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Development of Cloud enabled Smart Parking Management System for Hospitals

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Abstract **- Hospital traffic congestion impacts timely and quality healthcare delivery, largely due to limited parking spaces. Inadequate parking forces users to park in unauthorized areas, causing delays and road obstructions. This can result in late patient arrivals or delayed responses from medical staff. To address this, the proposed smart parking system uses IR sensors, servo motors, NodeMCU, LCD displays, and the ThingSpeak IoT platform. It automates entry/exit based on slot availability, displays real-time slot status, and includes a 10-minute emergency parking feature with alerts for overstays. Remote monitoring via ThingSpeak enables efficient management, reducing congestion, improving turnaround time, and enhancing the overall hospital experience.**

Keywords - ***NodeMCU, Ultrasonic Sensor, IR Sensor, Servomotor, I2C LCD, thingspeak***

I. INTRODUCTION

Hospitals are fast-paced and high-traffic environments where an efficient parking management system is essential for ensuring smooth operations and maintaining a positive experience for patients, visitors, and healthcare professionals. Traditional parking setups often struggle with issues such as long queues, poor space utilization, and difficulty locating available spots challenges that become even more critical during emergency situations. In such cases, delays caused by inefficient parking can hinder patient care and disrupt critical operations.

Smart Parking Systems address these limitations by incorporating advanced technologies such as IoT, AI, cloud computing, and mobile applications. These technologies enable real-time monitoring of parking availability, guide drivers to vacant spaces through digital displays or mobile apps, and streamline the process through automated ticketing and contactless payment methods. This reduces manual intervention, shortens waiting times, and ensures smoother vehicle movement throughout the hospital premises.

Features such as continuous slot detection, priority parking for emergency vehicles and staff, intelligent traffic flow control, and data-driven decision-making contribute to overall operational efficiency. By reducing idle vehicle circulation and minimizing emissions, smart parking solutions also support environmentally sustainable practices.

Parking systems have become increasingly relevant in everyday life, as parking requirements are present in homes, offices, malls, hospitals, and other commonly visited places. Recent technological advancements have resulted in highly specialized parking management systems designed to enhance automation, convenience, and safety. In hospital environments, such systems are especially crucial, as they help regulate sensitive areas like ambulance bays and emergency parking zones. These systems employ barriers, sensors, and display units to ensure controlled access while clearly communicating available spaces.

The “Cloud-Enabled Smart Parking Management System” integrates multiple hardware components along with cloud-based monitoring to optimize parking operations. This system utilizes a NodeMCU microcontroller, ultrasonic sensor, servo motors, and infrared (IR) sensors. IR sensors placed at the entry and exit points detect the presence of vehicles and automatically activate servo motors to open or close the gates. These servo motors act as automated barriers, ensuring controlled and efficient vehicle movement.

Within the parking area, an ultrasonic sensor continuously monitors each parking slot to determine if it is occupied or free. This is especially critical in the emergency parking zone. If a vehicle remains in the emergency slot beyond a predefined threshold time for example, 10 minutes the system triggers a buzzer to alert nearby staff that the vehicle has overstayed. At the same time, an automatic email notification is sent directly to the vehicle owner or driver, instructing them to immediately remove the vehicle to free up the emergency space for incoming critical cases.

To further enhance monitoring capabilities, the system is integrated with the ThingSpeak cloud platform. ThingSpeak updates and displays real-time data indicating whether the emergency parking slot is currently occupied or available. This ensures that hospital administrators and security personnel can remotely supervise parking conditions at all times, enabling prompt action when needed.

By combining sensor-based automation, cloud integration, alert mechanisms, and real-time data visualization, the system provides a comprehensive and intelligent solution for managing hospital parking facilities—especially critical emergency zones.

