May-June 2020
ISSN: 0193-4120 Page No. 4811-4816

Application Based Smart Parking Reservation System using OpenALPR

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Article Info
Volume 83
Page Number: 4811-4816
Publication Issue:
May-June 2020

Article History
Article Received:*19 November 2019*
Revised: *27 January 2020*
Accepted: *24 February 2020*
Publication: *16 May 2020*

Abstract

This paper discusses on smart parking system for slot reservation based on image processing technique and electronic parking fees collection based on OpenALPR. The aim of this project is to develop and implement an automatic parking system that will increase convenience of the public car parking zone as well as collecting parking charges without interference of humans. The proposed system processes the frame drawn at parking lot and produces the information of the empty car parking spaces. Cars can be allotted a slot based on the availability of parking lot. When the slot is vacant, it is made digitally available and helps the user discover it through our web-based application. In addition to that, it has an infrastructure where people can open our application and book a slot prior to their visit to that place. The system uses a camera as a sensor to take photos to show the occupancy of car parked. It then uses OpenALPR algorithm method for license plate extraction from car images and respective billing system to calculate the parking charges. The parking charges can be paid through application.

Keywords: *Smart Parking; OpenALPR; Image processing; Slot Reservation; Parking fees collection; Automatic Parking System.*

1. Introduction

The advancements in urbanization and the dependence on transportation lead to the evident increase in the number of vehicles on the roads around the world, which have a negative impact on the quality of life. Increase in road accidents, inadequate capacity of roads, construction and maintenance costs of road, traffic management are some problems that are severely affecting public health and resources which initiate the need of advanced solutions in Transport System.

Development of urban cities and increasing number of vehicles around the world lead to apparent increase in demand for parking spaces. It is noted that searching for free parking spaces have created increase in traffic volume. It is estimated [7] that over 70% of the European population living in urban cities nearly experiences constant impacts of air pollution and noise caused by road traffic. Secondly, the problem called cruising for parking has affected nearly 30% of the standard total traffic congestion and it takes the driver an average of 7.8 min to find a parking space [5]. A study has been reported that, over a year in a Los Angeles business district, cars cruising for parking created almost 38 trips around the world, burning 47k gallon of fuel and producing 730 tons of carbon dioxide [7][3]. This clearly shows the need of innovative Smart Parking System.

In this system, Image processing is used to detect the cars and the license plate is detected using OpenALPR. Automated License Plate Recognition (ALPR) is a technology which uses optical character recognition (OCR) to automatically recognize license plate characters. MQTT is used to exchange data between host and web application, which displays all the user activity. The system helps the user to know the availability of parking spaces on real time basis.

The paper is organized as follows: Section 2 is a report which shows the various analyses and research made in their felid of interest on the above topic. Section 3 describes the methodology, design and implementation of the system. Section 4 shows the outcome of the system. Section 5 acknowledges and Section 6 concludes the paper.

May-June 2020
ISSN: 0193-4120 Page No. 4811-4816

2. Literature survey

Chase Dowling et al. [7] in their paper, they explore city-level traffic and parking data to determine how much cruising for curbside parking contributes to overall traffic congestion. Robert C.Hampshire and Donald Shoup [5] have pointed out the excessive use of fuels caused by cruising for parking slot. Muhammad Alam et al. [3] writes about innovative ideas which has to be implemented in order to overcome the current problems with the urban parking system in their paper.

Manjusha Patil and Vasant N. Bhonge [13] has proposed a Smart Parking System which uses wireless sensors and RFID tags for detection of empty slots and directing the driver to a particular slot. But this system doesn't provide prior booking of slot. Usage of RFID tags are comparatively expensive. Harmeet Singh et al. [12] proposed a system where identification of a particular user can be done though the users mobile Bluetooth. This paper used rack and pinion mechanism to transport the vehicle to a particular spot. This could mean that the parking lot must be designed with mechanical components such as rack and pinion mechanism. Hence cannot be used in existing parking system. Nithinya G and Suresh Kumar R [11] proposed a system in which Detection of free slots and type of vehicle using Image processing directs the vehicle to slots based on the size of vehicles. If a Bus is detected at the entrance, it is directed towards west and if a Car is detected, it is directed towards the east and if Two-Wheeler is detected, it is directed towards north side of the parking area based on the availability of parking status. But prior reservation of slots and automatic Fee collection features are not implemented in the same. BenjamiKommey et al. [4] proposed a system in which the vacancy of parking slots is detected using Image Processing. Projecting the same at the entrance allows the driver to know his free slots when arrived. But this system didn't provide a web based or mobile based application for booking slots in prior. There was no automatic Fee collection feature. J. Cynthia et al. [2] proposed a system where IoT for smart parking system allowed the user to book slots in prior and payment could be done through an application. IR sensors where used at every slot to detect the vacancy of the slot. WIFI module is used to transmit the status and the location of the IR sensor. In this system, usage of IR sensors at every slot to detect vacancy is expensive and information transfer through WIFI module is unreliable.

