

Smart Parking based on iOS Apps for Smart Cities

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ABSTRACT

Parking problem has become a big problem for us in daily life. Mainly in urban and city corporation area like mall, market etc. we face this problem more and finding space for parking here is very difficult. As a result, we spend a lot of time and energy. Finding a parking space has become a much more frustrating event for the driver or user. If the users or drivers do not get any parking space and park their vehicles randomly anywhere then the road will be jammed and the safety of the vehicles will be threatened. It is also the cause of many accidental incidents. It is the manual system that we usually see. We need a smart parking system that will play a role in creating the smart city of the future. We propose an iOS apps-based parking system to solve this problem of manual system. It allows users or drivers to find parking spaces and park their cars through mobile apps i.e., our developed iOS apps for smart parking. Then we do a comparative analysis of our system with the manual system with direct participation of users and see if our system is used then the existing problems will no longer exist.

Keywords: Ultrasonic Parking Sensor; User/Driver; IoT; Raspberry Pi; Cloud Database; iOS Apps

INTRODUCTION

Almost we go to cinemas, malls, markets etc. and there we face a common problem and that is parking problem. Parking problem is increasing day by day in urban and metropolitan cities. Finding a parking space has become a much more difficult and at a time frustrating event for the driver. As a result, user/ driver spends a lot of time and energy. If the users/drivers do not get any parking space and park their vehicles randomly anywhere then the road will be jammed and the safety of the vehicles will be threatened. It is also the cause of many accidental incidents. To solve the existing problem of parking, we need a smart parking system that will play a role in creating the smart city of the future. It allows users/drivers to find parking spaces and park their cars through mobile apps. That is users can easily find parking slots using a mobile application that the space is empty or not. User/driver can easily find the vacant slot of parking space using the mobile app and book in advance as per their requirement. The booked slot will be valid for that user/driver till the specified time. Users/drivers can pay the parking fee through the app while exiting the parking spot. With the aid of Internet of Things (IoT) technology, smart parking systems can be developed which make user/driver life much easier and better. The internet of things, or IoT, is an interconnected network of computing devices, digital and mechanical machinery, items, animals, or individuals who are given unique id (UIDs) and the capacity to transport data across a network without the need for human-to-human

or human-to-computer contact. The following presentation illustrates a simple equation for the Internet of Things (IoT), in which a physical object follows the function of the things, and since it is connected to the internet, it can be managed and monitored online.

Physical objects + Controller, Sensors and Actuators +
Internet = Internet of Things (IoT)

Finally, the objectives of our studies/proposals are: based on the following hypothesis execute a comparative analysis of our proposed system and the existing system and from the results observed that our proposed systems are much better in all aspect.

Q1: Finding a parking space has become a much more difficult, frustrating and time-consuming event for the users/drivers in urban area i.e., manual parking.

Q2: Implementation of smart parking system aimed at smart cities helps drivers to find parks easily and save time i.e., our proposal

Q3: This IoT technology supports to make a better environment in municipal areas without overcrowding and by reducing carbon dioxide emissions, it makes people's lives better and more reliable.

The rest of the paper is organized as follows: in section 2 we the covers the literature review. In section 3 discuss about our proposed methodology. Section 4 covers the experiment; experimental results are in section 5. Finally, conclusion and future Scopes are summarized 6.

