

Smart and Effective Real-Time Management of Street Parking

Sahil Khandait, Kunal Appa, Aryan Choudhari, Kartik Doye
Guide : Prof.Ashish Golghate

S B Jain Institute of Technology Management and Research Nagpur Department of Emerging Technologies

Abstract

On-street parking is an essential component of parking infrastructure for smart cities, which allows users to park near their destinations for short term. However, due to limited capacity, saturated on-street parking becomes a serious and widespread problem for urban transportation systems. Greedily searching for an on-street parking spot in a saturated area is often a frustrating task for drivers, and cruising for vacant parking spots results in additional delays and impaired local circulation. With the recent development of networked smart parking meter, real-time city-wide on-street parking information becomes available for more efficient parking management. In this paper, we design an online parking guidance system that recommends parking spots in real-time based on the parking availability prediction. With a receding horizon optimization framework, our solution minimizes the user's driving and walking cost by adapting the spatiotemporally dynamic supply and demand in the local area, significantly reducing parking competitions in a timely manner. We implement and evaluate our solution with a dataset of 13,503,655 parking records collected from 5118 in-ground sensors distributed in the Australian city Melbourne. The evaluation results show that our approach achieves up to 63.8% delay reduction compared with existing solutions.

Keywords: on-street parking, smart cities, parking infrastructure, parking availability prediction, real-time guidance system, receding horizon optimization, spatiotemporal dynamics, parking competition, urban transportation, smart parking meter.

Introduction

The proper management of the available parking spaces in the urban areas is a necessity to assist the drivers in locating the parking spot quickly during the busiest hours of the day as well as to enable the city authorities to earn their revenue by proper utilization of the parking areas. So, smart parking management is treated as an important aspect of the smart city services [1] in today's world. Thus, the development of smart parking system (SPS) for metropolitan areas to address the above mentioned issues has become an important field of research. Although a lot of research efforts have been contributed in designing various SPSs over the past few years, most of them focus on the detection of free parking slot within a parking area by using some wireless technology like radio frequency identification (RFID), sensor node, sensor network etc [2, 3, 4, 5, 6, 7]. Very few works concentrate on the automated management of the parking spaces which is a necessity to keep track of available free parking slots within the parking area as well as to enable driver to reserve some parking spot of his/her choice. Longer the search for a suitable parking slot, more increases not only the fuel consumption, but also the traffic congestion as well as the air pollution. On the other hand, none of the automated parking management systems proposed in literature till now has been designed with the aim of managing all parking areas available throughout the city in real-time. Moreover, such systems should ensure the automatic collection of the parking charges based on the duration of parking slot's occupancy by some vehicle. To address the above mentioned issues, the framework of an IoT based E-parking system for

smart cities has been proposed in the earlier work [8]. But no experimental results have been provided to validate the proposed work. Thus, this paper not only presents the detailed design of the proposed automated real-time parking management system, but also the experimental results to demonstrate the effectiveness of the proposed system. The automated parking management system (APMS) proposed in this paper aids the driver to find out and reserve a parking spot of his/her choice in real-time in a secured way via some control server which is responsible for management of all parking spaces available throughout city as well as the city authorities in automatic collection of the parking charges. Various screen shots depicting the graphical user interface (GUI) of android based mobile application that enables the authenticated drivers to locate the nearest parking spot and then reserve it, have also been provided in this paper.

LITERATURE REVIEW

The parking industry is an essential component of the urban transportation system, and its importance has been widely recognized in the literature.

