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IoT Based Smart Car Parking System

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Abstract

The surge in urban infrastructure development has led to a significant rise in the number of private vehicles, causing traffic congestion that adversely affects traffic flow and the overall quality of life for city residents. Parking has emerged as a major problem in urban centers. This research paper proposes an IoT-based smart car parking system designed to alleviate the current parking issues cost-effectively. Previous solutions, such as automatic car parking systems, aimed to minimize the space required for parking, particularly in densely populated areas with limited space, by utilizing multi-level car parks that stack vehicles vertically to increase parking capacity. The proposed smart parking system utilizes the latest advancements in Information and Communication Technologies (ICT) and is structured into four layers: Application, Middleware, Networking, and Sensor layers. This system is environmentally friendly, reduces emissions during parking, and functions as a fully automated, computerized system without the need for human intervention. The research compares traditional parking systems with IoT-based smart parking systems and presents a framework for implementing a smart parking solution. This system aims to improve the parking experience for users by saving time and effort, while providing parking lot owners with a reliable and efficient management tool.

Keywords: Smart parking system, IOT, automation, arduino, vehicles

INTRODUCTION

The fast developmental growth in the world is reflected in the expanded number of vehicles on streets around the world. It is anticipated that number cars in world will rise from 841 million to 1.5 billion by 2035. These days shortage of available of vehicle space is apparent in numerous public places, for example, shopping centers, airports, hospitals, market regions and stadiums. Governments hope to improve their current transportation frameworks and foundations. Finding vacant parking spots is a typical issue in most present-day urban communities particularly during busy times of different celebrations. This issue shows up generally in the advanced urban areas people stop by their vehicles bringing about a high number of vehicles contending for a couple of empty parking spots and security for their left vehicles. Besides, in indoor vehicle leaves, often is on looking for empty stopping place which likewise makes traffic jam. The situation becomes even more problematic when each parking lane has multiple parking spaces. Furthermore, the greater part of the populace utilizes their own vehicles for voyaging which leads to more blockage in urban communities which thus postpones the interaction of tracking down a vacant parking spot for the remainder of the drivers. In recent exploration in metropolitan urban communities alongside the expanding populace their vehicle thickness on streets. opening. Drivers typically spend a lot of times in discovering a space on roads through luck. In the most pessimistic scenario, individuals neglect to discover any parking spot

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particularly during top hours and merry seasons. Overall, stopping is a colossal agony spot for some drivers. Wasteful designation of room, absence of information about stopping accessibility, and absence of perceivability regarding walkers, daze spaces, and threat zones all significantly add to stopping issues. The process of finding a parking space can be made easier with the help of IoT. In the present system we have used IR sensors. The type of IR sensors used in this one are reflective type IR sensor in which transmitter and receiver are placed together, i.e., the angle between them is zero degree. The IR sensors are connected to NodeMCU ESP8266. The sensed data is then sent to the webpage. The process of finding the parking space can be made easier with the help of IoT [1–8].

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In the present system we have used IR sensors. The type of IR sensors used in this one are reflective type IR sensor in which transmitter and receiver are placed together, i.e., the angle between them is zero degree. Their sensors are connected to NodeMCU ESP8266. The sensed data is then sent to the webpage [9–15].

OVERVIEW AND BACKGROUND

Finding parking slot now a days has become a tough task. illegal on-street parking is one of the primary reasons why major city centers face progressively worsening traffic conditions. Inadequate and poorly managed parking facilities often lead vehicle owners to resort to illegal street parking. When such parking encroachments spill over to sidewalks, they wreak havoc on pedestrians' lives too. Even the widest of roads experience bottlenecks due to illegal parking. The above problems can be addressed through IoT based smart parking system as shown in Figure 1 [16–19].

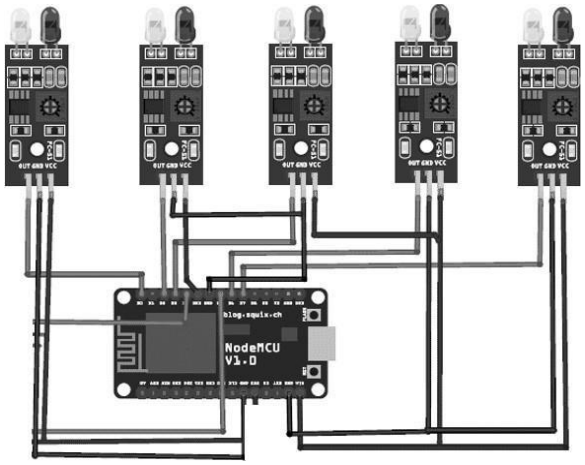

Figure 1. Circuit diagram of the project.