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II. LITERATURE SURVEY

Al-Balushi et al. (2025) present a study titled *"Development of a Smart Parking System for Royal Hospital using IoT"*. This research aims to develop a smart parking system for the Royal Hospital to efficiently manage traffic through IoT integration with a mobile application, thereby reducing the time spent searching for available parking spaces. The proposed framework utilizes distance-measuring devices (sensors) connected to a control unit with Wi-Fi capabilities. Additionally, the system integrates cloud services and a mobile application, providing users with real-time information to locate vacant parking spots. The study demonstrates a comprehensive strategy for project implementation, facilitates collaboration among stakeholders, and provides a detailed depiction of the prototype system [1].

Joshua et al. (2025) introduce the *"Hospital Parking Management System using Internet of Things"*. Efficient parking management in hospitals is critical, particularly for vulnerable patients, despite the trend in some cities to reduce vehicle dependence. This study employs IoT technology to automate parking allocation effectively. The system enables wireless access, allowing users to monitor parking availability remotely. Searching for parking often consumes significant time and energy, which can be detrimental for patients in urgent need. The proposed solution allows users to view parking information via the ThingSpeak platform or a mobile application, minimizing waiting times. Authorized users can access free parking areas through RFID technology [2].

ElakyaR et al. (2025) present the study *"Smart Parking System using IoT"*, which focuses on the automation of parking management to allocate available spaces efficiently. The system uses IoT technology to provide wireless monitoring of parking availability. Rapid urbanization has led to increased vehicle numbers, causing severe traffic congestion. This research addresses this problem by enabling users to receive real-time notifications regarding free parking spaces, thereby minimizing time spent searching for parking. Additionally, RFID technology is incorporated to prevent vehicle theft [3].

Amira A. Elsonbaty et al. (2025) propose *"The Smart Parking Management System (SPMS)"*, based on Arduino components, Android applications, and IoT technology. The system allows users to check the availability of parking spaces and reserve slots in advance. IR sensors detect the presence of vehicles, and the data are transmitted via a Wi-Fi module to a server, where the information can be accessed through a mobile application. The system offers multiple user-friendly features at no cost, allowing efficient management of reservations. IoT connectivity enables seamless monitoring of parking occupancy [4].

Yashwanth et al. (2025) introduce a *"Smart Parking System using IoT"* aimed at providing drivers with real-time information about available parking while reducing traffic congestion. The system incorporates RFID technology, early booking of parking slots, and a modern smart parking website. An ESP-WROOM-32 microcontroller controls the system's operations, while infrared sensors detect vehicle presence within parking slots. The system can also enhance revenue generation for urban centers while offering end users an intuitive platform to monitor parking activity [5].

Steven Yong et al. (2025) present a smart parking system leveraging IoT sensors with the primary objective of designing and evaluating the system's performance. Ultrasonic sensors are deployed in each parking slot to detect vehicle occupancy, with data sent to a NodeMCU ESP8266 microcontroller. The microcontroller updates cloud-stored parking data, which users can access via QR codes or directly online. The study also addresses common challenges, such as sensor malfunctions or misidentification of vehicles versus pedestrians. Performance evaluation indicated that the prototype achieved 100% accuracy. Compared to other smart parking solutions, this system demonstrates higher cost-efficiency and reliability, reinforcing its potential to save drivers' time and reduce environmental pollution [6].

III. SYSTEM DEVELOPMENT

A. Hardware Architecture

Figure 1 illustrates the detailed system diagram. In this system, the NodeMCU acts as the central control unit. Two IR sensors are installed at the entry and exit gates to detect vehicle presence, enabling automatic gate operation. These sensors identify objects by transmitting and receiving infrared signals. Two servomotors serve as entry and exit barriers, rotating to open or close the gates as required. An ultrasonic sensor continuously monitors parking slot availability and transmits real-time data to the ESP8266. The system also incorporates an emergency parking feature: if a vehicle remains parked beyond a predefined time, a buzzer is activated to alert the driver. Furthermore, the system is integrated with ThingSpeak, which sends email notifications to the driver, providing real-time updates on the occupancy status of parking spaces.