1. (LITMAN, 2019) This study highlights the importance of parking management as a tool for reducing traffic congestion, improving mobility, and promoting sustainable transportation. The study emphasizes the need for a comprehensive parking management strategy that considers the demand for parking, the supply of parking spaces, and the pricing of parking services.
2. (SCHALLER, 2018) This study highlights the challenges facing the parking industry, including inadequate parking infrastructure, the lack of a regulatory framework, and the need for technological advancements in parking management. The study suggests that the parking industry needs to adopt innovative solutions to improve the efficiency and sustainability of parking operations.
3. (VAIDYA ET AL, 2017) This study analysed the parking situation in Pune city and found that the existing parking infrastructure was inadequate to meet the growing demand for parking spaces. The study suggested the need for a comprehensive parking policy that considers the needs of all stakeholders, including motorists, local authorities, and private operators.
4. (JAISWAL AND YADAV, 2019) This study analysed the parking situation in Delhi and found that the lack of a regulatory framework and standardization of parking rates and services was a major challenge facing the parking industry. The study suggested the need for a comprehensive parking policy that considers the needs of all stakeholders and promotes the efficient use of parking resources.
5. (IYER AND VEERARAGHAVAN, 2016) This study the parking industry in India is largely unorganized and lacks proper regulations. The study suggests that the government should develop policies and guidelines for the industry, which would help to improve the parking situation in the country. The study also highlights the need for efficient parking management systems and the use of technology in parking facilities.
6. LOHANI ET AL, 2017) This study investigated the parking situation in Delhi, the capital city of India. The study found that the lack of parking infrastructure and the unavailability of parking spaces were major issues in the city. The study also suggested that the government should take steps to improve the public transportation system, which would reduce the number of private vehicles on the road.
7. (MANCHIKANTI ET AL, 2019) This focused on the parking situation in Bangalore, a major metropolitan city in India. The study found that the parking industry in the city was largely unorganized, and there were several challenges in managing parking facilities. The study suggested that the government should take a more active role in regulating the industry and implementing standardized parking policies.
8. (SETHI, 2017) This study examines the parking facilities in five Indian cities – Delhi, Mumbai, Kolkata, Bangalore, and Chennai. The study finds that the availability of parking spaces is limited, and the demand for parking exceeds the supply in most areas.

The study also highlights the poor quality of parking facilities, lack of proper signage, and the absence of standardized parking fees as major challenges. The study suggests that the government needs to take a proactive role in improving the parking infrastructure and regulation of the industry.

9. (GOYAL ET AL., 2018) This study compares the parking policies of six Indian cities – Delhi, Mumbai, Kolkata, Bangalore, Chennai, and Hyderabad. The study finds that there is no standardized parking policy in India, and the policies vary significantly across cities. The study also highlights the lack of coordination between different agencies responsible for parking management as a major challenge. The study suggests that the government needs to establish

a unified parking policy and regulatory framework to improve the parking infrastructure in the country.

10. (KHADILKAR ET AL, 2019) This case study examines the parking management in Pune, a rapidly growing city in western India. The study finds that the parking infrastructure in the city is inadequate, and the demand for parking spaces exceeds the supply. The study also highlights the lack of proper parking management, including the absence of parking regulations and the use of outdated technology, as major challenges. The study suggests that the government needs to take a more proactive role in parking management and adopt innovative parking models to address these challenges.

THEORY OF THE PROJECT

- 1. The Problem Definition:** People usually travel around within the parking regions trying to find an appropriate place to park in, to solve this problem, the automated car parking system has created. Assistive technology is needed, which may provide parking information for registered customers using smartphones and their applications. Users can obtain the service by registering, and in case of booking, the destination and the estimated time of arrival are determined, and the booking details are sent to the user.
- 2. Aim of the project:** The smart car parking system is an integrated system to recognize the nearest available parking zone. So, the main purpose of

the system is to provide a solution to the parking problem, to reduce the time to search for parking lots, and to eliminate unnecessary travel for vehicles.

- 3. How Smart Parking Works:** Smart parking suggests an IoT-based system that sends data to free and busy parking places via net/mobile applications. The IoT-network includes sensors and microcontrollers, which are found in each parking place. We implemented an enclosed smart parking project (SPMS), that using the Internet of Things and IR sensors, where available parking places can be displayed in a web application, then the user receives a live update about the availability of all parking places and chooses the best one. Smart parking IoT implementation is usually divided into the following parts:

1	Collection	The collection depends on parking sensors to collect real-time parking. The parking systems may use sensors like Infrared, and Ultrasonic Sensors detect whether a parking slot is empty or not [10]. Also, an ESP8266 Wi-Fi chip comprises of the TCP / IP protocol, that licenses any microcontroller to contact a Wi-Fi network.
2	Processing	The processing unit acts as interference between the sensors and the cloud [11]. It includes an Arduino which is a processor on-chip. All the sensors are wirelessly connected to the processing unit, and data collected from various sensors are sent to it through the esp8266 chip.
3	Deployment	It deals with communication methods. Message Queue Telemetry Transport Protocol (MQTT) is a publish-subscribe based messaging protocol that is used on top of the TCP/IP protocol [12].
4	Srvices	It can be made available to users once they finish storing data and monitoring information.
5	Connection	Interested in the Internet of Things layer that deals with the database of parked cars through a shared server. The cloud stores data for available parking lots, user sites, profiles, etc. [13]. It keeps a track of each user connected to the system and stores a backup of the information stored in the cloud.
6	Mobile application	It is the interface application between humans and the system.

