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Review RTSRT

Smart Car Parking and Maintenance Systems: Leveraging IoT for Efficient, Sustainable Urban Transport

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Abstract

One of the main objectives of the smart city aspect is to facilitate sustainable mobility, and one vital component of that is the creation of an intelligent parking system. The solution to the parking issue cities face is the allocation and monitoring of parking spaces. Using the results of this survey, we have investigated this issue. As a result, an effective parking management system is now required. We can provide excellent service to citizens who wish to park their cars on any organization's property by employing an Internet of Things (IoT) based parking management system with the aid of a computerized system. In this case, information and communication technologies (ICTs) are connected to physical parking spot infrastructures through sensors, enabling cloud-based smart management services. An end user will be able to reserve a specific parking lot and check if parking spaces are available using this mobile application. Every parking lot would have a control system installed, allowing for the tracking of the quantity of empty and occupied spaces as well as the notification of users regarding the state of the lot (open, closed, or with free, available parking spaces). The application would also show the cost of parking services based on how long a user parks. Additionally, it will detect if a car has pulled up to the gate to open it automatically. Customers can now easily check online for available parking spaces from anywhere at any time. Thus, the mechanism resolves the parking issue. The need for effective and sustainable parking solutions is growing as urbanization and vehicle density rise. Smart Car Parking and Maintenance Systems, powered by IoT, ICT, and cloud-based services, present novel solutions to ease urban transportation difficulties. By providing automated maintenance scheduling, optimized traffic flow, and real-time parking spot availability, these technologies lower carbon footprints and improve user convenience. To show how well IoT, ICT, and cloud computing can be integrated into smart parking and maintenance systems, this study examines this integration, gives user input, and analyses experimental findings.

Keywords: Mobile application, Infrared Sensor (IR) sensor, GPS, RFID reader, smart city

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INTRODUCTION

As cities are home to more than half of the world's population, they are completely inhabited. Consequently, there are now more cars in the cities. A recent poll indicated that there has been a 7.64% annual increase in the number of cars used. Therefore, traffic congestion is a recurring problem. According to reports, cars account for 22% of the traffic. The increased use of cars has resulted in severe parking problems. According to a motorist poll, 81% of respondents say it frequently takes 20 min or longer to locate a parking space, and 45% say parking is their largest monitoring concern. Many hours are lost looking for a parking space, and

during the process, terrible and dangerous gases are released into the atmosphere. Therefore, parking surveillance is critical. The implementation of a system that can gather data on parking spaces available in a certain region and process the data in real-time to enable simple parking at available locations is a key component in finding a solution to this problem. We used IR sensors to detect parking lot occupancy and a DC motor to act as a gate opener to illustrate this idea. To facilitate online parking reservation inspections, the device tracks the total number of parking spaces that are available and updates data with the server located in the cloud. Consequently, the system provides customers with an effective IoT-based parking management system and resolves parking problems in cities.

The population and number of automobiles in urban areas are growing rapidly, which causes clogged roadways, parking lot congestion, and ineffective management of vehicle upkeep. Conventional parking systems lead to traffic jams, higher fuel use, and environmental damage, because they are labor-intensive, manual, and do not provide access to real-time data. Integrating cutting-edge IoT technologies with automated systems, cloud computing, intelligent data analytics, and smart car parking and maintenance systems can address these problems. Real-time updates on parking availability, alarms for preventive maintenance, and sustainable urban transport management have been guaranteed by these developments. The relevance of IoT, ICT, and cloud-based services in developing effective and environmentally friendly urban transport systems is discussed in this study.

