

An IoT based Smart Outdoor Parking System

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Abstract—The Internet of Things (IoT) is the vast area of implementation where research and implementations are still going on. Numerous applications based on IoT provide more benefits and reduce manpower. As the population increases, day by day, the dependency on transportation also increases. This increases the dependency on parking vehicles. People visiting public places in urban cities like malls, parks, temples, theatres etc are facing difficulties in parking vehicles. Even though many systems have reported in documents, most of the places are organized under manual parking systems. Most of the visiting places in smart cities are provided only with an organised indoor parking system. Regulations for outdoor parking of vehicles are not yet defined to be followed. Traditional parking systems are way too old and burdensome for urban cities where we find difficulties in finding the vacant slots. This may cause a lot of traffic, minor collisions and accidents in public. Therefore, a smart outdoor parking system can be designed based on IoT (Internet of Things) using weighbridge load sensors for an organised, well timed, flexible, convenient and safe parking of vehicles in public.

Keywords—*Outdoor parking system, Smart Cities, Weighbridge load sensor, Internet of Things (IoT), Smart parking, Traditional parking systems.*

I. INTRODUCTION

The Internet of Things (IoT) embedded with software, sensors and other various technologies plays a vital role in this developing world to design and build impeccable ideas and technologies. IoT has become more in need to help both people and work smarter and easier. IoT has shown drastic performance in automation and it's more beneficial by monitoring a business process and helps to make better business decisions effortlessly, saves money and time, and generates more productivity and revenue [1]. Industrial needs are the real-time consumers focused application of IoT where our proposed system with smart transportation and smart parking comes into the role. The ruling aim and intent of this project is to propose a smart and automated outdoor parking system using IoT for secured and trouble-free parking of vehicles in parking spaces. Due to the rapid development of technology and population in today's world, the demand for transportation has more need for parking vehicles, especially in public places. This system can upgrade driving comfort and safety by reducing traffic and parking

accidents [2]. Shopping malls have a minimum space allocated for parking lots when compared to other public places and valet systems parking fare in shopping malls, theatres, railway stations etc parking is a little expensive and the parking fare in airports are highly expensive. In some cases, people face difficulties like finding the correct location of their vehicle parked in indoor parking, missing the parking ticket. Proposed systems need to be manually checked for empty spaces.

Drivers don't have prior information on the available slots. We know that the IoT algorithms widely apply to parking systems and it is a new paradigm that enables better communication between devices [3]. It is progressively becoming an important aspect that brings extensive systems together. Improvised car parking systems would bring the customers a developed view of the malls and this would help in their businesses. The parking industry has witnessed tremendous growth with an increasing vehicular population. Thus transparency in parking slots is important in this situation. Various types of detectors have been developed based on cameras and GPS (Global Positioning System) etc, but they are comparatively expensive, require high computational power and are inaccurate. In this paper, we propose smart outdoor parking without requiring manual intervention with the convenience of other similar systems.

II. LITERATURE SURVEY

In [1] proposed a parking spot identification system using the turn detection mechanism. A Smart Parking System using Low Energy Bluetooth Beacons With Particle Filtering was proposed by [2]. [3] proposed the deployment of WSN for Smart Car Parking Systems both in indoor and outdoor environments. [4] proposed An Intelligent Real-Time Parking Monitoring and Automatic Billing System using IoT. [5] proposed the Mobile Outdoor Parking Space Detection Application using the detection mechanism. Survey for a Cloud-Based Parking System using IoT Technology by [6]. Investigation of Smart Parking Systems and their technologies by [7].

III. RELATED WORKS

In general, outdoor parking systems exist in sensor-based or computer vision-based such as camera-based surveillance systems to identify the vacancy of parking spots and also

provide security of vehicles. In computer vision-based parking systems, cameras cost high and maintenance is tedious. Even though they use camera-based parking systems for security purposes, there is a need for monitoring the vehicles to avoid any destruction or theft [6,9,11].