System Design

In this section, a discussion of the design of the proposed smart real time parking controlling and monitoring system has been presented. Figure 1

shows the system architecture, which consists of four main components: the monitoring unit, processing unit, cloud-side unit, and user application. Each component is discussed in the following.

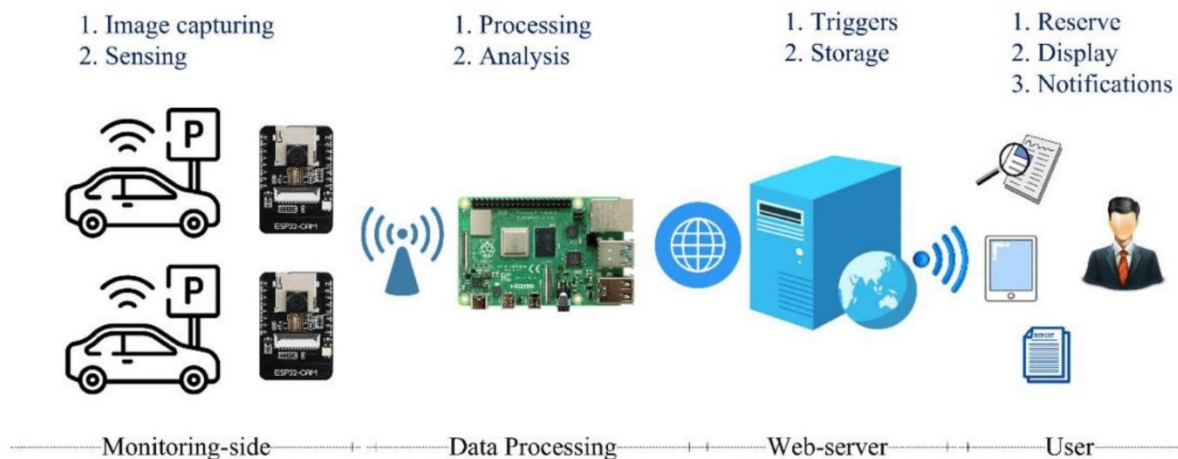


Figure 1.
The main

architecture of the proposed system.

Monitoring Unit: The monitoring unit is hosted at each parking slot and consists of a smart IoT device. This low-cost, small-sized,

and low-power consumption unit can detect the presence of a vehicle, take a picture, and transmit it to the processing unit.

Processing Unit: This unit consists of a low-cost computer (Raspberry Pi 4) that can receive the images taken by the monitoring units, process and retrieve the required information from the images using an Automatic Number Plate Recognition (ANPR) system and transfer the retrieved data to the cloud-side unit to make it available for the user application.

Cloud-side Unit: This unit collects the extracted information from the images

received from the IoT device, records the final details in the database, and performs the user alerting function. The information includes the vehicle's license plate number, parking time, and parking slot identity number.

User Application: This application has been designed to enable users to perform various functions, such as registration, booking, and modifying bookings

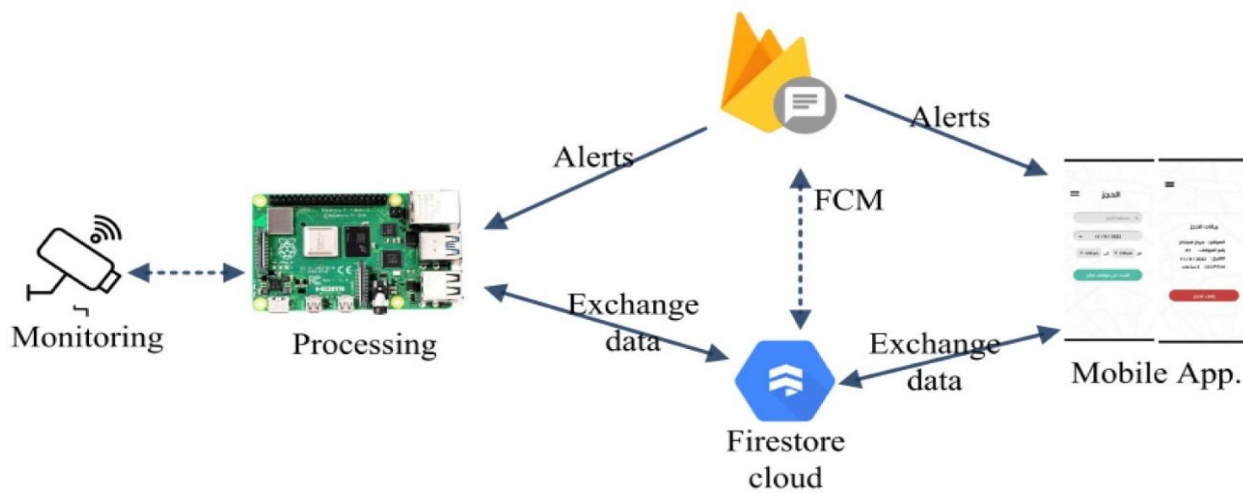


Figure 2. Data exchange between the proposed systems' components.