LITERATURE SURVEY

Ji et al. [1] used a cloud-based platform to present a generalized idea for parking cars in smart cities. It primarily concentrates on the primary goal of finding, allocating, reserving, and offering the greatest parking space for automobiles. The mechanism uses an automatic threshold method to determine the available parking space for cars. The presentation layer, website tier, and persistence tier comprise the top-down structure. The deployment and design of a smart automobile parking system on a university campus were explained in their study. The application, communication, and sensor layers comprise three levels that constitute the parking structure [2]. Every parking space has a sensor placed to identify the existence of cars. A parking meter uses a set of sensors to gather data regarding the presence of a car in proximity. An automated request for a free parking space is sent to the Open source gate initiative (OSGI) car parking web server using the user's smartphone as they get closer to the university campus. In addition to finding an ideal parking spot, the server uses maps to direct the user. Large university campuses are an ideal fit for their system, which also makes it easier for users to locate parking lots on campus. However, this technology cannot be used to park cars on city streets, nor can the service be rendered without a smartphone.

Grodi et al. [4] presented a wireless sensor network (WSN)-based smart parking system. It offers an efficient way to reduce the amount of time spent looking for a spot to park, the cost of getting stuck in traffic, and the expense of wasting petrol. The entire parking system was divided into two main sections: user notification and empty parking spot detection. This study covered several sensors, including inductive proximity sensors, active ultrasonic sensors, RFID sensors, LIDAR sensors, and camera detectors, that can be used to identify unoccupied parking spaces [5]. The sensors must be linked to the user's notification system, which can be accomplished in several different ways. The user can receive notifications via one of three methods: directly connecting the sensor to the notification system, connecting all the sensors to a central coordinator that can display the data, or enabling the central coordinator to post the data online [6]. The XBee devices, Node.js Webserver, MySQL database, and ultrasonic sensor were all controlled by an Arduino Uno in this setup. The suggested strategy is cost-effective, effectively tracks open slots, and provides commuters with up-to-date parking spot information. Even without the use of a mobile application, this system is capable of providing services.

Components Required

IR Sensor

The car detection system used this IR sensor. As shown in the diagram, the VCC, GND, and OUT were designated on the three male headers. Arduino's five volts were wired to the VCC pin. The Arduino's

ground and ground are connected. As shown in the circuit diagram, the OUT pin is connected to the Arduino's Input-Output (IO) pins. "One is the Tx while the other is the Rx" refers to the IR LEDs, which are represented by the black and white LEDs [7].

NodeMCU ESP8266

We can observe car parking spaces from anywhere in the world with the aid of this Wi-Fi module, NodeMCU ESP8266. As can be observed, every pin has an obvious label. The 5 V Arduino should never be used to power the NodeMCU ESP8266 Wi-Fi module. If you power this Wi-Fi module using Arduino's 5-volt power source, it will restart itself repeatedly. To solve this problem, an independent power supply can be built for this module using an LM7805 voltage regulator [8].

Automatic Parking Space Detection System

It offers a system that counts the total number of available parking spots and notifies vehicles of this information, making parking for cars simple. The system uses a webcam to capture photographs of the parking IoT and image processing algorithms are applied to determine whether an automobile is present or not. Automatic parking space detection is shown in Figure 1. The status is updated each time a vehicle enters or exits a parking area [9].

The movies used in the framework were taken from the top of the parking lot. A keyframe was chosen from each part of the video after it had been divided into frames. This keyframe subtraction method estimates the motion of the car when it enters or exits the parking arena. After converting these RGB photos to grayscale, they were calculated to provide unique coordinates for parking lots and vehicles [10]. These coordinates were used to split the parking lot into blocks of the same size. To create a black parking lot and a white car, each grayscale block is first transformed into a binary and then an inverse binary. Each block's threshold value is determined to determine whether a car is present in that block. The block is free if its quantity is less than the threshold and occupied if it is larger. Compared to edge- and ROI-based detection techniques, this approach is more effective. Nevertheless, weather might influence the accuracy of the captured images [11].

