

# A Survey on Smart Parking Management System

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With the large increase in population, automated industries and need of vehicles, parking of the vehicles is becoming a critical issue in various cities. Unmanaged parking of vehicles leads to noise pollution, air pollution, traffic congestion. During peak hours, it is difficult task to find vacant parking lot and it becomes the major challenge for driver to park the vehicle. A lot of work is being done in the whole world to manage the efficient parking of vehicles. To give the clear overview about efficient parking system, we go through some existing studies over the period of 2009-2022 which proposed various parking solutions. This survey gives an exhaustive study of available parking solutions and also proposed some recommendations for future research in providing smart parking management system.

**Keywords:** Smart Parking, IoT, Zigbee, Firefly Algorithm, Edge Computing

## 1. Introduction

IoT (Internet of Things) has changed the life of many peoples as it provides the ease. Due to this, the use of IoT devices is increasing day by day in every area such as smart home automation, smart city, smart parking system etc. With the rapid growth in use of IoT devices and cloud systems, smart cities have great opportunity in changing the people’s lives and leads to technological development and ease in accessibility. Smart parking is one of the main concepts in smart cities as the efficient parking system leads to reduction in environment pollution by reducing the fuel and time consumption. Fahim *et al.* [1] presented a review to describe and compare existing smart parking approaches based on sensors used, networking technologies adopted, computational approaches used, and user interfaces used. They have also described pros and cons of existing smart parking approaches and sensors used. Kalid *et al.* [2] studied all the studies related to smart parking solutions (digitally enhanced parking, empty slot detection, and route planning) and autonomous valet parking solutions (short range autonomous valet parking and long range autonomous valet parking).

Fig 1 [3] shows use case diagram of smart parking management system. This use case diagram includes 8 different actors and 8 different use cases for both administration and operation viewpoints. This use case diagram gives all the details about managing parking data, generating billing receipt, updating parking status and setting the parking rates.

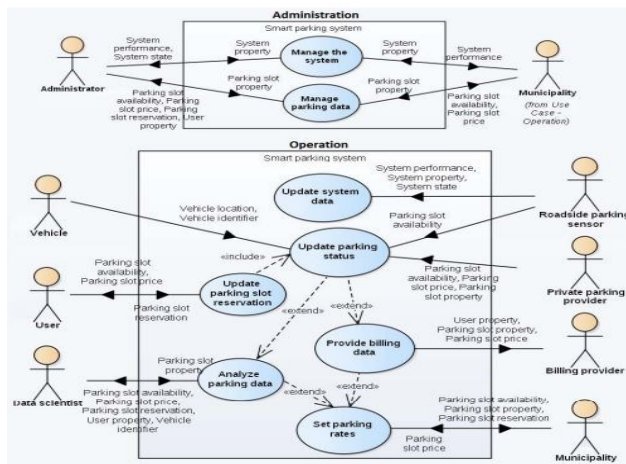
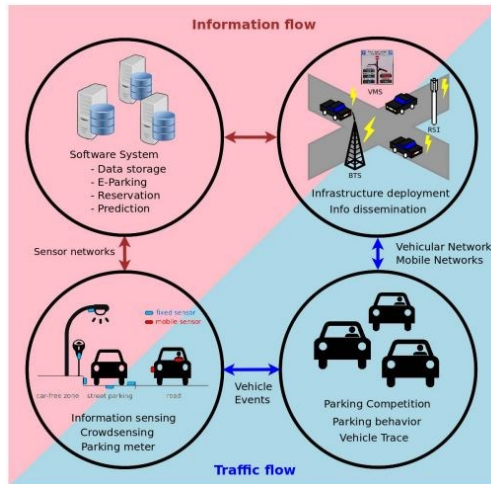


Fig. 1: Use Case Diagram of Smart Parking System

Smart parking system is divided into two flows: information flow and traffic flow. Both flows are represented in fig 2 [3]. The traffic flow gives the information about vehicle events and provides the path. The information flow gives all the information related to parking of the vehicles at all the moments such as from the moment when sensors detect the vehicles to the moment when parking reservation displays on the driver's terminal.

Various authors gave many methods and algorithms to manage the efficient parking of vehicles. In this paper, we have given the existing studies over the period 2009-2021 mainly focused on providing various parking solutions. In these studies, the authors have been used various machine learning, deep learning and ensemble techniques for building prediction models, metaheuristic approach such as feed forward back propagation neural network and firefly algorithm and various devices such as Zigbee, BLE beacons etc. Some of the authors have also proposed algorithms to build the efficient parking systems.