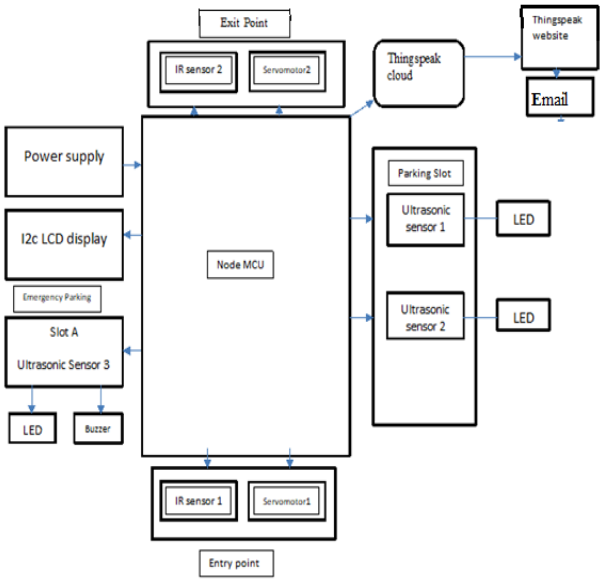

Fig 1: Block Diagram of the Project

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B. NodeMCU/ESP8266-1

The NodeMCU (Node Microcontroller Unit) is an open-source platform designed for implementing Internet of Things (IoT) applications. It is built on a System-on-a-Chip (SoC) architecture and is an affordable device, technically referred to as the ESP8266-12E. NodeMCU facilitates rapid prototyping of IoT projects using Lua scripts. Developed and manufactured by Espressif Systems, it integrates essential computing components, including a CPU, Wi-Fi networking, RAM, an operating system, and a software development kit (SDK), making it highly versatile for a wide range of IoT applications. In essence, NodeMCU functions similarly to an Arduino, with the key advantage of built-in Wi-Fi connectivity. It can be programmed using Lua scripting or the C language through the Arduino IDE and provides 10 General Purpose Input/Output (GPIO) pins for interfacing with external devices.

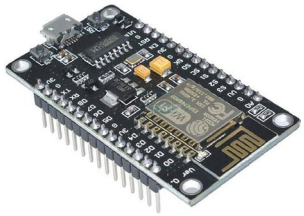

Fig 2: NodeMCU

C. Ultrasonic Sensor

The ultrasonic sensor will give an accurate distance with minimum error possible. It consists of four pins; those are VCC, GND, TRIG, ECHO pins. It requires 5v to operate and it ranges up to 5 meters far from the sensor. The ultra-sonic sensor emits the sound waves which are at high frequencies that a human can't hear. When the sound waves are emitted and when they hit any object or obstacle then the sound waves get reflected back to the ultrasonic sensor. The ultra-sonic sensor will calculate the time duration between emitted and reflected sound waves and with that time it can tell at what distance the object or obstacle is located. The ultrasonic sensor is shown below

Fig 3: ultrasonic sensor

D. BUZZER

A passive piezoelectric buzzer is commonly used in circuits to produce sound when supplied with a varying voltage. Unlike active buzzers, it does not contain an internal oscillator and therefore requires an external circuit, such as an Arduino, to generate the driving frequency.

Fig 4: BUZZER

E. I²C LCD

An LCD screen is an electronic display module that uses liquid crystals to produce visible images. The 16×2 LCD is a basic and widely used module in DIY projects and electronic circuits, capable of displaying 16 characters per line across 2 lines. When equipped with an I²C interface, the LCD can communicate with microcontrollers using only two data lines (SDA and SCL), simplifying wiring and reducing the number of GPIO pins required.