LITERATURE REVIEW

The IoT-based smart parking system and its specifications hardware and software devices and components, which include ultrasonic sensor, cloud server, and Arduino Uno, were highlighted by Jambotkar et al. in their study (Mudaliar, S., Agali, S., Mudhol, S. & Jambotkar 2019). The study featured Thorat et al. (2017) who demonstrated how online approaches and Radio frequency Identification (RFID) and Infrared sensor (IR) have transformed parking into a smart and systematic way to find parking places. The article highlighted Lookmaung et al (Lookmuang, R., Nambut, K., & Usanavasin, S. 2018).’s work, the embedded controller (Raspberry-pi), cloud API, features and interface of cellular applications that check parking slots, set timers, and accept online payments, as well as the design and algorithm that were used to address the parking difficulties. According to the paper’s definition of Gupta et al. (2017).’s smart parking management system, parking spaces are assigned using an ultrasonic sensor, an Arduino Uno, an ESP8266-01 Wi-Fi module, and the cloud server and how to book a parking spot. In order to book a parking lot using mobile apps, the paper defined Thangam et al (2018).’s smart parking booking System. In order to provide security and architecture, the smart parking system’s implementation uses optical character recognition (based on the KNN algorithm) and facial recognition (based on the Vector machine method). According to the study by Bachhav et al. (2017), an IR sensor or a smart parking slot can be utilized to identify objects and offer security for the parking system. The paper suggested cloud computing vehicular technology, MQTT protocol with smart parking system, and Dhar et al. (2016). The report highlighted Kamble et al (2018).’s Android mobile apps are used in an intelligent parking method to reserve a parking space in advance using an OTP. The author suggested that Rizwan et al. (Rizwan, M., Asif, M., Ahmad, M. B. & Masood, K. 2018) utilize an android app, google map API, working of app, database, functionalities and to navigate the user/driver for finding a parking spot as a solution to parking problems. The article focused on Desai et al [Desai, J., Bhanje, A., Biradar, S., & Fernandes, D. 2017].’s smart car system, which uses an android app, an ultrasonic sensor, a Raspberry Pi 3 with a camera, and a quick response code to methodically manage car gate entrance. Using an IR sensor, the system suggested by Natarajan et al. (2018) determines if a parking space is empty or not and updates a display board at the parking gate prior to entering the parking lot. Khanna et al. (Khanna, A. & Anand, R. 2016).’s parking system, which uses a mobile application and cloud computing to store and manage data, was emphasized in the study. This system is operational and has been used in a real-world setting.

The study offered Cynthia et al. (2018).’s management of parking through android app development, identify a vacant slot, navigation of the parking area, car authentication, etc. In the study, Fatima et al. (2018) described a parking

system that used a mobile app, an IR sensor, and the cloud, pioneering a latest tech known as the “cloud of things” (CoT). Al Waili et al. (2018), the ultrasonic sensor, Wi-Fi unit, Street view, Android, and Arduino Microcontroller were highlighted in the study as being used to construct parking slots using the Internet of Things. An IoT-based carpark system using a smartphone app with cloud - based solutions or cloud of things, system design, operating, and specified software was proposed by Thomas et al. in the paper (see Thomas et al. 2016).

An intelligent parking system, IoT module, operating of the smart parking using a smartphone app, requirements are described, and algorithm of proposal to reserved parking spot were emphasized in the article by Kumar et al. (2018). In the study, Dhumal et al. (2016) suggested an automated parking system using a smartphone app for pre-booking parking spaces, a microcontroller, and mobile parking spot detection and reservation with digital payments. The intelligent parking system combining Internet of Things, communication tech, RFID, and smart invoicing procedure developed by Atiqur et al. (2021) was emphasized in the article. The IoT-based parking intelligent system is one area of interest.

Parking bookings, the Internet, Bluetooth technology, wireless sensors, SPARK parking management system, RFIDS, speed vernier caliper, peripheral interface controller, microchips, Lcd screen, and other technologies were suggested in the paper by Mani et al. (2019). The article offered a smartphone-based parking system by Mitra et al. (2021) that allows users to reserve parking spaces quickly and in ahead with digital payments, QR codes, and GPS tech. The research offered a smart parking system by Anitha et al. (2017) that allows users to reserve a parking space in ahead for a certain time with an electronic payment method. It was suggested in the paper by Vennila et al. (2018) that an Intelligent parking system would make it easier for customers to choose the optimum spot for parking their car by employing a wireless sensor system and GPS. The paper suggested Basavaraja SR et. al. (2019). booking-oriented parking system, which allows drivers to book a parking spot using a Smartphone app that uses RFID, parking spot detecting, and MCU to assist you find a spot while consuming less time and gas. Singh et al. (2020). IoT-based smart parking method with a smartphone app and assistance from the Knn classifier, Raspberry Pi Operating system, and IR sensor was suggested in the paper.