The organization of this paper is divided in various sections which are as follows: Section 2 describes the existing methodologies which have already proposed some parking solutions. Section 3 describes the conclusion based on all the studies considered in this survey. Section 4 describes the research gaps found from these studies or in other terms we can say that section 4 describes the future research works which can be done to provide the efficient parking solutions.



**Fig. 2:** Information flow and Traffic flow

## 2 Existing Methodology

Smart parking is the most important part in smart cities which helps in improving the quality-of-life cycle in cities. As production of vehicles are increasing day by day, these vehicles on the streets leads to time and fuel consumption due to which environment gets polluted. So, to overcome this problem, there is a need to build the efficient parking solutions. In this section we will go through some existing studies which helps in introducing efficient parking management system.

There is a need to build an automated, cost-effective, real time and easy-to-use parking management system for car parking. Srikanth *et al.* [4] proposed a Smart PARKing (SPARK) management system which was used to satisfy the requirements of car parking management system. They used wireless technology to provide automatic guidance, effective parking reservation mechanism and remote parking monitoring.

Many approaches have been stated for smart parking but due to covid 19 outbreak there is a need to build a model which also considers social distancing measure because social distancing is the only preventive measure to overcome the virus. Thierry Delota and Sergio Iarri [5] proposed a method that gives recommendation to drivers about safe vacant parking slots. The main objective of their study was to introduce a methods which gives the suggestions of available parking slots on the basis of social distance measure and also this system maximize the safety of vehicles and the people available in parking lot.

H. Canli and S. Toklu [6] proposed a deep learning-based application. For the experimentation purpose they used ISTPARK dataset. The objective of their study was to build a deep learning and cloud-based application so that the searching time for vacant parking slot get reduced and they also used deep learning with LSTM in the proposed application to predict the parking space.

Tang *et al.* [7] in their study generated a fog computing based smart parking system to improve the real time smart parking system. They performed the experiment on Golden eagle mall parking space. The proposed system combines the benefits of both VANET's and fog computing in order to reduce gasoline waste, average parking cost and vehicle exhaust emission, and this system also improves the parking facilities.

Lin *et al.* [8] introduced a Smart Parking Algorithm (SPA) whose working is based on the behaviour of the driver. This proposed algorithm maximizes the benefits of the parking space owner and improves the service quality. Also, this algorithm predicts the parking time based on the past data of parking records.

Misra *et al.* [9] introduced an intelligent parking scheme to fulfil the vision of parking 4.0. The

objective of this study was to fulfil the vision of parking 4.0 as a digital reimagination of the end-to-end parking chains as to provide collaborative ecosystem. This scheme provides right parking at correct place at cheap price.

As vehicles are increasing day by day then finding the empty parking space is a major issue. Conventional methods for parking system are very costly as they use installation of sensors at every parking space. Singh *et al.* [10] build an improved parking system so that vacant parking space searching time gets reduced. The objective of this study was to build a system for park the vehicles using metaheuristic approach such as using feed forward back propagation neural network and firefly algorithm. This approach considers two parameters parking efficiency and parking space search time. Parking efficiency is improved using firefly algorithm and parking space search time is reduced using feed forward back propagation neural network.

Mackey *et al.* [11] build a system which was based on BLE beacons. The objective of this study was to provide smart parking system for both indoor and outdoor spaces. In this system, each parking space is paired with unique BLE beacon to provide guidance and secure payment system and to improve the accuracy, particle filter is used. In this study they used BLE beacons, Google's Eddystone protocol and MATLAB for experimentation work. They introduced Smartphone application which was based on BLE beacon devices and they used Google's Eddystone protocol for secure payments. This study results in more accurate result for checking parking availability.

Provoost *et al.* [12] proposed a prediction system which predicts the parking occupancy via ML techniques such as Random Forest and Neural Network. They did the experimentation on various places such as Gelredome stadium, Dutch metrological institute KNMI, Weerlive API, National Databank Wegverkeersgegevens, Open data service of NDW, Centraal Garage, Municipality portal parking data. The objective of this study was to examine effect of Web of things and artificial intelligence to foresee the vacant parking space. In this study traffic cameras were used as web of things sensors. The result of this study show that ML methods score a MSE (Mean Squared Error) of 7.18 in a time duration of 60 min.

As there is an increase in vehicles in the city, it becomes difficult task to find empty parking space.