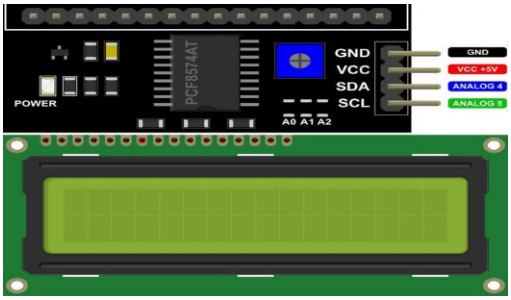

Fig 5: LCD

F. LED

The system includes two LEDs labelled as Open (green) and Close (red), which serve as status indicators. The green LED illuminates when the system is in the "open" state, indicating that the relay is energized and the door is opening or unlocked. Conversely, the red LED lights up when the system is in the "close" state, signifying that the relay is de-energized and the door is closing or locked.

Fig 6: LED

G. IR sensor

An infrared (IR) sensor is an electronic device that detects infrared radiation in its surroundings. It operates by emitting and sensing infrared light, which is invisible to the human eye but detectable by the sensor. As shown in Figure 6, IR sensors are widely used for proximity sensing, object detection, and

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motion detection. When an object enters the sensor's field of view, it reflects or emits infrared radiation, which is then detected by the sensor. This detection triggers a response, such as activating an alarm or signalling the presence of an object. IR sensors are favoured for their low cost, simplicity, and reliable performance in detecting objects without relying on visible light.

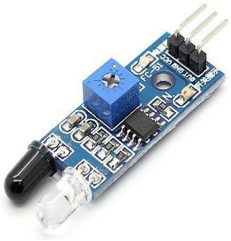


Fig 6: IR sensor

H. Servo motor

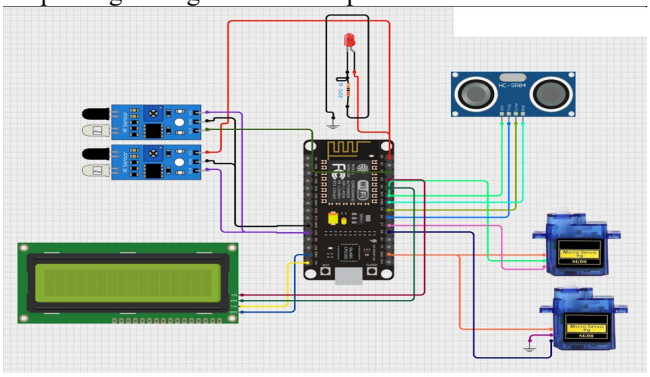
A servo motor is a type of rotary actuator that enables precise control of angular position, as shown below. It comprises a motor coupled with a feedback sensor typically a potentiometer and a control circuit. The control circuit continuously compares the desired position with the actual position of the motor shaft and adjusts the motor's speed and direction to achieve and maintain the target position. Servo motors are widely used in applications requiring accurate and repeatable motion control, including robotics, remote-controlled vehicles, industrial automation, and hobby projects. They are valued for their high torque-to-size ratio, fast response, and precise positioning capabilities.

Fig 7: servo motor

IV. EXPERIMENTAL SETUP AND RESULT DISCUSSION

A. Circuit Diagram

The circuit diagram for the development of cloud based smart parking management for hospital is shown below



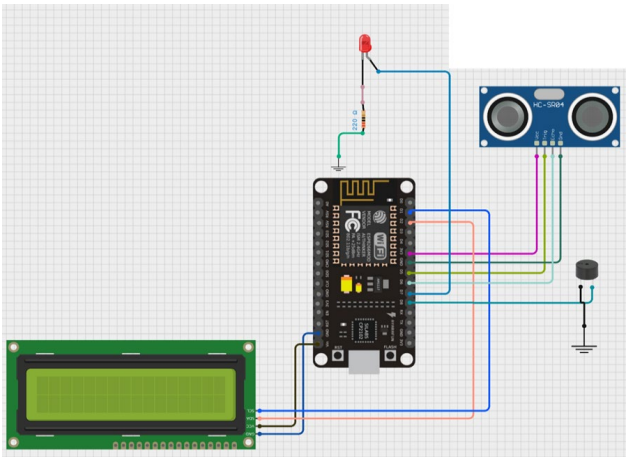


Fig 8: circuit Diagram

B. Result and discussion

The experimental results were obtained after assembling and connecting the circuit. Additionally, the Arduino program was used to test the NodeMCU, I²C interface, and all sensors. The NodeMCU also serves as a storage unit, retaining the program information for future use if required.