IoT-based Smart Parking System

Two key concerns regarding smart cities pertain to parking facilities and traffic management: Khanna et al. [3] demonstrated a cloud-integrated smart parking system based on IoT is demonstrated by Abhirup Khanna et al. [3]. Using an IoT module deployed onsite, parking space monitoring, parking lot availability signaling, and booking in accordance with the information are all made possible. The solution hides the challenges required for an application to function properly using a mobile application that is linked to the cloud and serves as a middleman between objects and apps. A cloud-connected mobile application allows users to view many vacancies in real-time. Storage capacity, computing power, bandwidth for communication, scalability, seamless integration, and accessibility are the factors that lead to the connection of clouds with IoT. The parking system uses three different types of sensors: ultrasonic,

Figure 1. Automatic parking space detection.

passive infrared, and infrared. It aids in determining whether a slot is available. The Raspberry Pi processor unit, which serves as a bridge between the cloud and sensors, was used by the system. The Wi-Fi module serves as a middleman to transfer the data gathered from multiple sensors to the controller. The data were transmitted to the server by the controller via a single channel using a protocol. The angular framework and Apache Cordova-developed mobile application, which is compatible with both Android and iOS, aid in information provision and allow users to schedule a time window. Data was transferred between the smartphone program and the server using the JSON format.

All the papers relating to parking areas and end users who have access to the system are saved in a database on the cloud-hosted server. Continuous data backups are sent to the cloud for simple and rapid recovery in the event of system failure. However, if the user does not have a mobile application, the inability to register on-the-spot is a drawback.

EXISTING SYSTEM

The enormous amount of time people spends parking their automobiles at malls, multiplex systems, hospitals, offices, and mega markets is the primary driving force behind the creation of car parking services. The traffic of cars is shown in Figure 2.

PROPOSED FRAMEWORK

A few holes were also identified in the survey. A few remedies that writers have developed to fix these gaps are covered in more detail in this section. The fact that our project now includes an on-the-spot registration feature is one of the disadvantages of these suggested solutions. A strong and well-thought-out security mechanism is added, something that other suggested systems do not have. A well-designed car parking system is shown in Figure 3. Along with the previously mentioned capabilities, the system also includes a mobile application that allows users to reserve parking spaces in advance

Figure 2. Traffic of cars.

Figure 3. Well-designed car park.

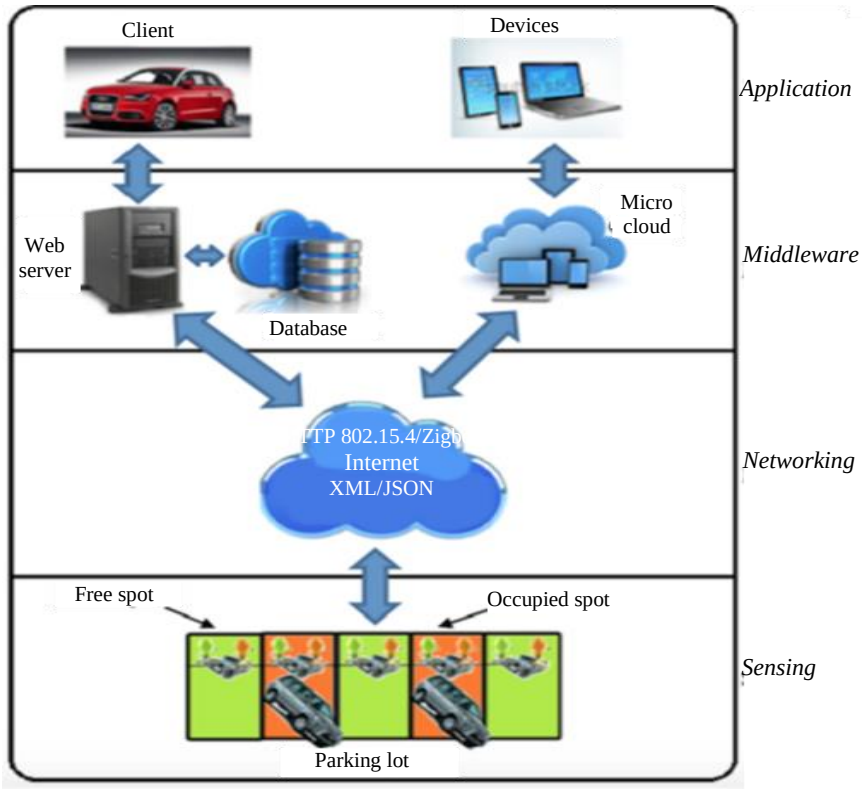

Figure 4. Block diagram of the smart parking system.

within a 2-kilometer radius—a feature that is not available with other systems. A block diagram of the smart parking system is shown in Figure 4. Most systems that have been placed in restricted spaces, such as shopping centers, college campuses, hospitals, and offices, do not provide safe street parking options. These issues were resolved using the proposed model.

