IoT - Driven Parking Optimization

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Abstract:- **Today various advancements have been employed to develop metropolitan cities, which leads to the explosive growth in the number of visitors, in turn increases the need of parking their vehicles. Traffic issues are caused by a sharp increase in the number of cars on the road as well as flyovers. As a result, an effective parking management system is now required. The development of a smart parking system is necessary to prevent such issues. With the successful implementation of a computerized system for managing parking spaces, this innovative idea can provide service to the patrons who wants to park their vehicle quickly and without hassle. For better accomplishment of parking system, the use of technology called the internet of things is required to monitor the status of parking spaces in the real-time. Infrared Sensor is fused with Arduino microcontroller to check whether the vehicle is being parked in the allotted space or not. By the data sent from the sensor, drivers are able to identify the free space through mobile application that handles the real-time data and the driver need not to worry about finding the parking spaces. This ensures smart and efficient way of parking.**

Keywords:- **Smart Parking System, Infrared Sensor, Internet of Things, Arduino, Mobile Application.**

I. INTRODUCTION

Industrialization in the world results in increased number of vehicles on the roads globally. Nowadays, the need for available car spaces is required in many public places such as parks, airports, shopping malls, hospitals, market areas etc., hence governments are seeking for the betterment of existing transportation systems and infrastructures. The common approach to find space for parking is to search around until a free space is found [1]. Finding empty parking spaces is a common problem in most cities, especially during festival season. As a result, people compete to occupy parking spaces, which ensures the safety of their vehicles. Additionally, since most people travel in their own cars, the increase in traffic in cities causes the process of finding an empty parking space to be delayed for other drivers [2]. It is terribly frustrating for the users who search for parking spot in a parking lot. To master this problem many parking optimization systems are being offered in recent times that try to enhance basic parking management system. All the optimizations require simple mechanism to detect if a vehicle is present in a parking spot.

A. Research Background

The Internet of Things is one of the most popular technologies of the 21st century. IoT refers to a society where physical objects and inmates as well as virtual information and environments all interact with each other at the same place and moment of time through the internet. IoT is an interconnection network of physical devices that has the ability to share the real-time data between them, without the need of human intervention. The forementioned technology detect objects by the help of sensors which are controlled by remotely accessible mobile application. Furnished with an internet connection and sensor network, electronic devices in this digital world are interlinked through IoT technology. It allows user to afford wireless technology to switch data between cloud and them, ensuring efficient data transfer. A mobile application lets an end user to look at the reachability of parking space and arrange for a particular parking lot accordingly in advance [4].

B. Research Rationale

From the sayings of *Simeon Preston* ***"The biggest part of our digital transformation is changing the way we think".*** Today parking areas are in demand for people. According to the research done by *International Journal of Scientific Engineering and Research (IJSER)* in 2014, there will be a massive rise in the population of vehicles over 1.6 billion around 2035 [3]. The parking industry is being added with new technologies that allows cities to minimize the rates of congestion significantly. A smart car parking facility provides a real-time visual output denoting available parking spaces rather than driving aimlessly. The driver looks into the mobile application to seek empty parking space. This paper follows the coloration of set of LEDs which refers to respective parking status. The colorations can be green, red, yellow indicating the status empty, full, booked respectively.

C. Aims and Objectives

Aims:

To provide user the best access to available parking lot by dividing parking lots for optimizing the effective allocation of vehicles in the available parking spaces. The concept of parking optimization in a smarter way includes systematic tracking and management of the parking lots for an effective usage [5]. Instant booking of parking space through online for occupying the parking space is provided with instantaneous parking time notifications.