Prof. PradnyaRandive et al. [10] is a review paper on Automatic License plate recognition (ALPR). The idea behind this paper is to resolve all the issues regarding Algorithms used for ALPR in previous years. Abhirup Khanna and Rishi Anand [9] gives us an idea on how internet of things gives us an optimal solution for smart parking system. Zhongsheng Wang et al. [8] includes MQTT broker in its proposed system for data transfer. S. Dong et al. [14] gives us a detailed explanation on AJAX (Asynchronous JavaScript and XML) as a web presentation layer technology. Abhishek Agrawal et al. [6] used IR sensors for Car Parking system and Maher Hassan Kadhim [1] used ultrasonic sensors for Arduino based Parking Manage system.

3. Proposed System and Implementation

3.1 Occupancy Detection

This subsystem includes the processing of the frames to determine whether a slot is occupied or not. We use OpenCV to process the frames (images) to do the same. OpenCV is an open source python library used for image analysis and image processing. The math of the Transform into HoughLines() in OpenCV is a popular feature extraction technique for detecting lines. But detecting lines over the parking space using HoughLines() was a difficult approach due to the presence of many other earthly elements(such as trees).
To overcome the same, it was reasonable to expect the administrator to mark the slots on his own. Hence, we could do this using a mouse as a "paintbrush". Once the application is launched, a frame is captured through a camera. The Administrator is prompted to mark 4 points (for each slot) over the captured frame as shown in Fig 1. These slots are then marked with their index (1,2...). The coordinates of the marked slots are saved in a yaml file. Once the slots are marked, the video is captured and sent as frames to the motion detector where the status of each slot is determined. In this, the average of the pixels is taken. If the average is high, it is interpreted as not occupied by any car as in Fig 2. If the average is low in a particular slot, it is marked as occupied represented in Fig 3 and the coordinates of the slots are fetched. These coordinates are used to crop the slot. The cropped Image is then fed into ALPR.

Figure 1: Marking Slots

Figure 2: Unoccupied slot

TEST Engineering & Management

May-June 2020
ISSN: 0193-4120 Page No. 4811-4816

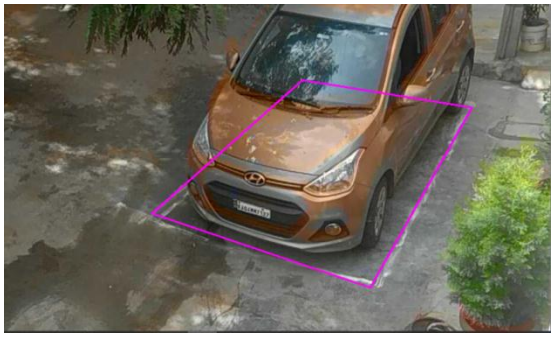

Figure 3: Occupied slot

3.2 License Plate Regonition

Once the openALPR receives the cropped image, it processes the image and gives the output in the text representation of any license plate characters, brand of the car, color of the car, make and model of the car. OpenALPR is an open source Automatic License Plate Recognition library written in C++ with bindings in C#, Java, Node.js, and Python. The library analyzes images and video streams to identify license plates [10].

When a car enters the parking space and parks in a particular slot, a snap of the car parked is taken through the camera and fed to the OpenALPR. The required information, received from the OpenALPR is stored in a database along with the check-in time and slot status as shown in Fig 4. In this database, slot number is considered as primary key. Once the car leaves the parking slot, the status of the slot is updated and the data of the respective slot number is retrieved from the database. The data is converted into json format and it is appended with check-out time as represented in Fig 5. This data is published through MQTT broker to the cloud. Json being a lightweight interchange format, makes it easy for machines to parse and interpret the data.

Once the data of the specific car is published to the cloud, the database is updated wherein the information about the departed car is deleted from the database and status of the slot is made free to be occupied by the incoming cars.

	plate	brand	entry_time	slot
1	HR26DK8337	maruti-suzuki	23:36:02	1

Figure 4: Database


```
[
    {
        "number_plate": "HR26DK8337",
        "brand": "maruti-suzuki",
        "entry_time": "23:33:39",
        "exit_time": "23:33:48",
        "slot_number": 1,
        "place_name": "Mantri Mall"
    }
]
```


Figure 5: Slot information

3.3 Database Management

Smart parking system requires independent two-way flow of data between host and server, the data such as license plate number, slot number, check-in time and check-out time of the car is collected from different hosts in different places are to be stored at the server end and also server should respond to the queries post by the front end.