PROPOSED SYSTEM AND METHODOLOGY

A methodology is a set of predetermined strategies or approaches for creating, organizing, and designing a work or a system. The working of apps and systems with software and hardware that will be employed for system development is explained in this session. To accomplish the goal of this work or system, the results should have been examined.

OVERVIEW

The projected system is about to find a parking spot using cellular apps with software and hardware requirements. An app that checks whether a spot is available before allowing a user to park and allows users to book a parking spot in advance for a specific time makes it simple for users and vehicles to find a parking spot. The availability of a parking spot for a car can be determined by infrared and ultrasonic parking sensors. These sensors provide the controller with the availability information and save it in the clouds. By using a Wi-Fi module, the user/driver can access these cloud data to know and monitor the space in their own cellular app, and quickly track the parking lot without taking more time. Google Maps makes it simple to find a parking spot, and depending on how long they left their car there, they may make payments digitally.

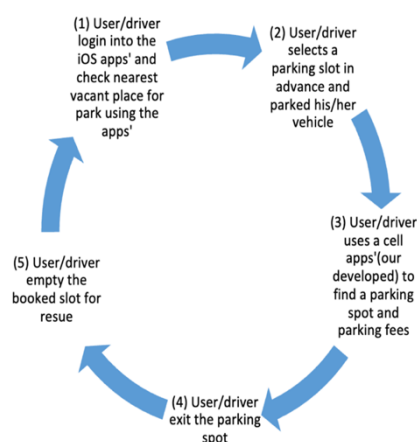


FIGURE 1. Methodology Diagram

Figure 1 graphically shows our proposed methodology, following which we have developed our system. Below is a step-by-step description of each step in the graph:

1. A user or driver must first register and log in to the iOS apps before utilizing them to find a nearby empty space. The developed iOS app that checks whether a spot is available before allowing a user to park. If the parking lot is vacant then green light is shown and if not vacant then red light is shown, and thus the user can use the app to understand when the parking space is available and when the space is not available, Process (1)
2. A user or driver pre-selected a parking space and parked the car. The developed iOS app for cellular devices instantly updates parking space in real-time. The alert to add the driver's license plate number comes in the app when drivers park in the designated parking lot. Services offered by our proposed iOS apps for users, like automobile location tracking, digital payments, and monitoring, Process (2)

3. A User or driver search for parking spots and pay for it using a cellular app like our developed iOS app. The app automatically creates a parking cost based on duration after a car is parked in a vacant spot, and the user may conveniently pay the charge digitally before leaving the parking spot, Process (3)
4. A user or driver leaves a parking spot. When a driver exits a parking spot after paying their parking cost digitally, the app is modified the database server, Process (4)
5. When the user vacates it can be used by another user following the same steps in the app and thus the whole process continues, Process (5)

DATA ANALYSIS

Data collection for this article's dataset was done using Online Questionnaires. Data is a precise numerical data that has been obtained in relation to the hypothesis we've put out. The data are then analyzed and chi-square calculation is used to support the hypothesis. Here data are collected for both the manual system and our proposed system and both types of data are tested for comparative analysis i.e., proving the above-mentioned hypothesis.

HARDWARE COMPONENTS AND MODULES

1. Raspberry Pi-4: Raspberry Pi4 is a debit card sized single-board PC with an OS Raspbian mounted. The Raspberry accumulates the quantity of parking slots from apiece NodeMCU V3 and processes the information as well as up to date the database server with a total number of empty slots. (2019)
2. Node MCU V-3: NodeMCU version-3, is an expansion board that turns on the ESP8266 by the express if non-operating system s/w development kit and h/w centered on the ESP-12 unit (2019). NodeMCU is a low-cost open source IoT platform.