Sarang Deshpande [13] proposed M-Parking: algorithm which uses hierarchical wireless sensor networks for vehicle parking guidance system. In this study they used ADC, flash memory, transceiver, Zigbee. M-Parking is more energy efficient as there are 3 passive sensors per parking slots and results are accurate as single active sensor per parking slot.

According to a survey, drivers spend lot of time to search for empty parking space in parking lot. Tekouabou *et al.* [14] proposed a prediction model on the basis of ensemble techniques such as bagging and boosting and IoT. The main objective of this study was to build an integrated model of

IOT and regression algorithms to build prediction model so that drivers can predict available parking space in smart parking. They used Birmingham parking dataset for experimentation. The result of this study shows that Bagging regressor model improves the best existing prediction performance by [166.6% and reduces the system complexity.

Zhang *et al.* [15] proposed a parking system which makes use of Edge Computing. The objective of this study was to generate a P2P based smart parking management system which uses cloud computing, edge computing and P2P network techniques which helps in navigation, enquiries etc. To perform the experiment, they used XD Smart Park protocol and various algorithms such edge computing, cloud computing, P2P algorithm and mobile nodes.

Jong-Ho Shin and Hong-Bae Jun [16] introduced a smart parking guidance algorithm which provides actual time status of availability of parking in smart cities. This algorithm considers many parameters such as driving distance to the guided parking facility, expected parking cost, walking distance from the guided parking facility to destination, and traffic congestion due to parking guidance. The experimentation is performed in Luxembourg city. Proposed algorithm helps in effective usage of parking spaces in the city. It reduces the energy consumption and traffic congestion in the city.

Qadir *et al.* [17] proposed smart parking system which was time and energy efficient and based on Zigbee. The main purpose of their study was to provide communication between various devices with low power consumption and more effective way of parking by sharing the actual time scenario of nearby vacant parking lots. They used Arduino UNO interface and digital transceiver for experimentation purpose. Also, this system can provide location of the vehicle to driver if the vehicle gets theft.

Pampa Sadhukhan [18] proposed an IoT based E parking system. The objective was to build an Internet of things-based E- parking system which uses parking meter to solve various issues such as estimating parking usage by each vehicle, collecting parking charges, detecting improper parking. Parking meter, WLAN or Wifi enabled laptop/workstation, Wifi access points were used to perform the experiment. This system provides reservation based smart parking facility, smart payment to collect payment charges, detects improper parking vehicles within parking lot.

Alharbi *et al.* [19] proposed web application based on OCR algorithm for solving smart parking problem. This application provides the facility of pre-reservation of vacant slots in order to avoid traffic congestion. As wireless sensors play an important role in building smart parking solutions, so

Kumar *et al.* [20] proposed an intelligent approach for smart parking solution which is based on wireless sensors. Table 1. shows the summary of selected existing studies related to smart parking system

**Table 1:** Summary of the selected existing studies

<b>Author Name</b>	<b>Year</b>	<b>Keywords</b>	<b>Dataset and Component used</b>	<b>Findings</b>
Srikanth <i>et al.</i> [4]	2009	Wireless Sensor Networks (WSN), Automated Guidance, Smart Parking, Lot Reservation, Remote Monitoring.	Sensor node, Sink node, GSM device, LEDs	Proposed a Smart PARKing (SPARK) manager system which provide automatic guidance, effective parking reservation mechanism and remote parking monitoring.
Jong-Ho Shin, Hong-Bae Jun [16]	2014	Parking facility, Smart parking guidance, City transportation management, Parking guidance algorithm.	Luxembourg city five objects: parking lot, central server, personal navigation device, parking management system, driver.	Proposed algorithm which helps in effective usage of parking spaces in the city. It reduces the energy consumption and traffic congestion in the city and also provides actual time status of parking availability in a city.
Sarang Deshpande [13]	2016	Hierarchical Wireless Sensor Networks, Parking Information Subscription, Vehicle Parking Guidance.	ADC, flash memory, transceiver, Zigbee	Proposed an algorithm using hierarchical wireless sensor networks for vehicle parking guidance system. It is more energy efficient as there are 3 passive sensors per parking slots and results are accurate as single active sensor per parking slot.