TECHNOLOGY INTERVENTION

Infrared radiation is an electromagnetic wave with a wavelength range of 700 nm to 1 mm, emitted by objects with temperatures above 0 Kelvin [19–22].

The temperature of the emitting object determines the intensity and wavelength of this radiation. Infrared sensors are designed to detect or measure this radiation or any changes in it, whether from an external source or an internal one. Sensors that utilize the properties of infrared radiation to detect environmental changes are categorized as infrared sensors. The general working method of infrared sensors includes the following steps:

The Infrared Source

The infrared source can be either built-in or come from the external environment. The detection range and the specific wavelength of the infrared radiation to be detected can be configured.

Transmission medium:

1. Vacuum
2. Air

Optical Fibers

Optical System

1. To converge the infrared radiation into the detector
2. Optical lenses or mirrors

Detector

1. Thermal detectors have detector material and is independent to wavelength.
2. Quantum detectors are wavelength dependent.

Signal Processing

- Infrared sensors are essential tools in many applications, as they detect and measure infrared radiation. Because the signals produced by these sensors are usually weak, amplification is necessary to ensure accurate detection and measurement. Infrared sensors can be categorized into two primary types based on their function: active and passive.
- Active Infrared Sensors: These sensors operate by emitting infrared radiation and then detecting the reflections of that radiation from objects in their environment. An active infrared sensor usually comprises an emitter (like an LED or laser diode) and a detector. When an object disrupts the emitted infrared beam, the reflected signal changes, and this change is detected by the sensor. Active infrared sensors are frequently used for applications such as proximity sensing, motion detection, and measuring distance.
- Passive Infrared Sensors (PIR): Passive infrared sensors, in contrast, do not emit any radiation. Instead, they detect the infrared radiation naturally emitted by objects, particularly the heat from living beings. PIR sensors are designed to detect variations in infrared energy levels in their environment. These sensors are commonly used in motion detectors for security systems, automatic lighting systems, and other applications that require the detection of people or animals.
- Both types of infrared sensors produce signals that are often too small to be useful without amplification. Therefore, amplifiers are used to boost these signals, ensuring that they are strong enough for accurate analysis and interpretation.
- Thermal infrared sensor
- Quantum infrared sensor

Based on working mechanism the infrared sensors are classified into two types:

- Active infrared sensor
- Passive infrared sensor

Active infrared sensors emit infrared radiation that is subsequently received by a receiver. The IR is emitted by an IR Light Emitting Diode (LED) and detected by components such as a photodiode, phototransistor, or photoelectric cell. During detection, an object of interest alters the IR radiation between the emission and reception process. This alteration changes the radiation received by the receiver, and this change is used to generate the desired output with the help of associated electronic circuitry (Figure 2).

Reflectance sensors operate using the reflective properties of infrared (IR) light. An IR emitter projects a beam, which is then reflected by a nearby object. This reflected IR is captured by a receiver.

The presence of an object alters the characteristics of the reflected IR or changes the quantity of IR that the receiver detects. The extent of this change depends on the object's reflectance. By monitoring variations in the received IR, it is possible to determine properties of the object, such as its surface texture and reflectance. output. For example, let us consider a Break beam sensor and a conveyer belt. When an opaque object interrupts the IR flow the receiver doesn't receive any signal thus the conveyer belt stops.

Figure 2. Pin diagram of IR Sensor.

Reflectance sensors operate using the reflective properties of infrared (IR) light. An IR emitter projects a beam, which is then reflected by a nearby object. This reflected IR is captured by a receiver. The presence of an object alters the characteristics of the reflected IR or changes the quantity of IR that the receiver detects. The extent of this change depends on the object's reflectance. By monitoring variations in the received IR, it is possible to determine properties of the object, such as its surface texture and reflectance. Our IR sensors are categorized under the reflectance sensors. These sensors are ideal for a parking area, because upon detecting an object in front of it, it transmits to the controller that it has detected an object, and this stays true unless the object moves away from the sensor.

So, it can be agreed that it provides not only detection but also assertion and consistency throughout transmission.