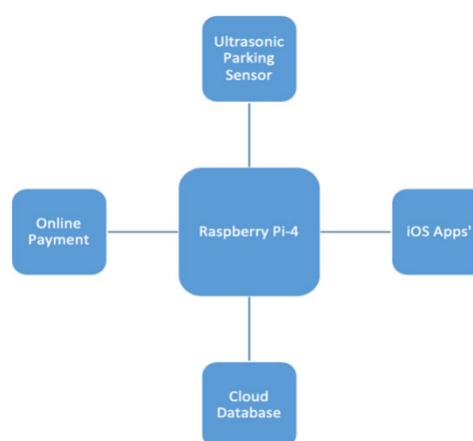


FIGURE 2. Block Diagram

3. RFID: Radio frequency identification tags, or RFID tags, are electronic tags that communicate with an RFID reader to exchange data. An RFID active tag is what we mostly use. The main application is tracking. This tag has antenna, chips, and memory.
4. Ultrasonic Parking Sensor: It works as an input for capturing data and sending it to the Node MCU microcontroller.
5. GSM Module: It is a gadget that establishes connection between cellphones and microcontrollers. Through smartphones, voice and SMS communications are sent. High data transmission is possible with the help of this gadget.
6. Reader Unit: This tool scans RFID tags and gathers data from them. It's employed for object tracking.
7. iOS Module: It facilitates user connection from the parking lot.
8. Cellular App: A user / driver gets a mobile app i.e., our developed iOS app to their phone through which they may follow a parking place to determine whether or not there is vacancy and reserve a slot in ahead prior to actually arriving.
9. Digital Payment System: Users can pay their parking fees online as they exit the lot. The payment is made via a variety of methods, including internet banking, Credit/Debit card, etc., and depends on how long they parked for.

Finding a parking spot takes time, according to 72 men and 24 women in the aforementioned graph figure 3, while 71 men and 22 women said it was difficult to find space in urban areas. The graph shows that the majority of respondents believe that obtaining a parking space in an urban setting is more challenging and time-consuming for the driver or user of the vehicle.

Based on the hypothesis, we ran a chi-square test, where we first constructed an observed table, then an expected table, calculated the chi-square, and then determined the degree of freedom to provide a tabular chi-square value. The alternative hypothesis is accepted and the null hypothesis is rejected if the calculated chi-square is bigger than the tabular chi-square.

A. Table of Observed Value

Table (a)

Response (R)	User (M)	User (F)	Total (T)
Yes	72	24	96
No	22	4	26
Total (T)	94	26	122

Formula for finding expected value =
 (Observed value – Expected value) 2 % Expected value

The Expected value:

Table(b)

Response (R)	User (M)	User (F)
Yes	73.96	20.45
No	20.03	5.54

Calculation of X²:

Table(c)

Observed value (O)	Expected value (E)	(O-E)	(O-E) ²	(O-E) ² % E
74	73.96	0.04	0.0016	0.000021
24	20.45	3.55	12.60	0.616
22	20.03	1.97	3.88	0.193
4	5.54	-1.54	2.37	0.428

Chi-square calculated = 1.237021
 Degree of freedom = (column-1) (row-1) = (2-1) * (2-1)
 = 1*1 =1
 Chi-square tabular =1
 Chi-square calculated = 1.237021
 Chi-square calculated > Chi-square tabular

EXPERIMENT

Out of 100 people, 94 samples—94 from men and women—were taken. Online questionnaires were used for the dataset for this article's data collection. We created a questionnaire for analysis and answer. For the manual and our proposal, we conducted different analyses using separate sets of data which is shown below. It is a quantitative study using data that is notional in nature. Out of 96 samples, 24 women and 72 men replied. Orange in each graph denotes women, whereas blue denotes men.