Pampa Sadhukhan [18]	2017	Smart parking system (SPS), Internet-of-Things (IoT), parking meter (PM), E-parking, parking lot.	Parking meter, WLAN or Wifi enabled laptop/workstation, Wifi access points	Provides reservation based smart parking facility, smart payment to collect payment charges, detects improper parking vehicles within parking lot.
Tang <i>et al.</i> [7]	2018	Parking slot, fog computing architecture, Smart VANETs, real time.	Golden eagle mall	Fog computing based smart parking system that combines the benefits of both VANET's and fog computing in order to reduce gasoline waste, average parking cost and vehicle exhaust emission and improvement in parking facilities.
Qadir <i>et al.</i> [17]	2018	Internet of Things (IOT), Arduino, Microcontroller, ZigBee, GSM, IR Sensors.	Arduino UNO Interface, Digital Transceiver	Zigbee is both time and energy efficient as compare to bluetooth and Wi fi. Also, this system can provide location of the vehicle to driver if the vehicle gets theft.
Misra <i>et al.</i> [9]	2019	Parking 4.0	IPX (Intelligent Parking Scheme)	This provides right parking at correct place at cheap price.
Zhang <i>et al.</i> [15]	2020	Smart parking, Cloud computing, P2P network, Edge computing, Intelligent transportation system.	XD Smart Park, cloud computing, edge computing, mobiles, mobile nodes, P2P algorithm	Proposed a P2P based smart parking management system which is more friendly and effective smart parking management system as compared to others which is based on P2P based algorithms. Introduced XD smart park protocol to implement this system.
Tekouabou <i>et al.</i> [14]	2020	Smart cities, IoT, Regression,	Birmingham parking dataset	Integrated model of IOT and ensemble methods to predict the available parking space in smart car parks. Bagging regressor



		Parking availability, Ensemble models.		model improves the best existing prediction performance by 6.6% and reduces the system complexity.
Mackey <i>et al.</i> [11]	2020	Eddystone, Bluetooth low energy (BLE) beacons, Particle filter, Parking availability estimation, Internet of Things (IoT), Smart cities, Smart parking.	BLE beacon device, Google's eddystone protocol, Matlab	Smartphone application based on BLE beacon devices and for secure payments system, google's eddystone protocol is used. It gives more accurate result for checking parking availability.
Provoost <i>et al.</i> [12]	2020	Internet of Things, Neural networks, Machine learning, Parking occupancy, Web of Things.	Gelredome stadium, Dutch metrological institute KNMI, Weerlive API, National Databank Wegverkeersgegevens, Open data service of NDW, Centraal Garage, Municipality portal parking data.	The prediction performance of the Machine Learning models for searching vacant parking space was better than the previous work in the problem under study. ML methods achieve a MSE (Mean Squared Error) of 7.18 in a time period of 60 min. The historical rate of occupied space (i.e., the look-back window) was the most important forecast variable, followed by traffic flows calculated at the orbital highways.
H. Canli and S. Toklu [6]	2021	Smart city, SVM, Deep learning, RF, LSTM, ARIMA model.	ISTPARK Dataset	As compared to Support Vector Machine, Random Forest and ARIMA models, this model improves accuracy. The accuracy rate is 99.57% which is dependent on capacity, time, density, day and holiday.

Singh et al. [21]	2022	Virtualization, Sustainable city, Blockchain, Deep LSTM, Energy efficiency	IoT and sensor devices	Proposed block chain enabled secure approach for smart parking in order to provide energy efficient solution in sustainable environment.
Awaisi et al. [22]	2022	Smart parking, IIoT, Deep reinforcement learning	Smart camera, cloud server, and fog nodes	Proposed deep reinforcement learning based solutions for industrial IoT (IIoT) based smart parking. Result shows that this approach correctly detect vacant places with minimum processing time.

### 3 Conclusion

With the increase in population and traffic congestion, there is a reduction in land, so smart parking becomes a major topic to work on, not only from research point of view but from economic point of view also. Drivers have to spent more time in finding the available parking space due to which there is more consumption of fuel and increase in environment pollution. In this paper, we have performed a literature survey of existing parking solutions. We have also explained the methodologies used in these studies and these methods solves the parking problems. After analyzing the previous work done, we found that there are some shortcomings in the existing studies. The main objective of this survey is to identify the research gaps that can help in building the new and efficient parking system.

#### 1 Future Scope

We can extend the existing parking solutions to analyze the results in various cities means make the results more generalizable and integrating existing route planning applications to this system so that there is an ease to drivers in finding parking occupancy. Also, for building prediction models, we can use hybrid algorithms instead of machine learning and ensemble techniques. As there can be an increment in traffic density due to waiting in parking, exiting from parking, and searching vacant space in parking, so, we can analyze effect of parking system on traffic density and can introduce some method which helps in reducing traffic density.

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