Giuseppe Riccardo Leone et al proposed a smart parking monitoring system using WSC. WSC is a wireless live camera built with an embedded unit for visual representation and image processing of the parking area. Even Though WSC is low cost and wireless, it requires high maintenance and monitoring of parking areas through WSC has to be done to avoid any vehicle destruction or theft in the parking area[10]. JERMSURAWONG Jermisak et al have proposed an analysis of parking demand in the present world for one long day using a single camera vacancy detection for accurate statistics of requirement in parking. According to the analysis of parking demand observed in the Abu Dhabi parking area for one long day, the accuracy of 92% of the parking area was observed occupied. This shows that the demand for vehicles and parking is becoming a big issue and demand. The need for parking of vehicles concerning both indoor and outdoor areas especially in the heart of the cities and in common public places like shopping malls, theatres, temples, parks etc is increasing rapidly every year [8].

Abdulla Al Saadi et al have proposed an outdoor parking system using GPS locators which are commonly used in previous works. But using GPS to detect the vacancy of a parking spot in a parking area won't be an efficient solution. Sometimes the location shown by the GPS can be inaccurate because in some cases the signal might be weak and can lead to the inaccurate location detection of parking spots. The solution might get wrong when accuracy fails. GPS performance slows down the whole system. We can find the accuracy errors concerning distance. To overcome GPS we should find an alternative. So the improvement measures taken by previous works is using Inertial navigation systems (INA). It is used to detect/locate moving objects like ships, aeroplanes, submarines [4].

Andrew Mackey et al proposed a system using BlueTooth beacons to detect vehicles impose a new flaw of security, Wireless methods to detect and process parking spaces are inefficient as the interface poses more vulnerabilities, Since our proposal uses physical sensors, it is more secure than the already proposed system, the low energy consumption of the proposed paper is overruled by their particle filtering technology[7]. Sensors like PIR (Passive Infrared) sensors, Ultrasonic sensors, Infrared sensors can be used to detect the occupancy of vehicles in the parking spots. [13]Abhirup Khanna et al proposed an IoT based Smart Parking System using Infrared sensors to detect whether the vehicle is parked in a particular parking spot. In cloud-based parking systems, the best case idea for IoT-based parking systems based on RFID (Radio Frequency Identification), GPS. This paper provides a specific algorithm that increases network architecture performance. [11] Vishwanath Y et al proposed an effective Cloud and IoT based

parking system which calculates the user allocated space of the vehicles. Cloud holds the information of the vehicles, accurate location of the location detected by the GPS and the distance between the vehicles and the vacant parking spots in the parking area. Even though it is an effective cloud-based parking system, there are few drawbacks like the registration of the user should be done in advance to book the parking spots. Our system consumes less energy than the proposed one as we use modern ARM (Advanced RISC Machines) processors and WiFi (Wireless Fidelity) for communication, while BlueTooth keeps searching for signals but WiFi is always connected and consumes less power on the idle state[7].

In [8] proposed a system where the usage of cameras and Classifier Neural Networks, uses a lot of computational power and needs a dedicated server that can analyse and predict real-time data at very high speeds. This system is not scalable since the amount of data generated grows exponentially with the infrastructure. So our system does not need lots of computational resources. A simple server to manage the database is sufficient and our system is scalable with no increase in computational needs, as the modules themselves are capable of performing all basic and necessary computations [5]. Therefore, our proposed smart outdoor parking system provides organised and secured outdoor parking with no labours.