As the HTTP protocol has a passive type, it can only ensure that the date is transferred to the server but cannot guarantee changes in transmission and notify the server, unless the client long polling i.e. the host computer to send HTTP request to obtain the latest server data [9]. But its costly system resources. Therefore, MQTT protocol a reasonable way of message subscription mechanism, to communicate between host and server.

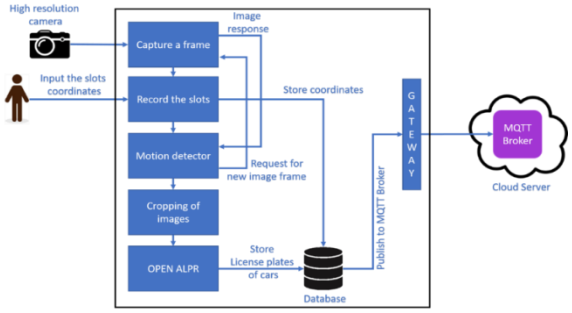

Figure 6: Cloud Server

MQTT [Message Queuing Telemetry Transport], is a lightweight messaging protocol that uses publish/subscribe operations to exchange data between clients and servers, supporting two-way messaging [8]. In this system python based open source tool Paho is used to implement MQTT client. The data published to the MQTT cloud server as shown in the figure 6, which is in json format is subscribed and converted into python format and stored in database. Based on the check-in and check-out time, time duration of the parked vehicle is calculated and stored in database. The parking fee is charged based on the number of hours the car has been parked, which can be accessed by the web application.

3.4 Web Based Application

The backend subsystem can be deployed on any machine that can be remotely accessed by the users. This subsystem is composed of two main components HTTP web server and Billing system.

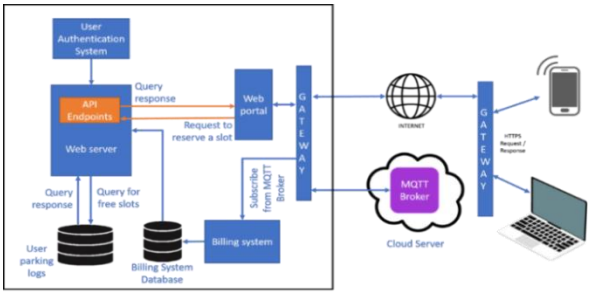

Figure 7: System Design

May-June 2020
ISSN: 0193-4120 Page No. 4811-4816

A secure webpage is designed and developed which provides a user interface to the users and the server. Users can access this webpage though any web browser for reserving a parking slot as shown in figure 7. They will have to choose the date and time along with the place where they are interested to park. When the user is satisfied with his slot, he/she then submits an AJAX [14] request to the server. AJAX (Asynchronous JavaScript and XML) is a collection of techniques used for web development, this is implemented on the client side to make asynchronous web applications [14]. With this technique, applications can send and receive data from the backend server without interfering with the existing page which is displayed. The web page does not reload every time when the user checks for any free parking slots. This makes the application look and feel more responsive to the users. Server checks through the database to find any free slots and responds back to the user. Another use of this web application could be to log the user's parking activities.

4. Results and Discussion

The proposed Application based Smart Parking Reservation System using OpenALPR was tested to determine its ability to accurately extract vacancy information from captured images of the parking space. The motion detection algorithm works accurately in detecting the vacancy of the slots. OpenALPR API returned the license plate characters which was published to the backend system. This data was processed with pre-defined algorithms and successfully generated the bill. The bill was then displayed on the web application where the user could pay securely.

Fig 8 presents the average occupancy of the park on a daily basis. An overview on the graph shows a 12-hour window pattern, a higher occupancy rate between 8 and 20 followed by an abrupt decrease and almost vacancy in the remaining hours. Moreover, it can be seen that the parking lot is not used in full capacity having its maximum attendance between 10:00 and 12:00 (95%). After this peak, the number of occupied parking slots gradually descends until reaching the end of the 12-hour window. These results and subsequent pattern can be explained by the park vicinity, mostly composed by working spaces namely: offices and the university campus.

