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Real Time Parking Assistance Using ESP32-MCU

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Abstract: This paper proposes a real-time parking assistance system leveraging the ESP32 Microcontroller Unit (MCU) integrated with Internet of things (IoT)technologies. The system dynamically monitors available parking spaces using sensors and transmits live data to a cloud server via Wi-Fi. Drivers receive up-to-date parking availability through a mobile or web application, enabling smarter and quicker decision-making. Unlike traditional systems that rely on static signage or manual management, the proposed method emphasizes scalability, low-cost deployment, and minimal maintenance. Experimental validations demonstrate the system's reliability and potential to significantly reduce search time for parking spots, thus contributing to sustainable urban mobility.

Index Terms **- ESP32, Internet of Things (IoT), Mobile app, Sensors.**

I. Introduction

The figure1 shows a real-time parking assistance system using IoT technology. Parking and traffic sensors detect vehicle presence and transmit data via IPv6 over Low-Power Wireless Personal Area Networks(6LoWPAN) networks. A gateway collects the information, making it accessible through mobile apps. This device reduces traffic and increases efficiency by helping cars find parking quicker.

In recent years, the growth of urban populations has significantly strained existing parking infrastructures, leading to longer search times for available spots and contributing to environmental pollution. Conventional parking assistance methods, such as manual supervision and basic sensor-based indicators, are often limited in scalability, responsiveness, and real-time data dissemination. To address these limitations, the integration of IoT technologies into parking management offers a transformative solution.

This introduces a real-time parking assistance system shown in figure 1, utilizing the ESP32 microcontroller, known for its built-in Wi-Fi and Bluetooth capabilities, low power consumption, and processing efficiency. The system is designed to detect vehicle presence in parking slots using IR sensors, transmit occupancy information to a centralized cloud server, and display the status to end-users through a user-friendly interface. By focusing on real-time updates, the solution aims to minimize drivers' time spent searching for parking, thereby reducing traffic congestion and environmental impacts. This paper discusses the system architecture, implementation details, and performance evaluation, demonstrating the practicality and effectiveness of ESP32-based IoT solutions in modern smart parking applications.

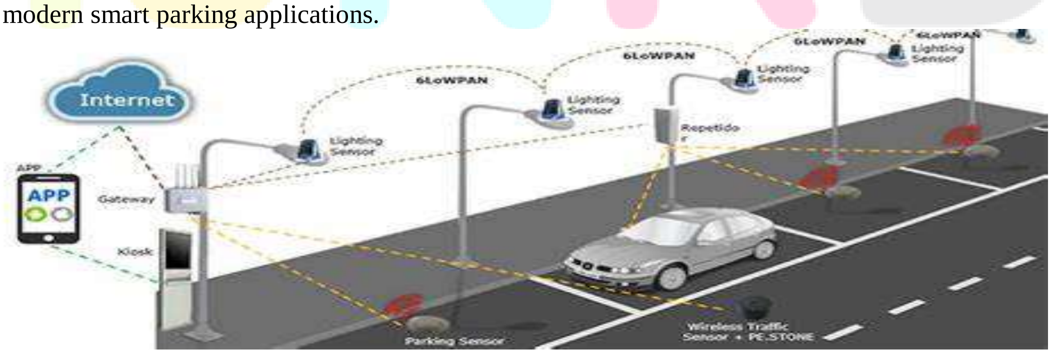

Figure 1: Real Time Parking Assistance

II. LITERATURE REVIEW

A real-time parking assistance system using ESP32 and IoT is an intelligent, embedded solution that leverages the ESP32 microcontroller's wireless capabilities to monitor, manage, and communicate parking space availability and vehicle positioning through a network of sensors.

In paper [1], authors designed a vehicle positioning system using ARM architecture to enable low-cost and efficient vehicle tracking. The system demonstrated potential in real-time applications but faced challenges with precision and hardware limitations in dynamic environments.

In Article [2], authors developed a smart parking system using IoT and ESP32 to streamline urban parking. The solution improved space utilization and user convenience, but scalability and network dependency remain critical concerns.

In Research paper [3], authors developed an IoT-based automatic accident alert system that sends real-time notifications during collisions using GPS and GSM modules. While it enhances emergency response, inconsistent network coverage may affect alert delivery reliability.