Node MCU ESP8266

The ESP8266, produced by Espress if, is a widely used SoC module for IoT applications that supports Wi-Fi connectivity. It is built around a 32-bit RISC CPU based on the Tensilica Xtensa L106 architecture, operating at a base frequency of 80 MHz, with the potential to be overclocked to 160 MHz. The module includes 64 KB of boot ROM, 64 KB of instruction RAM, and 96 KB of data RAM, with external flash memory accessible through SPI.

As a cost-effective standalone wireless transceiver, the ESP8266 is ideal for IoT endpoint development. It communicates with microcontrollers using a set of AT commands over UART at a specified baud rate Figure 3.

Communication with Internet

The communication of the sensors with the internet is done with the help of the ESP 8266 module which is called as Wi-Fi module The ESP8266, manufactured by Espress if Systems in Shanghai, China, integrates a Tensilica L106 32-bit RISC processor, providing low power consumption with a maximum clock speed of 160 MHz. Its built-in Real-Time Operating System (RTOS) and Wi-Fi stack ensure that

80% of the processing power is available for user applications and development. This System on Chip (SoC) includes integrated antenna switches, an RF balun, a power amplifier, a low-noise receive amplifier, filters, and power management modules, making it ideal for compact devices due to its small footprint. The ESP8266 modules can operate with ESP-AT firmware to provide Wi-Fi connectivity to external host microcontrollers or function as standalone MCUs using an RTOS-based SDK that can independently run connectivity applications. These modes offer advantages such as instant cloud connectivity, low power consumption, and support for Wi-Fi security protocols like WPA3.

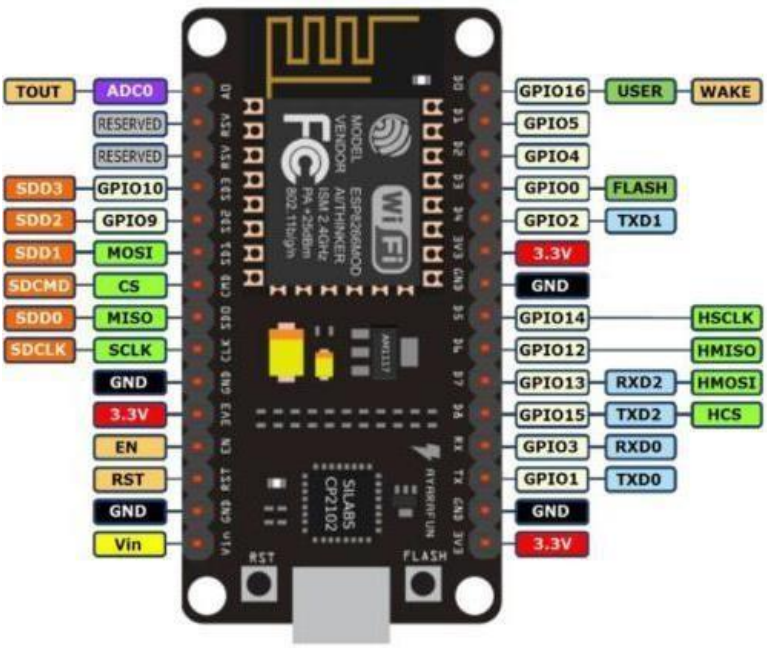

Figure 3. Pin diagram of Node MCU ESP8266.

Featuring strong on-board processing and storage capabilities, the ESP8266 can interface with sensors and other application-specific devices via its GPIOs, requiring minimal development effort and runtime overhead. The ESP8266's extensive on-chip integration minimizes the requirement for external components, thereby conserving PCB space. It also features Automatic Power Save Delivery (APSD) for VoIP applications and supports interfaces for Bluetooth coexistence. Additionally, the self-calibrating RF guarantees reliable performance across different conditions without the necessity for external RF components.

TECHNOLOGY INTERVENTION

The system consists of four sensors which are connected to Node MCU. Initially all the slots are empty, therefore, all the slots are being displayed as 1 implying that all the slots are empty. One can see slot 1 became 0 implying there is vehicle being parked at slot 1.

METHODOLOGY

The main methodology while transferring the data from NodeMCU to webpage is HTTP, i.e., HyperText Transfer Protocol (HTTP) is an application-layer protocol used for transmitting hypermedia documents like HTML. It was initially designed for communication between web browsers and web servers but can be used for other purposes as well. In the client-server model used by HTTP, the client initiates a connection to send a request and then waits for the server to respond. As a stateless protocol, HTTP does not retain any information about previous requests, meaning the server treats each request independently. While HTTP typically runs over TCP/IP, it can be used with any reliable transport protocol, including Reliable UDP (RUDP).

