vacant mode.

In case the vehicle reaches to entry and exit gate at the same time, then the vehicle at the exit will be given first preference because there might be a chance that there is no vacant parking slot inside. To make sure this issue never occurs this priority is maintained.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{flowchart.png}
\caption{Flowchart for Entry of vehicle}
\end{figure}
2.1 Key Feature of the proposed model:

1. Optimize Parking Space usage which can access online. A real-time process and information about the parking slots.
2. Simplifies the parking experience.
3. Easily regulates the free flow of traffic at parking areas.
4. Easy to access vacant spot for the next parking car.
5. The parking system is well organized to accommodate for maximum parking space.
6. Smart Parking allow managing of available parking slots and real-time monitoring.
7. Accurately sense and predict spot/vehicle occupancy in real-time.
8. Provides tools to reduce workforce management.
9. Safe and Secure updates the user about the vehicle leaving the slot.

2.2 Allotting Parking Slot

The present parking system allows slots without using any sensors. The slot for an entering vehicle is given from the software used. As we capture the image of the vehicle and store the vehicle number in the database, the same vehicle number is used here to allow a free parking slot that is displayed on the screen. In the source code, we take an array of the size which is equal to the total number of slots available and initialize the array with "vacant". The software searches for a "vacant" initialized index in the array, assign a free slot for an incoming vehicle and store the vehicle number in the corresponding index of the array. The example below can give more insight into the above-explained model.

2.2.1 Scenario 1

On a new day, all the parking slots are free, when a vehicle enters the parking zone the image of the vehicle is captured and the vehicle number is assigned in the array of index 1, the same is displayed on the screen, SLOT 1 is free.

2.2.2 Scenario 2

Considering another instance where only slot 3 is vacant and when a vehicle enters the image of the vehicle is captured, the vehicle number is extracted, the software searches for the vacant position in the array that is the SLOT 3 and assigns the vehicle number in the index 3 of the array.

When a vehicle exits, an image is captured, the software searches for the vehicle number in the array and makes the index where the vehicle number found to "vacant".

2.3 Hardware requirements

2.3.1 Arduino Uno

Arduino Uno is the machine that is embedded in our system. The microcontroller used is ATmega328P. Arduino Uno is an open-source technology for developers and has good community support. This can be programmed using the Arduino IDE which has an inbuilt function that brings down the efforts of the user. But in this system, we used Python as our go-to language for programming because of the same above-mentioned advantages with Arduino Uno. In the successive section [2.3] we have discussed how do we bridge Python with Arduino.

2.3.2 Infrared (IR) Sensor

IR sensor is an electronic device that detects infrared radiations around it. When an object comes close to this sensor the infrared rays from the transmitter reflect off the object and are detected by the receiver. In the presented model, the IR sensor is used to detect a vehicle passing through the turnstile gate.
2.3.3 Servo Motor

It is a simple motor used to turn the turnstile gate up and down. When the IR sensor detects the vehicle, the camera captures an image then the motor opens the turnstile and after a pause of 5 seconds, it closes. This can be accessed by importing the SERVO library from pyFirmata [2.3].

2.3.4 Display

As introduced that the user is guided to the vacant parking via displaying the vacant slot number. We use an LCD screen that shows the vehicle number and the slot number where the vehicle needs to be parked shown in figures 3(a) and 3(b) for the two-vehicle respectively.

![Figure 3(a) first entry; (b) second entry](image)

2.4 Software Requirements

Arduino sketches are generally written in a language that is very relatable to C++ then compiled and stored in the flash memory when we press "Upload" from the Arduino IDE. While we can also use other High-Level languages to program the Arduino. There are some techniques to use Arduino and program it with other High-Level Languages, such as Python is a robust programming language and provides easy usage of the code lines, it is open-source with a vibrant community, the availability of vast libraries, simple syntax, the most accessible software, the maintenance can be handled in a great way, and debugging can be done easily too. The above reasons made to choose Python as our main source code and to program Arduino. One way to use Python and Arduino is by using the Firmata protocol. This protocol came into existence to completely transfer control of the Arduino to external software. The above process is performed by developing an Arduino program that is controlled by using a serial port. So, the developed Arduino program Firmata is a generic protocol that enables the communication between Arduino and the external software. The Firmata protocol solved the complication of uploading the Arduino sketch every time there is a modification done. Upload the Standard firmata protocol to the respective Arduino to avoid constant uploading even after a small change. Once burned successfully Arduino is ready to accept connection from other programs or Software like Python that supports serial communication.

As this system uses Python as the substitute for the Arduino IDE sketch, there is a need for a library that can help in bridging Python and Arduino. The required library needs to support both serial communication and support the Firmata protocol. The pyserial library can support serial communication but lacks support for the Firmata protocol. As introduced earlier about the vast libraries included in Python, there is a library to fill the absence of support by the pyserial library, which is done by the pyFirmata library which is built on the pyserial library. So, we import pyFirmata into our Python code for the successful establishment of serial communication with Arduino along with the support of Firmata.

3. Software Interface to detect number plate

Section 2 explains the camera used to capture images is done with the help of CCTV/webcam. This camera is accessed and captures images with the aid of the Python library Open Computer Vision (OpenCV) which is an open-source licensed image processing library that contains functions for any type of image processing functionality like image decoding, enhancement, colour space conversion, object tracking and detection and
many more features. The captured image is stored in the local mainframe. This captured image is then sent to the ALPR cloud is shown below in figure 4, which can be accessed through the system’s main source code with the aid of a secret key provided by the cloud services.

The ALPR cloud in return gives us the unique number from the image given as shown in figure 5. The number received is then stored in the database for security purposes as shown in table 1.

![Images given to ALPR](image)

**Figure 4 Images given to ALPR**

![Vehicle number on Python Shell](image)

**Figure 5 Vehicle number on Python Shell**

| Vehicle Number | Entry Time | Date       | Slot Number |
|---------------|------------|------------|-------------|
| DL4CAF4943    | 12:03:43   | 24:02:2021 | 1           |
| MH01AE8017    | 12:03:58   | 24:02:2021 | 2           |

**Table 1. Database of Entry Lane**

4. **Comparison with Existing Model.**

The parking system used so many sensors like Infrared Sensors. These sensors are used to check the parking slots whether the slots are available or not. In this system, ultrasonic sensors [11] are wirelessly connected to the processor using a Wi-Fi module which makes the whole system hectic and energy-inefficient. As compared to other automated parking systems where a lot of sensors are used, here we optimized the need of sensors number to a minimum which makes effective, and efficient systems thus the cost-effectiveness of our system makes it viable for all types of users. Our system makes this whole hectic work into a simple process.

Our system used software i.e., arrays that help to count the slots and displays which slots are free. The parking system also stores information in the local database and also in the cloud to avoid adding any accidental damage which helps to get the list of cars arrived is a key feature of our system. For more security purposes we are sending an e-mail about the car to the registered user every time it leaves the parking zone, makes our system the first choice for safety purposes. Thus, it makes our system a disciplined parking system which enables us to systemized and power-efficient parking system.

5. **Conclusion**

The sole purpose of this work was to take the conventional parking system to another level by adding automated parking and security for vehicles. By automation, whole manual process of noting the vehicle numbers and showing the free parking slot was replaced by a system which captures images and extracts vehicle number from that image and sends it to the database. Based on the database, a free parking slot that is allotted to the specific user is displayed on the screen at the turnstile gate. We also included security for registered users by sending a notification to the respective user.
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