1) Testing of Entry Point

At the entry point, an IR sensor is installed to detect the arrival of a vehicle. Upon detection, the gate is automatically opened with the assistance of a servo motor, as shown in the figure below.

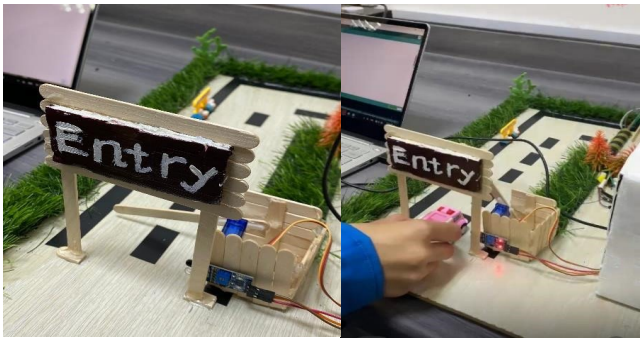


Fig 9: Entry gate

The LCD display indicates the number of cars that have entered the parking area, as shown in the figure. This information is also accessible via the serial monitor, as illustrated.

Fig 10: LCD display and serial monitor

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2) Testing of Parking Point

When a car occupies a designated parking slot (e.g., slot 2), the LCD display indicates that the slot is occupied, and the corresponding red LED is activated, as shown in the figure below. When the vehicle leaves the slot, the display updates to show that the slot is available, as illustrated in the subsequent figure.

Fig.11 LCD display shows Slot 2 is occupied and LED glows.

Fig 12. LCD display shows slot 2 is available and also LED is off

The Serial monitor output is shown in fig.13

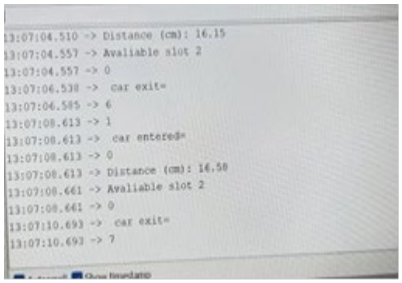

Fig. 13 Serial Monitor output

3) Testing of Exit Point

The exit gate opens automatically once a car leaves, as shown in the figure. The LCD display and serial monitor update simultaneously to show the number of cars that have exited the parking area.