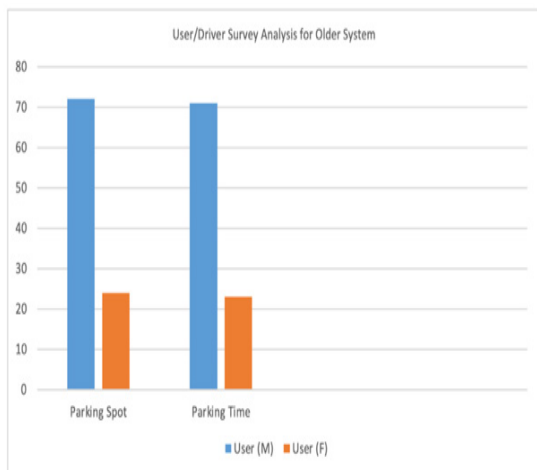


FIGURE 3. Survey Analysis for Older System

We accept alternative hypothesis; this experiment is based on the manual system. After that based on the same above-mentioned hypothesis and collected data, again we run the chi-square test to prove that our system best corresponds to the hypothesis.

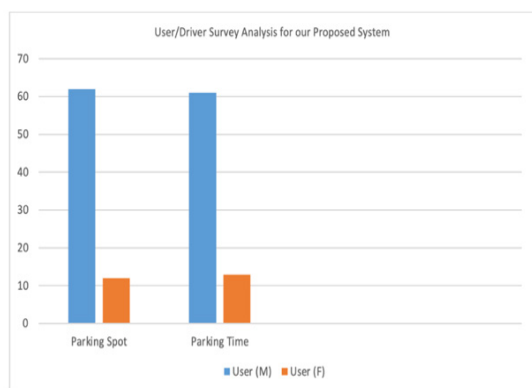


FIGURE 4. Survey Analysis for Proposed System

B. Table of Observed Value

Table(x)

Response (R)	User (M)	User (F)	Total (T)
Yes	72	21	93
No	20	6	26
Total (T)	92	27	119

Formula for finding expected value =
 $(\text{Observed value} - \text{Expected value})^2 \div \text{Expected value}$

The Expected value:

Table(y)

Response (R)	User (M)	User (F)
Yes	71.89	21.10
No	23.68	5.89

Calculation of χ^2 :

Table(z)

Observed value (O)	Expected value (E)	(O-E)	(O-E) ²	(O-E) ² ÷ E
72	71.89	0.11	0.0121	0.00016
21	21.10	-0.1	0.01	0.00047
20	23.68	-3.68	13.54	0.57189
6	5.89	0.11	0.0121	0.00205

Chi-square calculated = 0.574574
 Degree of freedom = (column-1) (row-1) = (2-1) * (2-1)
 = 1*1 =1
 Chi-square tabular =1
 Chi-square calculated = 0.574574
 Chi-square calculated < Chi-square tabular

From the calculated result we conclude that we accept our proposal/hypothesis.

RESULTS OF THE PROPOSED SYSTEM

Data analysis was carried out by gathering all the necessary information from the provided questionnaire and running a chi-square test in relation to the hypothesis we made. Therefore, the experiment's Q1 hypothesis—which is supported by the majority of respondents—is accepted, and it is demonstrated that obtaining a parking place in urban locations takes a lot of time and it is also a difficult job. After that, again we run the chi-square test for our system and from the experiment Q2 and Q3 hypothesis is accepted that means we can clearly migrate to our system for the betterment of in all aspect.

CONCLUSION

We presented a smart parking system in this work employing a cellular app with booking-oriented control, monitoring, and assistance in locating nearby sites, as well as with a digital payment option based on how long you left a car parked together with defined software and hardware components. The paper's main argument is that finding a parking spot in urban or large cities takes more time than it should and it challenging also. In order to conduct survey analysis or data analysis for this study, we gathered particular comments on the difficulty finding a parking spot experienced by vehicle users and drivers. We then conducted a chi-square test on the data. In the conclusion, we determined that the majority of users and drivers reported having parking issues and that it was taking them longer to find a parking place, particularly in big cities and areas. We offer the simplest method for parking a car.