Objectives:

- To identify presence of vehicles in a specific parking space with great precision.
- To transfer the data into a system for optimization and analysis which is driven by parking asset officers.
- To provide access to cost efficient and low power consuming sensor technology.
- To ensure lossless end-to-end connectivity between physical objects and the software.
- To supply a reliable sensor directed application by modern smart parking solution.
- Sensors just figure out the number of vehicles without recording any information. Thus, storage of data is understated.
- To automate and reduce time spent physically exploring for an optimal parking lot [6].
- To optimize the parking space utilization, enhancing the efficiency of parking operations and contribution.
- To offer a productive deployment of the parking.
- To create a greater green and sustainable parking environment by imposing technology.
- To benefit each customer and parking asset operators by contributing to ordinary city advancement goals.
- To connect with internet in order to track, receive and send data to the network server.

The remainder of the paper is as follows. Section II proposes literature reviews. Section III presents a detailed description of smart parking optimization. Section IV shows the working model of this paper. Finally, concluded the paper in section V with the future direction.

II. LITERATURE SURVEY

Wael Alsafery [7] says that users can reduce the amount of time they spend looking for the closest parking lot by using a smart parking system to help them find a spot. This method would be helpful in giving consumers real-time information so they can avoid traffic jams and save time. This system doesn't manage the large scale of users in the real world. Dr. Vipin Kumar Sharma [8] says that Conventional parking systems frequently suffer from issues like inefficiency, traffic, and a deficiency of real-time driver information. To solve these issues, this research paper provides a thorough analysis of the deployment of an IOT-based smart car parking system. The suggested system builds a network of networked devices, comprising actuators, sensors, and a centralized control system, using IOT technologies. In order to track the occupancy status of parking spots in real time, these sensors are placed strategically throughout the spaces. Drivers may reserve parking spaces, find the closest open spots, and get real-time parking availability information using mobile applications and web portals. Additionally, the system makes use of sophisticated algorithms to effectively distribute parking spaces, lessen traffic, and shorten vehicles' search times. This project does not mention about any payment process. Aditya Bhargav Vankamamidi [9] says that finding a parking spot for a car has become one of the most important problems in our daily lives in an environment that is increasing quickly and where cars are a necessity. This problem is often causing traffic congestion during peak hours because there are more cars on the road. The user won't waste time looking for parking spots or park incorrectly because of insufficient information if they have accurate information about the available slot. Users can access parking spaces in the closest parking zone and receive real-time data about their accessibility from the system. Its primary goals are to shorten the time spent looking for a parking space and to allow users to avoid spaces that are already full. This project consumes more power on hardware components and user-friendly application was not implemented. Yashwanth Gowda M [10] says that the project's objective is to lessen traffic while providing automobile owners with free parking spots. Rapidly urbanizing cities have challenges. Radio Frequency Identification (RFID) technology, an early parking slot booking option, and a modern smart parking website can all be used to address this problem. All of the smart parking system's functions are controlled by an ESP WROOM 32 microcontroller. It is possible to tell whether a car is in or out of the slot by using infrared sensors. It is quite easy for end customers to stay informed about any parking activity. The author does not use this application; instead, automated fee production and online fee payment are accomplished through payment interfaces such as Google Pay, Phone-Pe, Amazon Pay, and others, which may be accessed by scanning the QR code that is displayed in every parking spot. Every parking lot can have battery charging stations installed. The author does not cross-reference the vehicle's data with a database by using cameras to read license plates. Ratnadira Widyasari [11] says that IoT hardware in parking spaces will transmit data on the status of the space, and IoT hardware in parking lots will transmit data about any automobile that enters or exits. Parking personnel and users' crowd sensing is used to cut down on the number of sensors. The author's automated data retrieval mechanism from the user's location within the parking lot is not upgraded. The system may be able to automatically get the data with the aid of this automatic data retrieval. Akshat Tiwari [12] says that an energy management and smart parking system for an organized setting, like a multi-story office parking lot. The system suggests combining cutting-edge Honeywell sensors and controllers with cutting-edge Internet of Things (IoT) technology to create a methodical parking system for consumers. Lamps are used to identify unoccupied car parking spaces, guiding users to an empty spot and removing the need for them to look for one. The central system can virtually store the occupied parking spaces on the cloud, directing approaching cars to available spaces. In addition to saving energy, the