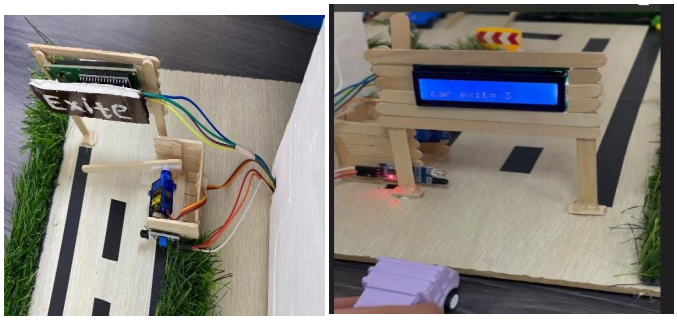

Fig14 LCD display shows number of car exited

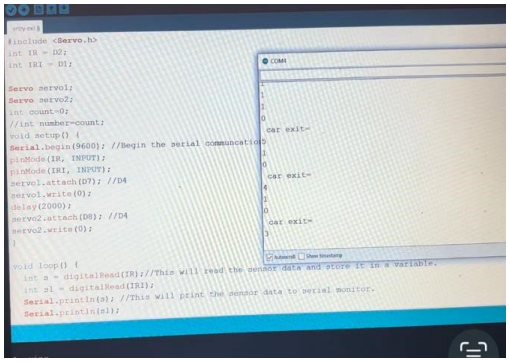

Fig 15. Serial Monitor shows number of cars exited

4) Testing of emergency ParkingPoint

This system is designed to monitor and manage emergency parking slots, ensuring their availability for critical and time-sensitive situations. When a vehicle occupies a designated emergency slot, an LED indicator automatically illuminates to confirm occupancy, and the system begins tracking the duration of parking. If the vehicle remains in the slot beyond a predefined threshold (e.g., 10 minutes), a buzzer is activated to alert nearby personnel. Simultaneously, an email notification is sent to the driver, prompting immediate removal of the vehicle to free the emergency slot.

For remote monitoring, the system is integrated with the ThingSpeak platform, which provides real-time status of the emergency parking slot:

- A red LED indicator on the ThingSpeak dashboard signifies that the slot is occupied.
- A green LED indicates that the slot is vacant.

This approach ensures efficient management of emergency slots, prevents misuse, and supports rapid turnover for critical vehicles such as ambulances and emergency responders. The results are displayed both on the serial monitor and the ThingSpeak website. Testing of the emergency slot is shown in the figure below.

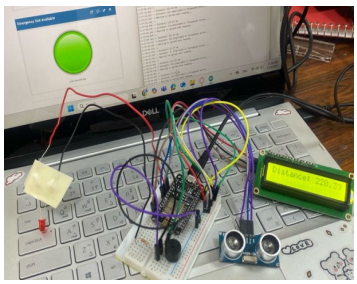

Fig 16 testing of emergency parking circuit

The figure below shows the results displayed on the serial monitor and the ThingSpeak website. In the ThingSpeak output, a green LED indicates that the emergency slot is free, while a red LED signifies that the slot is occupied

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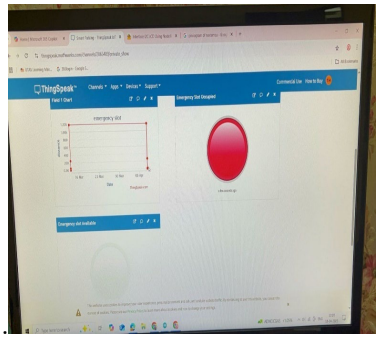

Fig 17 Serial monitor and thingspeak

If an ambulance remains parked beyond a predefined duration (e.g., 10 minutes), the alert system is triggered. A buzzer notifies nearby personnel, and an instant email is sent to the driver with the message “Move Immediately.” The figure illustrates the email alert.

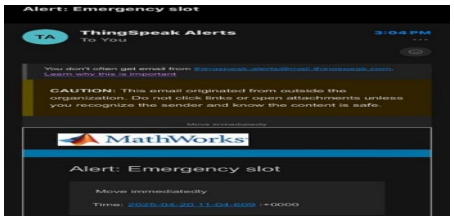

Fig 18. Email Alert

The final project is shown below

Fig 19. Final Prototype

V. CONCLUSIONS

Smart parking services have become essential for the development of smart cities. this paper focuses on implementing an integrated solution for smart parking. the proposed system offers several advantages, including the ability to detect available parking spaces. by using this system, we can save time, reduce pollution, and lower fuel consumption. in hospitals, a smart parking system provides an innovative solution that addresses the needs of patients and visitors by minimizing the time spent searching for parking. this system also helps ease congestion and improves the overall entry and exit experience. with the help of modern technologies, the smart parking system enhances the hospital's operational efficiency, reduces harmful emissions, and ensures a safe and comfortable experience for users. therefore, implementing such systems is a crucial step toward improving healthcare services, increasing user satisfaction, and addressing future challenges.

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