Future improvements will increase the number of survey respondents who are aware of the issue and analyze the data more accurately. As a result, system requirements could be expanded to include various parking lots with safer and more efficient parking. It included navigational technologies to make it easier for users to find a location or a parking space. It cuts down on time and allows for the implementation of applications like Artificial cameras and accident alarms.

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DECLARATION OF COMPETING INTEREST

None

REFERENCES

- Aishwarya, S. T., Yashomati, R. D., Harshala A. W. & Swati, R. S. 2016. Android Based Smart Car Parking System. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering* 5(3): 1371–1374. <https://www.ijareeie.com>
- Al Waili, Y. S. A., Hussain, S. M., Yusof, K. M., Hussain, S. A., Asuncion, R. & Frank, A. 2018. IoT based parking system using Android and Google maps. *International Journal of Applied Engineering Research* 13(20): 14689-14697.
- Aniket G., Sujata K., Vaibhavi J., Ved S. & Naman J. 2017. Smart Car Parking Management System Using IoT. *American Journal of Science, Engineering and Technology* 4(2): 112–119. DOI:doi.org/10.11648/j.ajset.20170204.13.
- Anitha, J., Thoyajakshi, Y., Ramya, A., Sravani, V., & Kumar, P. 2017. Intelligent parking system using android application. *International Journal of Pure and Applied Mathematics* 114(7): 165-174.
- Arivazhagan, R. Jayavadivel, G. & Vennila, D. 2020. An Analysis of Smart Car Parking Management System. *International Journal of Scientific & Technology Research* 9(01): 1892–1895. <https://www.ijstr.org>
- Ashutosh, K. S., Mohit, P., Shailesh, Y. & Pavan S. 2019. Smart Parking System using IoT. *International Research Journal of Engineering and Technology (IRJET)* 6(4): 2970–2972. <https://www.irjet.net>
- Atiqur, R. 2021. Automated smart car parking system for smart cities demand employs internet of things technology. *International Journal of Information & Communication Technology* 10(1): 46-53. DOI: 10.11591/ijict.v10i1.pp46-53 .
- Bachhav, J. D. & Mechkul, M. A. 2017. Smart car parking system. *International Research Journal of Engineering and Technology (IRJET)* 4(06). <https://www.irjet.net>
- Basavaraju S R. M. 2015. Automatic smart parking system using Internet of Things (IOT). *International Journal of Scientific and Research Publications* 5(12): 629-632.
- Chandran, M., Mahrom, N. F., Sabapathy, T., Jusoh, M., Osman, M. N., Yasin, Hambali M. N. A., Jamaluddin, R., Ali, N. & Wahab, Y. A. 2019. An IoT based smart parking system. In *Journal of Physics: Conference Series* 1339,(1) : 012044). IOP Publishing. DOI:doi.org/10.1088/1742-6596/1339/1/012044.
- Cynthia, J., Priya, C. B. & Gopinath, P. A. 2018. IOT based smart parking management system. *International Journal of Recent Technology and Engineering (IJRTE)* 7(4S): 374-379.
- Deorel, B. D., Kurkute, S. R., Pooja B., Kajal B. & Mokshada D. 2018. IoT Based Smart Car Parking System Using Android Application. *International Journal of Advanced Research in Computer and Communication Engineering* 7(3): 173–177. <https://www.ijarcece.com>.
- Desai, J., Bhanje, A., Biradar, S. & Fernandes, D. 2017.. IoT based vehicle parking manager. In 2017 7th International Conference on Cloud Computing, Data Science & Engineering-Confluence, pp. 222-225. DOI:doi.org/10.1109/confluence.7943153.