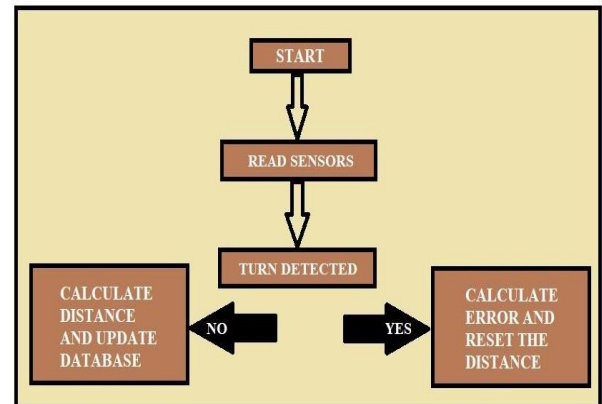


Fig 1. An existing system for parking spot identification using the turn detection system

IV. PROPOSED ARCHITECTURE

A. System Overview :

1. NodeMCU:

Node Micro Controller Unit is open-source hardware built with System - On - a - Chip (SOC) called the ESP8266 with unified TCP/IP (Transmission Control Protocol / Internet Protocol) stack that provides WiFi network to the microcontroller. This module is powerful enough to do on-board processing and

storage data that allows it to be integrated with the sensors and other devices and sensors through its GPIO (General Purpose Input Output pins) with minimal development and acute loading times. Its high degree of design and abstraction allows us to implement designs with minimal external circuitry.

2. Load sensor (Weighbridge resistor load sensor):

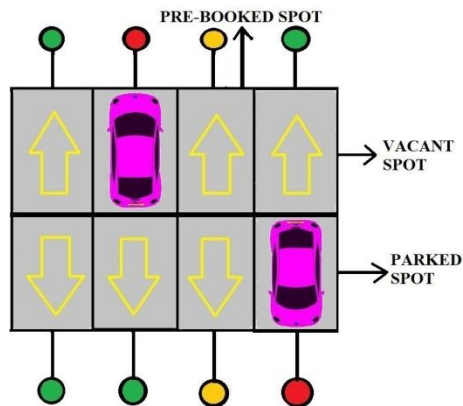


Fig 2. Overview of Outdoor Parking System

Load Cell is a sensor, which converts mechanical force into an electrical signal. It acts as a variable resistor when a load is applied. The load cell varies its resistance depending on the

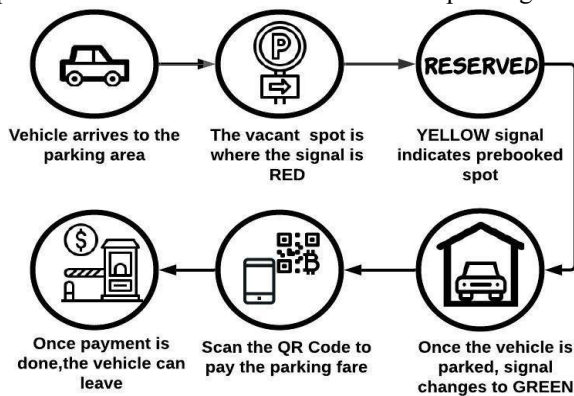


Fig 3. Smart Outdoor Parking System working model using the companion application

weight applied, the analog signal is then interpreted as a digital signal depending on the type of load cell used. If a project requires multiple load cells, each load cell should be distributed so that they measure the same proportion of the total weight.

B. Proposed Systems.

An independent module that uses a load cell to sense if any vehicle is parked on the module, then the indicator LED (Light Emitting Diode) shows that the parking was successful.

Vacancy of parking spots are detected using a weight sensor indicated by two signals - RED indicates the vacant spots and GREEN indicates the spot is occupied. The weight sensor is a small electronic device that is installed on the parking spot to detect and record the time a vehicle arrives and departs the bay. The module then sends the data i.e. "Time when the vehicle is parked" to the database, when the vehicle departs, then the database is updated and the parking fee is then calculated based on the time interval. This module is independent and scalable so that we can place these modules in the parking spot to make an automated parking system. These modules are rugged to survive the outdoor parking conditions.