HTTP employs various request methods to perform different functions. The GET and HEAD methods are universally supported by all HTTP servers, but other methods may not be:

- *Get:* Retrieves the full content of a specified resource.
- *Head:* Retrieves metadata about a specified resource without the body content.
- *Post:* Sends data to a specified resource for processing, often leading to changes in server state or other side effects.
- *Put:* Replaces or updates a specified resource with new data or creates the resource if it doesn't exist.
- *Delete:* Removes the specified resource.
- *Trace:* Returns a request's received data, aiding in debugging.
- *Options:* Provides information about the communication options available for the target resource.
- *Connect:* Converts the request connection into a tunnel, typically for HTTPS.
- *Patch:* Partially modifies a specified resource.

In the described system, the server is implemented using NodeMCU, while the client accesses it through a web browser.

The web browser sends are quest periodically. Since the parking slots are equipped with ir sensor the sensed data got by NodeMCU is then sent to the webpage. By this manner the web page is updated periodically.

APPLICATION AREA

The main application area where it will be useful is large parking lots where user needs to search for parking.

A smart city utilizes information and communication technology (ICT) to boost operational efficiency, provide information to the public, and enhance government services and citizen welfare.

The primary objective of a smart city is to optimize city functions and drive economic growth while simultaneously enhancing the quality of life for its residents using smart technologies and data analytics. The true value of a smart city lies in the effective utilization of technology, rather than merely the quantity of technology deployed. Thus, the system when implemented contributes to smart city development and not only that t also helps to reduce the fuel wastage which in turn is facilitating the environment.

ADVANTAGES

- Smart Parking is quickly becoming a highly adopted and rapidly growing solution in Smart City initiatives worldwide. Airports, universities, shopping centers, and city garages are among the entities recognizing the significant benefits of automated parking technology. The core of smart parking technology is its ability to connect, analyze, and automate data collected from devices through the Internet of Things (IoT).
- Smart Parking employs low-cost sensors, real-time data, and applications to assist users in locating available parking spots. This automation reduces the time spent manually searching for the best parking floor, spot, or lot. Some comprehensive solutions offer a full suite of services, including online payments, parking time notifications, and car locating functionalities for large lots. Such parking solutions provide numerous benefits for both users and lot owners:
- *Optimized Parking:* Users can quickly find the best available spot, saving time, resources, and effort. This efficient use of space benefits commercial and corporate entities by maximizing lot occupancy.
- *Reduced Traffic:* Improved traffic flow results as fewer cars need to drive around searching for open parking spaces.

- *Reduced Pollution:* It is estimated that searching for parking consumes around one million barrels of oil daily. An optimal parking solution can significantly decrease driving time, thereby reducing vehicle emissions and contributing to a lower global environmental footprint.

DISADVANTAGES

Installation of IR sensor-based parking is tough task and the costs also too high. The main drawback for this system is the IR sensors must be always powered up which leads to lots of power wastage. Another drawback is the system fails to work whenever there's internet problem in areas, such as forests hilly areas. The cost of implementation is somewhat high.

CONCLUSION

In well-developed cities, it is challenging and often prohibitively expensive to create additional parking spaces due to the high level of occupancy. As a solution, many cities are focusing on implementing Smart Car Parking Systems (SCPS) that utilize Internet of Things (IoT) technology to detect available parking spots. By integrating IoT and sensors with a user-friendly mobile application, identifying parking areas becomes significantly easier. This system aims to alleviate traffic congestion by helping vehicles find parking slots more quickly, thereby reducing the time spent idling and lowering carbon emissions. The proposed system is designed to be cost-effective, energy-efficient, and highly accurate, making it suitable for real-time implementation. Leveraging IoT technology offers numerous benefits and represents a step towards a more advanced future. Consequently, developing this system requires determination and innovation. Our simulation results demonstrate the efficiency of our method, showing it conserves more energy compared to other existing solutions. We have also addressed potential challenges and provided solutions, offering a robust platform for users. Implementing a smart parking system promises to simplify life for individuals who face daily parking challenges, providing real-time information about available parking slots in a given area.

Future Scope

The application can be further enhanced in future in such a manner that the ire sensors will be powered up only when car is present, and we will have a mobile application in which users have to register themselves and book a parking slot and only at that particular time the IR sensor in that particular slot will be powered up and thus reducing the wastage of power.

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