Figure 2 depicts the data communication of the proposed system. The monitoring unit captures a photo of the parked vehicle and transmits it to the processing unit (Raspberry Pi 4). The processing unit identifies the vehicle's license plate and recognizes the characters using Optical Character Recognition (OCR) from PyTorch. Once the characters are identified, a new record is created in the Firestore cloud database, and an alert is sent to the user using Firebase Cloud Messaging (FCM).

Conclusion:

This paper presents an automatic parking management system that addresses the problem of real-time management of all parking spaces available within a city. The proposed automated real-time parking management system has the following important features.

- It aids the driver to locate his/her preferable parking spot quickly.
- It can detect improper parking of an vehicle at some parking slot.
- It provides online reservation facility of the parking spot in a secured manner via an android application.

- It also ensures automatic collection of the parking charges by the city authorities via an electronic payment gateway.

The experimental results and various screen shots provided in this paper validate the effectiveness of the proposed system. Moreover, the parking reservation module proposed in this paper is much simpler and more cost effective compared to those that relies on Google Map and GPS technology.

References

1. Sadhukhan, P. :An IoT based Framework for Smart City Services. In Proc of 2018 International Conference on Communication, Computing Internet of Things (IC3IoT 2018), Chennai, India, 409-412(Feb. 2018).
2. W. Cho et al. :Robust parking occupancy monitoring system using random forests. In Proc of 2018 International Conference on Electronics, Information, and Communication (ICEIC), Honolulu, HI, 1-4(2018).
3. Baroffio, L., Bondi, L., Cesana, M., Redondi, A.E., Tagliasacchi, M. :A visual sensor network for parking lot occupancy detection in Smart Cities. In Proc of 2015 IEEE 2nd World Forum on Internet of Things (WF-IoT), Milan, 745-750(2015).
4. Fabian, T. :An Algorithm for Parking Lot Occupation Detection. In Proc of 2008 7th Computer Information Systems and Industrial Management Applications, Ostrava, 165-170(2008).
5. Suhr, J. K., Jung, H. G. :Sensor Fusion-Based Vacant Parking Slot Detection and Tracking. IEEE Transactions on Intelligent Transportation Systems, vol.15, no. 1, 10-36(Feb. 2014).
6. Ng, C., Cheong, S., Ha ji, E., Yap, W. :Mobile outdoor parking space detection application. In Proc of 2017 IEEE 8th Control and System Graduate Research Colloquium (ICSGRC), Shah Alam, 81-86(2017).
7. Delibaltov, D., Wu, W., Loce, R. P., Bernal, E. A. :Parking lot occupancy determination from lamp-post camera images. In Proc of 16th International IEEE Conference on Intelligent Transportation Systems (ITSC 2013), The Hague, 1287-1292(2013).
8. Sadhukhan, P. :An IoT-based E-parking system for smart cities. In Proc of 2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI), Udupi, 1062-1066(2017).
9. Khanna, A., Anand, R. :IoT based smart parking system. In Proc of 2016 International Conference on Internet of Things and Applications (IOTA), Pune, 266-270(2016).
10. Revathi, G., & Dhulipala, " Smart parking systems and sensors: A survey", proc., in 2012 International Conference on Computing, Communication, and Applications, 2012.
11. Abhirup Khanna, Rishi Anand, " IoT based Smart Parking System", proc., in International Conference on Internet of Things and Applications (IOTA) Maharashtra Institute of Technology, Pune, India 11 Jan - 13 Jan 2016.
12. <https://en.wikipedia.org/wiki/MQTT>, 18-7-2020.
13. Thusoo, A.; Sarma, J.S.; Jain, N.; Shao, Z.; Chakka, P.; Zhang, N.; Antony, S.; Liu, H.; Murthy, R. HIVE-A, "petabyte-scale data warehouse using Hadoop", proc., In 2010 IEEE 26th International Conference on Data Engineering (ICDE 2010), 2010.
14. https://www.researchgate.net/publication/331915551_Automated_Real-time_Parking_Management_for_Smart_Cities