C. Working Of The Module :

1. Detection Mechanism:

The vacancy of parking spots is detected and identified using a weighbridge load sensor/load resistor. When the parking spot is occupied by the vehicle, the weighbridge load sensor detects that the spot is occupied and the LED turns green to show that the parking spot is occupied. If the parking spot is not occupied the LED will show a red signal. In the future implementation, the parking spot can be pre-booked using a companion application or a driver app. If a parking spot is pre-booked, the LED will show an orange signal which shows that the parking spot is pre-booked.

2. Companion Application / Driver Application:

In the future implementation of our proposed system, a companion application will be developed to check the vacancy of the parking spot from anywhere at any time easily through their mobile devices effortlessly. The application acts as an interface between the parking system and the end users for easy identification of parking spots. Every driver/ user will be provided with authorization credentials and fare for parking can be done through this application by scanning the QR code (Quick Response Code).

Algorithm :

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if there is a change in load resistor then
  Check if the vehicle is parked properly in the spot
  Change the LED to green to indicate the occupancy
  Update the database with the time of parking
  Check whether the vehicle is leaving the spot
if again the load resistor shows any change then
  Update the database with the time of leaving
  Update the backend
  Calculate the fee and update the amount
  Change the LED to red to indicate the vacancy
  Update the database
  
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V. RESULTS AND DISCUSSIONS

In this section, the experimental analysis and results are given in brief. The result is obtained by an IoT module in which the load sensor senses the presence of vehicles and the indication to the vehicle owners is shown by the LED in the module. The load cell is designed in such a manner that when force is applied to it, The NodeMCU then sends the data to the database to record the time at which the vehicle is parked, Load cell acts as a transducer that converts a load or force on it into electronic signals by varying its resistance. As long as the load is applied to the proper spot on the cell, it provides accurate weight information.

Timestamps of the parking IN and OUT are registered following the activation of the load cell. The database contains all the details along with the slot number. The NodeMCU has high processing speed with inbuilt Wi-Fi. It can be powered using a USB (Universal Serial Bus).

These modules are independent and easy to scale and they can be scaled during operational time as the modules don't require any wiring. This system is cost-effective and trouble-free maintenance. Easy installation and no extra computations are required. The time spent on the parking lot to park or wait for a spot is reduced and can be monitored and further used as data to design efficient and modular parking spaces. Reduction of manpower is a key result as it doesn't require labouring to process and collect fare for parking. It provides an easier way to pay. Therefore, this proposed system helps to avoid minor accidents and traffic. A good percentage of detection accuracy has been achieved.

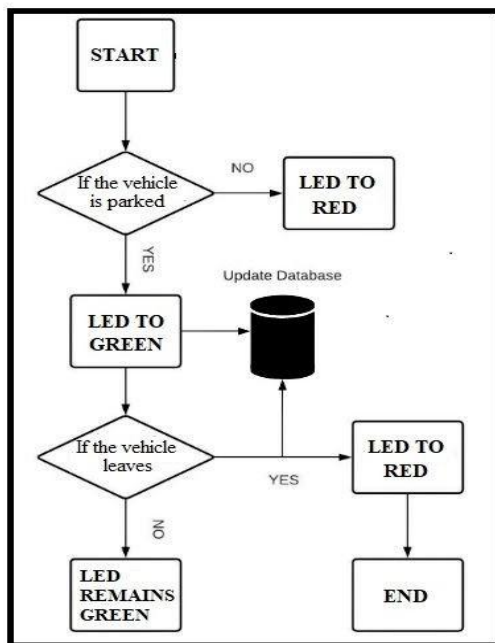


Fig 4. Working mechanism of smart outdoor parking system using IoT (Internet of Things)

VI. FUTURE ENHANCEMENTS

A companion application that facilitates the booking of parking spots for vehicles. With the help of this companion application, the driver can have a live update of the parking area and can choose the best and comfortable parking spot easily. Every individual can have their authorisation credentials to login and use for pre-booking of parking spots and make payments for parking of vehicles. Automatic fee generation and online fee remittance with the help of this application using the payment interfaces such as GooglePay, PhonePe, AmazonPay etc by scanning the QR code available in each parking spot.