automatically adjusted light illuminance illuminates the parking area for the user while they are in it. The author doesn't consider the parking in streets. Mohd Mustari Syafiq Ismail [13] says their project is to create a surveillance system that uses an AI camera and an ultrasonic sensor to detect the presence of a vehicle. This paper's goal is to suggest a way for parking fees to be paid using PayPal mobile applications. In addition to preventing traffic jams, this work offers intelligent user management, eliminates the need for extra devices, and expedites payment. The Internet of Things (IoT) smart parking system project operates when customers book a spot and pay with a PayPal mobile application, and ultrasonic sensors and a camera identify when a vehicle is there. This system uses old method of payment gateway and uses high-cost hardware. Waleed Zahir Al Qaidhi [14] says their suggested system has four layers: application, middleware, networking, and sensor layer. It makes use of the most recent developments in information and communication technologies. This Internet of Things (IoT) based smart parking system solution offers guidance on how to find and wait for a parking space while also preventing traffic jams, haphazard parking, and obstruction of traffic in the parking area. They draw attention to the contrast between conventional parking systems and IoT-powered smart parking systems. The major parking difficulties in many foreign countries like Japan, UAE have been researched. This paper does not mainly focus on application interfaces. P Bhavana Reddy [15] says, it takes a lot of time and effort to find a spot for a car in a large parking lot. In order to solve this issue, the system will use an LCD interfaced with an Arduino board to display information about the specifics of parking spaces that have been opened up. The concerned mobile phone will also receive this information via a Wi-Fi module. The initiative aims to raise the standard of living for the citizens of a city by improving parking facilities. This paper does not collect information about vehicles like number and vehicle tracking system is not implemented. Poonam Mangwani [16] says that smart online parking system acquires information about the available parking spaces in a particular area by the help of sensors. They have also added a feature of booking parking slots from home by paying for it online. But they don't have used the feature of navigation to the booked slot. The system is only available for the parking in malls, airports, markets, etc., where a parking asset is already built in an organised way. However, the system is not suitable for street parking. In [17] Ketaki Bhoyar proposes a system that uses new performance measures to automatically assist users in finding free parking spaces at the lowest possible cost. The system determines the user parking cost by taking into account both the distance and the total number of open spots in each parking lot. The system algorithm doesn't consider the traffic present in the path between the current place and the destination parking area. So, there can be some time delay if traffic is present in the streets and the booked parking slot remains waiting for them without helping the others who is in need of a parking area. The system is not ensuring about the safety of vehicles being parked in the parked space. In [18] Moh Sukron Mufaqih says that people who visit malls in Jakarta faces a lot of issues in finding a right parking for their vehicles. For that, they used an IoT system that has a data on the parking availability status which helps to guide users to a free space area for parking after a successful booking of the parking lot. The system doesn't bother about the other institutions or areas which is also facing traffic issues on parking. The solution is not applicable for street parking which is a major requirement among the people for a park in ease.

III. PROPOSED SYSTEM

A. Overview

The conventional parking helped the driver to know about the occupied parking spaces through a display containing the number of available spaces, whereas smart parking methodology connect the users to the internet in order to update the status of parking spaces. Table 1 depicts the comparison between the classical and the modern techniques for parking vehicles.

Attributes	Traditional Parking System	Smart Parking System
Planning	Without planning	With Planning
Type of Parking	Random	Organized
IoT Implementation	No	Yes
Safety	Not Guaranteed	Guaranteed
Reliable	No	Yes
Mode of Payment	Offline	Online

Table 1

Parking is an issue not only in India but also in many other developed countries. One of the Asian Gulf nations, the United Arab Emirates, is having trouble locating parking spots as a result of poor planning for parking management. Since Japan has small land areas and only about 20% of its land is appropriate for building and people, and the other portion is made up of mountains and volcanoes, the country is known for its smart parking, where in the early 1990s more than 40,000 parking places were embedded [14].