- Dhar, P. & Gupta, P. 2016. Intelligent parking Cloud services based on IoT using MQTT protocol. In 2016 International conference on automatic control and dynamic optimization techniques (ICACDOT), pp. 30-34.
- Fatima, N., Natkar, A., Jagtap, P. & Choudhari, S. 2018. IOT Based smart car parking system for smart cities. *International Journal of Advance Research, Ideas and Innovations in Technology* 4: 554-556.
- Ismail, M. M. S., Jusoh, M., Sabapathy, T., Osman, M. N., Rahim, H. A., Yasin, M. N. M. & Fazilah, A. F. M. 2019. IoT Based Smart Parking System. In *Journal of Physics: Conference Series* 1424 (1): 012021. IOP Publishing.
- Kamble, P., Chandgude, S., Deshpande, K., Kumari, C. & Gaikwad, K. M. 2018. Smart parking system. *Int J Adv Res Dev* 3(4): 183-186.
- Khanna, A. & Anand, R. 2016. IoT based smart parking system. 2016 International Conference on Internet of Things and Applications (IoTA) 255–270. DOI:doi.org/10.1109/iota.2016.7562735.
- Lookmuang, R., Nambut, K., & Usanavasin, S. 2018. Smart parking using IoT technology. In 2018 5th International Conference on Business and Industrial research (ICBIR) (pp. 1-6).
- Luque-Vega, L. F., Michel-Torres, D. A., Lopez-Neri, E., Carlos-Mancilla, M. A. & González-Jiménez, L. E. 2020. Iot smart parking system based on the visual-aided smart vehicle presence sensor: SPIN-V. *Sensors* 20(5): 1476.
- Mani, J. C. & Anandan, R. 2019. Slot allocation and reservation of parking system using IOT. *International Journal of Recent Technology and Engineering (IJRTE)* 7(5S3): 496–502.
- Mani, T., Masilamani, T., Hariharan, P., Jothi Prasath, N. & Deepak, S. 2017. Smart Parking Space Checking System Using IoT. *Int. Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering* 6(3): 1685–1692. <https://www.ijareeie.com>
- Mitra, A. & Patel, K. D. K. D. 2016. Android Based Smart Parking Reservation. *International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCCE)* 4(9): 15845-15849. <https://www.ijirccce.com>
- Mudaliar, S., Agali, S., Mudhol, S. & Jambotkar, C. 2019. IoT Based Smart Car Parking System. *International Journal of Applied Research and Technology* 5(1): 270–272.
- Natarajan, P. B. & Ghosh, S. K. 2018. Design and implementation of smart car parking system using lab view. *International Journal of Pure and Applied Mathematics* 120(6): 329-338.
- Pavan Kumar, G., Rajeev Kumar, C., Manikanta, V. J., & Azhagiri, M. 2018. IoT based sensor enabled smart parking system. *Int Res J Eng Technol* 10(5): 1174-1176.
- Raghav, R. S. 2018. IoT based smart parking system. *International Journal of Pure and Applied Mathematics* 119(14): 367-375.
- Rizwan, M., Asif, M., Ahmad, M. B. & Masood, K. 2020. PARK MY RIDE: Your True Parking Companion. *Communications in Computer and Information Science* 695–708. DOI:doi.org/10.1007/978-981-15-5232-8_60.

- Saidur Rahman. 2019. IoT Based Smart Parking System. *International Journal of Advances in Computer and Electronics Engineering* 4(1): 11–16. <https://www.ijaceonline.com>
- Thangam, E. C., Mohan, M., Ganesh, J., Sukesh, C. V. & Prof, A. 2018. Internet of Things (IoT) based smart parking reservation system using raspberry-pi. *International Journal of Applied Engineering Research* 13(8): 5759-5765.
- Thorat, S. S., Ashwini, M., Kelshikar, A., Londhe, S. & Choudhary, M. 2017. IoT based smart parking system using rfid. *International Journal of Computer Engineering In Research Trends* 4(1): 9-12.