The outdoor parking system can be implemented with high security by using a weighbridge load sensor attached with a clamp that clasps the rim of the vehicles securely and the vehicles will be departed from the parking spots only after the confirmation of the payment through the application. Pre-booking of parking spots can be done through the application. Solar panels and individual batteries to power up the module. The low cost of maintenance associated with the proposed system also acts as an advantage. The smart outdoor parking system can be further improved by using (NFC) Near Field Communication We can have parking tags that provide information about the user and the vehicle when the vehicle is parked in the spot.

The FASTag cards contain the information of the driver, vehicles owned by the particular driver and an inbuilt wallet which by default must be always filled with a required minimum balance to pay the fare for the usage of highways. This information is collected while registering for the FASTag which can be used by the National Highway Authority. The transaction for the usage of highways is automatic so that the driver does not need to stop and pay the fare as the amount is debited from the bank account that is provided when you apply for a FASTag.

Refer Figure 5 for the future implementation of our proposed outdoor parking system with the companion application below.

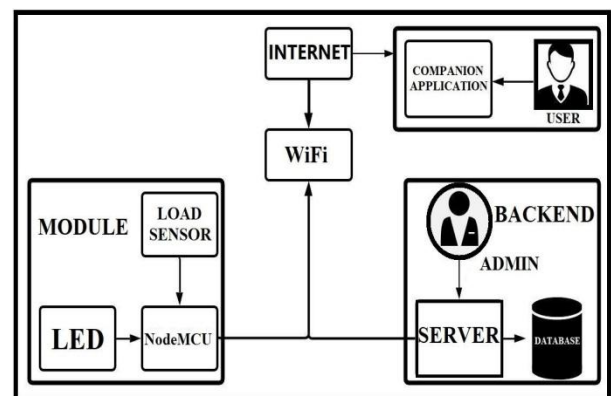


Fig 5. Diagram of the proposed system with future implementation

3. Frontend :

Frontend is a browser that acts as an user interface. The users can check and edit their details in the profile. Frontend can be designed using languages like HTML, CSS, JavaScript etc. Here the frontend is used for the following features in the application:

A. User Registration - Once the user registers the details of the vehicle and user in the application, an account will be created.

B. User login - The user can login the application using their credentials and book the parking spots.

C. Parking space detection - The user can check the vacancy of parking spots in the particular location. If any vacant spot is available, the user can pre book the parking spot.

D. Payment - During the departure of the vehicle, the application generates a receipt for parking along with the arrival and departure time. Once the payment process is completed using the payment interfaces like GooglePay, Paytm etc the car can leave.

4. Backend :

Backend is a database or a server where all the data is collected, stored, organised, accessed and managed by the users with the help of application programming. For all actions performed during the parking of vehicles are recorded. Data regarding the vacant and occupied parking spots fare for parking of vehicles, location of the parking area, arrival time and departure time, details of the user and the vehicles are recorded immediately in the database. The backend can be designed using SQL or MongoDB.

VII. CONCLUSION

This paper confers an ultra-modern framework for outdoor parking using the IoT. The ultimate aim of this project is to develop a companion application so people can avail parking spots easily and pay the fare for parking easily. The sensor-based parking system is more convenient to detect the vacancy of parking spots and provides high security and favourable parking of vehicles. The introduced system reduces labouring costs by reducing system complexity. According to the experimental analysis, future enhancements can be implemented over the existing model to improvise the parking system. Future implementations will provide accurate localization of outdoor parking spots effortlessly. The user-friendly application will stockpile the necessary details of the users which will assist the drivers to provide real-time visualization of parking areas and assist the drivers to easily visualize a live parking spots vacancy and location information from anywhere at any time in a very simple way.

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