B. Hardware components implemented

- Arduino UNO
- Node MCU 8266
- IR Transmitter Receiver
- Micro Servo Motor
- 16x2 LCD Display
- Resistors
- Potentiometer
- Breadboard

1. Arduino UNO

The Arduino UNO is a programmable, open-source microcontroller board that is simple to use and can be used into a variety of electronic projects. This board has the ability to control relays, LEDs, servos, and motors as an output and may be connected to other Arduino boards, Arduino shields, and Raspberry Pi boards.

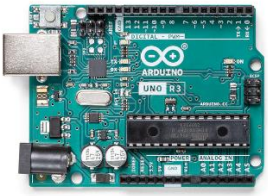

Fig 3.1 Arduino UNO

2. ESP 8266

ESP 8266 is a self-contained System on Chip (SOC) that is capable of offloading all Wi-Fi networking functions. It provides adaptability with embedded devices by giving any microcontrollers access to our network. This has TCP/IP stack that allows reading processing and transferring of data with high accuracy.

Fig 3.2 ESP 8266

3. IR Transmitter Receiver

IR Transmitter is a device which transmit infrared light to a small particular range. If this infrared light is incident on any physical objects in that range, it gets reflected back from the surface of the object and it is received by a device called IR Receiver. It works fine with input voltage of 3.3-5 V.

Fig 3.3 IR Transmitter Receiver

4. Micro Servo Motor

Micro Servo Motor is a small and lightweight hardware component with high output power. It can rotate approximately 180 degrees (90 in each direction). The operating voltage of Micro Servo Motor is 4.8-5 V and the operating speed of it is 60 degrees per 0.1s.

Fig 3.4 Micro Servo Motor

5. 16x2 LCD Display

Liquid Crystal Display (LCD) is a flat panel display type of device which is used to print the outcoming information. It is widely used since there are no limitations of displaying numbers, strings and even some animations. The operating voltage of LCD display is 4.7-5.3 V.

Fig 3.5 16x2 LCD Display

C. Working

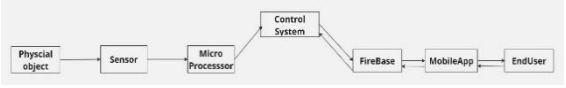

Fig 3.6 Block Diagram

The Smart Car Parking Optimization works on the principle of detecting the presence of physical object and visualizes the availability of parking space. The IR Transmitter Receiver is attached in each parking slot through which the vehicle detection is done. The sensor provides a digital output determining the presence or absence of the vehicle and sends it to the microcontroller. The data is then processed and sent to the firebase. The firebase is a common server through which the embedded system and the application of the end user interact with each other. With the help of the data provided by the firebase, parking availability in the application is updated. The same system is followed in street parking also.

In Parking Lot System, the IR sensor is placed in both the entrance and exit of the parking lot space. The maximum number of vehicles that can be parked in that parking area and also the available space is showed in the LCD display (Fig 3.7), which is placed at the entrance.

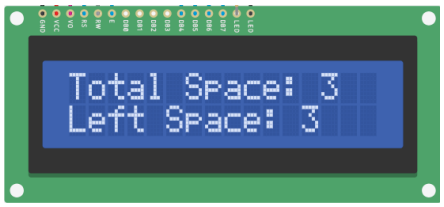

Fig 3.7 Parking Lot Display

If a vehicle arrives at the entrance, it is detected by the sensor present there. The gate opens by the help of servo motor, if the parking space is available in that particular area and the car is allowed to enter into the parking area otherwise the gate remains closed showing that the area is full. Once the car enters the area, the left space for that slot is decremented and the car is parked in the respective parking slot. The parking slot contains another IR sensor through which the availability for that particular space is updated in the application. If the car leaves from its parking slot, the availability in the application is updated. Once the car reaches the exit, it is checked out by another IR sensor present there. The gate present at the exit, opens for the car to leave the place. Thus, the left space is incremented.