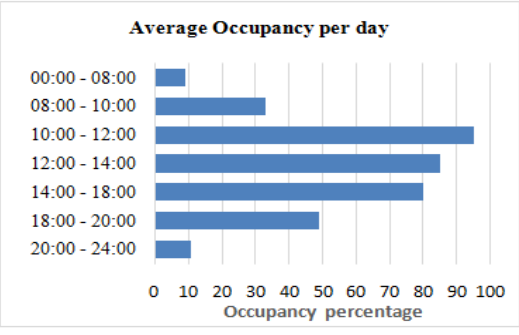

Figure 8: Average Occupancy per day

The Table 1 represents few features and their values of different sensors. The featured taken into account are range, cost and ease of installation. We can infer that camera and ultrasonic sensor [1] are easy to install when compared with other sensors.

Table 1: Sensor Features

Features			
Sensor type	Range (m)	Cost/10 slots (approx.)	Ease of installation
Camera	15	79USD	Yes
Ultrasonic	4	187USD	Yes
RFID	1	82USD	No
Infrared	3	231USD	No
Bluetooth	10	200USD	No

In Fig 9 the average range of the sensors can be analyzed. From this figure one can observe that RFID sensor has the least range i.e. less than 1 meter which is least suitable for detecting the occupancy of the parking slots [13]. The Infrared sensor and Ultrasonic has a range of 3 meters and 4 meters respectively, these sensors has an average range which would be ideal for detecting the slots easily at a distance [13-14]. Further analyzing the graph, we can observe that Bluetooth and camera sensors have range between 10 to 20 meters. Our proposed system covers a wide area of slots with help of a camera. Its detection functionality is tied to an image processing algorithm to determine the availability of a particular slot, hence making it more efficient.

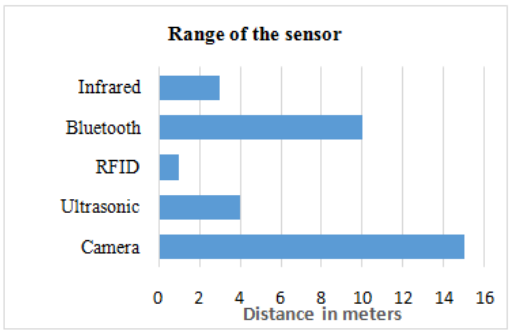

Figure 9: Range of the sensor

In Fig 10, we can observe that usage of camera and RFID is more economical when compared to sensors such as infrared, Bluetooth and ultrasonic. The usage of latter sensors at every slot makes it expensive.

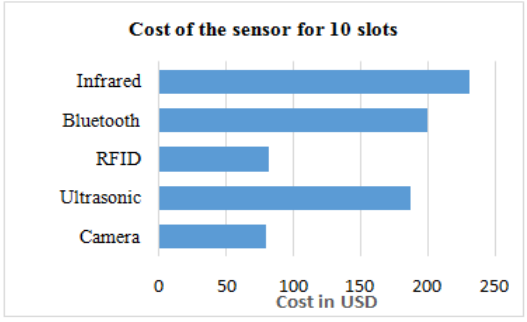

Figure 10: Cost of the sensors for 10 slots

May-June 2020
ISSN: 0193-4120 Page No. 4811-4816

5. Acknowledgment

It gives us great pleasure in publishing the paper on "Application based Smart Parking Reservation System using OpenALPR". We would like to express our sense of gratitude to our School of Computing and Information Technology Director Dr. Sunil Kumar S Manvi for providing us the means of attaining our goal. We would also like to take this opportunity to thank our project guide Prof. Dr. MallikarjunaShastry P.M. for giving us all the help and guidance needed.

6. Conclusion

In this paper, we have developed a prototype of Smart Parking System. This system consists of three subsystems that interact with each other and serves the purpose. First sub system is written in Python programming language and OpenALPR which is an open source application used to recognize the license plate of vehicles. The data which is to be transferred to the centralized server is implemented using MQTT protocol. Second sub system serves the purpose of maintaining the user's credentials and information, this sub system acts as the heart of our project performing all the logical calculations. The third sub system is a web-based application where the users can interactively view and reserve the parking slots. If this prototype is developed and deployed for service, it can reduce the work on labors because it is computerized. Paper works and printing of receipts are eliminated as reservations are made in database at the server. This approach also makes the users convenient to reserve a parking space temporally. Based on the obtained results from our study, we conclude that the proposed smart parking system can alleviate the problems faced by the current parking system.

7. Future Work

Furthermore, this system can be extended to add additional functionality which can analyze user's activity and suggest the best time and place to reserve a parking space. Machine learning algorithms and deep neural networks can be implemented to achieve this. Chat bot can be integrated to the web application to interact with the uses. Users can post queries to the chat bot regarding the parking space details.

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