Discussion and Description

Six parking lots and one entry/exit gate are included in the smart parking system model. For future maintenance, extra lot number seven has been left unplugged and should be used if any sensor malfunctions. Each parking lot contains a sensor that picks up an object whenever it passes within a certain range and can be counted. Every sensor was linked to the Arduino Uno kit, which provides electricity. The NodeMCU ESP 8266 was linked to the Arduino Uno kit. Instructions for sensors were imported into the ESP 8266 from the Arduino integrated development environment (IDE). The program used for coding was called Arduino IDE. Six infrared sensors were attached to Arduino pins 4 through 9, as shown in the diagram.

The infrared sensor VCC pins were connected to Arduino's 5-volt supply. The Arduino's ground is linked to the ground, and pins 4 through 9 are connected to the pins of each infrared sensor. The Tx and Rx pins of the NodeMCU module were linked to pins 2 and 3 of the Arduino. By contrast, the Vin pin of the NodeMCU module is connected to the output of the voltage regulator. Based on the LM7805 voltage regulator, this 5-volt power supply is regulated. Nevertheless, you may also be powered up using the laptop's USB port. Two USB cables are used: one for powering the Arduino and the other for the NodeMCU.

IoT's Place in Smart Vehicle Parking Systems

Through real-time data interchange, the Internet of Things (IoT) connects the parking infrastructure with users and vehicles, thereby improving the efficiency of smart parking systems. In smart parking, important IoT components include the following.

- *Sensors and cameras:* IoT-enabled sensors identify vehicle presence in parking spaces, and cameras monitor the flow of vehicles, ensuring real-time space availability.
- *Smart meters:* By utilizing IoT-based meters, automated payment systems minimize human intervention and enable users to pay parking costs with mobile apps or linked devices.
- *Real-time navigation:* By using smartphone apps or in-car navigation systems, IoT-based applications help drivers find open parking spaces and reduce the amount of time they spend looking for a place to park.
- *Data analytics for maintenance:* By tracking tire pressure, battery life, engine performance, and other important parameters, sensors monitor the health of the car and use linked platforms to send out predictive maintenance notifications.

Experimental Results

Urban mobility and energy savings have significantly improved in some cities owing to the installation of IoT-enabled smart parking systems. In a case study conducted in a densely populated urban region, smart parking solutions were found to reduce the average time spent searching for a parking spot by 30%, leading to a 10% reduction in fuel usage. Predictive maintenance systems also assist car owners in scheduling prompt repairs, which results in a 15% decrease in on-road breakdowns.

In terms of customer satisfaction, polls suggested that 85% of respondents regarded smart parking apps as convenient and timesaving, while 78% enjoyed automated maintenance alerts, which provided a piece of mind regarding vehicle health.

CONCLUSION

An overview of the various methods used for smart parking systems is provided in this study. The primary contribution of this study is its analysis of the benefits and drawbacks of each technique, along with a better alternative. The proposed model is a useful way to deal with unlawful parking and is ideal for use in smart cities. Urban transport is revolutionized by the integration of IoT, ICT, and cloud-based services in Smart Car Parking and Maintenance Systems. These systems provide real-time data on parking availability, automate car maintenance, and contribute toward energy conservation and sustainability. Test findings show notable decreases in on-road mechanical failures, fuel consumption, and traffic congestion, while user comments emphasize the practicality and economics of these solutions. Smart parking and maintenance solutions must be widely adopted to achieve effective and sustainable urban transportation systems, as cities continue to develop and change.

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