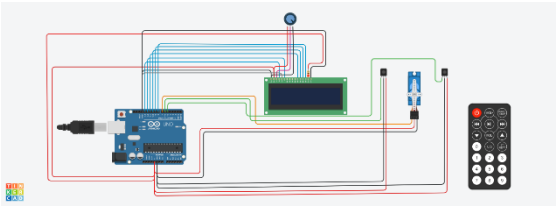

Fig 3.8 Tinkercad Simulation

The following Fig 3.9 depicts the hardware circuit implementation for Parking Lot:

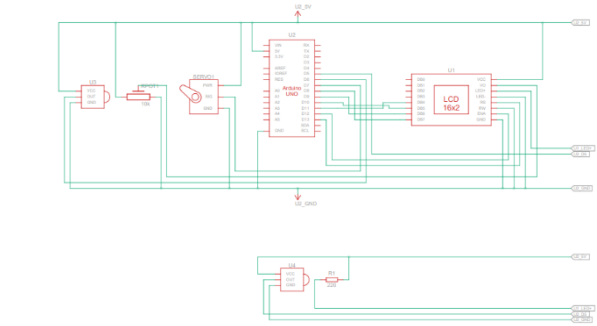

Fig 3.9 Circuit Diagram

In Street Parking System, the IR sensor is present in between the boundary line for vehicle parking. The vehicle is parked in the respective area which is detected by the sensor present there. This results in the change in the availability of street parking space in the application.

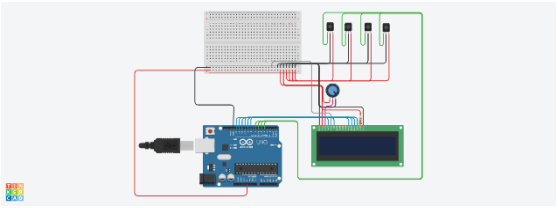

Fig 3.10 Tinkercad Simulation

The following Fig 3.11 depicts the hardware circuit implementation for Street Parking:

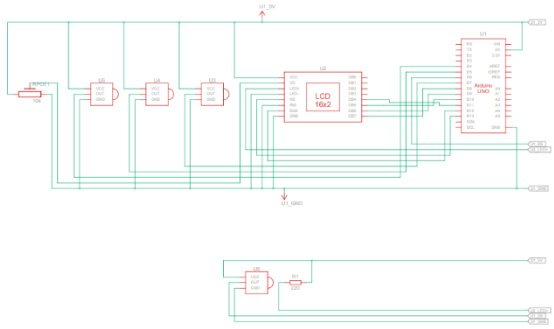

Fig 3.11 Circuit Diagram

D. Smart Parking Mobile Application

The Smart Parking Mobile Application is used to check the availability of parking space both in parking lot area and in streets. User has to select the respective area he wishes for parking his vehicle. The available space for parking is indicated by green colour and the parked area is indicated by red colour. The intermediate state i.e. the parking area that is booked but not yet parked is indicated by yellow colour. If the parking space is available, the user can continue for booking by entering the booking details. Payment is done through QR Code/UPI with successful payment confirmation. Then, the booked slot is turned yellow denoting the user to park in the respective area for his vehicle. Once the user parks his vehicle, the slot is turned red indicating the slot is occupied currently. If he leaves the slot, the parking slot turns back to green indicating other users can avail the area.

The flow of seeking availability and booking a parking space is explained clearly in the following flow chart representation (Fig 3.12).

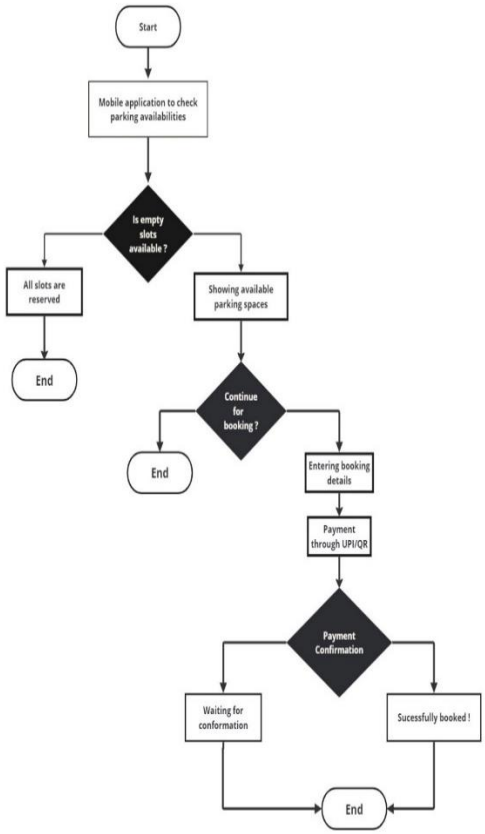

Fig 3.12 Flow Chart

IV. WORKING MODEL

The following Fig 4.1 shows the working model of Smart Parking Lot System:

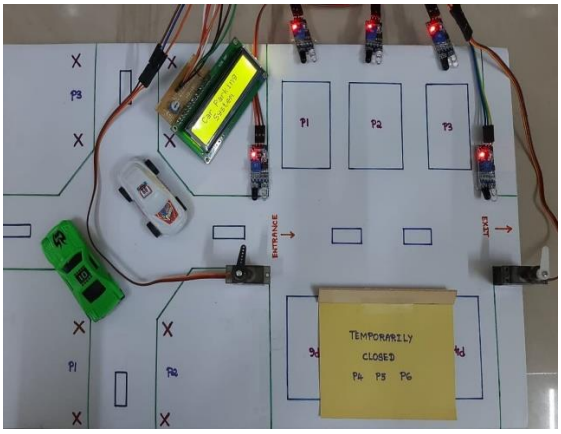

Fig 4.1 Smart Parking Lot System

The following Fig 4.2 shows the working model of Smart Street Parking System:

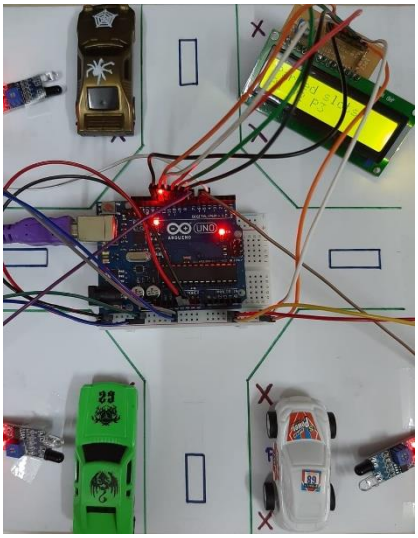

Fig 4.2 Smart Street Parking System

V. CONCLUSION

The Smart Cities are always a big dream for human society. The last three years bought a huge change in making smart cities a reality. Today's world doesn't contain the facilities of parking slot availability checker and parking reservation. This research has proposed a smart parking optimization that reduces the cost, power and time to find parking space. It also avoids traffic congestion and suppress the emission of gases from vehicles roaming for the need of parking space. IoT enabled sensors set up in parking lots detect and send real-time data on parking space availability. This helps to estimate the number of parking slots available in the area by counting the number of vehicles coming in and out of the parking area. This data is then sent to a centralized system, allowing users to access accurate and latest information about the availability through mobile application. By utilizing IoT devices and connectivity, the system improves efficiency, convenience, and protection in parking operations. The technology also enables automated payment gateways, eliminating the need for physical tickets or manual payments improving revenue collection for parking operators. The efforts made in this paper are intended for the overall improvement of parking facilities of a city and thus aiming to provide a quality of life of its people. Finally, the future step would be introducing a parking system that works with the help of GPS for navigating the user to their parking lot, AI&ML Algorithms for verifying the vehicle's registration number.

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