In Article [4], authors implemented a reservation-based parking system using GSM and RFID to reduce congestion in high-traffic areas. The system showed promise in time-saving but required prior user registration and had limited adaptability for dynamic spot availability.

In paper [5], authors designed an automatic aircraft parking system with visual guidance using an ESP32 microcontroller. It increased accuracy in aircraft positioning, though its effectiveness may depend on the visibility and proper maintenance of visual cues.

In Research paper [6], authors developed an IoT and AI with ESP32CAM for sustainable mobility in smart cities, enabling real-time traffic and parking analysis. The integration supported efficient urban planning, though high computational needs and privacy concerns were noted.

In Article [7], authors developed a smart parking assistant using ultrasonic sensors and IoT via ESP32 to enhance parking safety and automation. While it improves driver experience, sensor sensitivity and environmental interference could limit accuracy.

In Research paper [8], authors introduced an online parking system with LDR sensors and ESP32 to detect and display parking availability. The approach reduced search time, yet its accuracy may vary under poor lighting or sensor misalignment.

In paper [9], authors developed an IoT-based parking optimization system using facial and license plate recognition through ESP32-CAM and AWS. Although it mostly depends on cloud infrastructure and precise picture recognition, the system improved security and access control.

In Article [10], authors developed a digital twin-enabled smart car park system aimed at managing traffic and reducing emissions. The architecture supports sustainability goals, but its implementation requires complex modeling and high initial investment.

In paper [11], authors developed an accident prediction and crash recovery system using a car black box to record real-time vehicle data for post-crash analysis. The system enhances accident forensics and recovery support, but real-time prediction accuracy and data security remain concerns.

III. EXISTING METHOD

Several parking assistance systems have been proposed and implemented over the past decade, aiming to improve parking efficiency and driver convenience. Early solutions primarily involved static signage that indicated available spaces in parking lots, updated manually or through simple wired sensor networks. While effective to a certain extent, these systems lacked real-time accuracy and required frequent human intervention for updates. While ultrasonic sensor-based parking assistance systems using ESP32 offer a simple solution for real-time slot detection, they also present several disadvantages. First, installing ultrasonic sensors at each individual parking slot can significantly increase hardware and maintenance costs, especially in large parking areas. Ultrasonic sensors are sensitive to environmental conditions such as rain, dust, and extreme temperatures, which can affect their accuracy and reliability. Additionally, these systems often suffer from false readings caused by irregularly shaped vehicles, low-profile cars, or nearby obstructions. Camera-based smart parking systems also emerged, employing image processing algorithms to detect vacant spaces. Although offering detailed monitoring, such systems are often expensive to deploy and maintain, sensitive to environmental conditions (e.g., lighting, weather), and require high computational resources for image analysis.

IV. REAL TIME PARKING ASSISTANCE USING ESP32-MCU

The block diagram of Real Time Parking Assistance using ESP32-MCU Shown in figure 2 and presents a real-time parking assistance solution based on the ESP32 microcontroller, incorporating intelligent features to enhance driver convenience and safety. The ESP32 serves as the central control unit, efficiently managing multiple tasks such as sensor data acquisition, wireless communication, voice interaction, and actuator control with minimal latency. The car is equipped with a variety of infrared (IR) sensors to precisely identify surrounding obstructions, guaranteeing 360-degree coverage and reducing blind spots. The data collected from the IR sensors is processed by the ESP32 to provide dynamic feedback through various output modules. To guide the driver visually, a compact Liquid Crystal Display (LCD) display mounted on the dashboard presents real-time distance measurements, parking status, and obstacle warnings in an easily interpretable format. An audible alert system is integrated, featuring a buzzer that varies its tone based on the proximity of obstacles, providing immediate feedback without requiring the driver to divert attention from the road.

The ESP32's built-in Wi-Fi and Bluetooth capabilities enable seamless wireless connectivity; Wi-Fi integration allows the system to upload parking data to a cloud server for remote monitoring and historical analysis, while Bluetooth connectivity facilitates direct interaction with a smartphone app for adjusting settings, receiving alerts, and updating firmware. A servo motor is utilized to represent suggested steering adjustments, physically indicating optimal wheel alignments to assist the driver in tight parking situations.

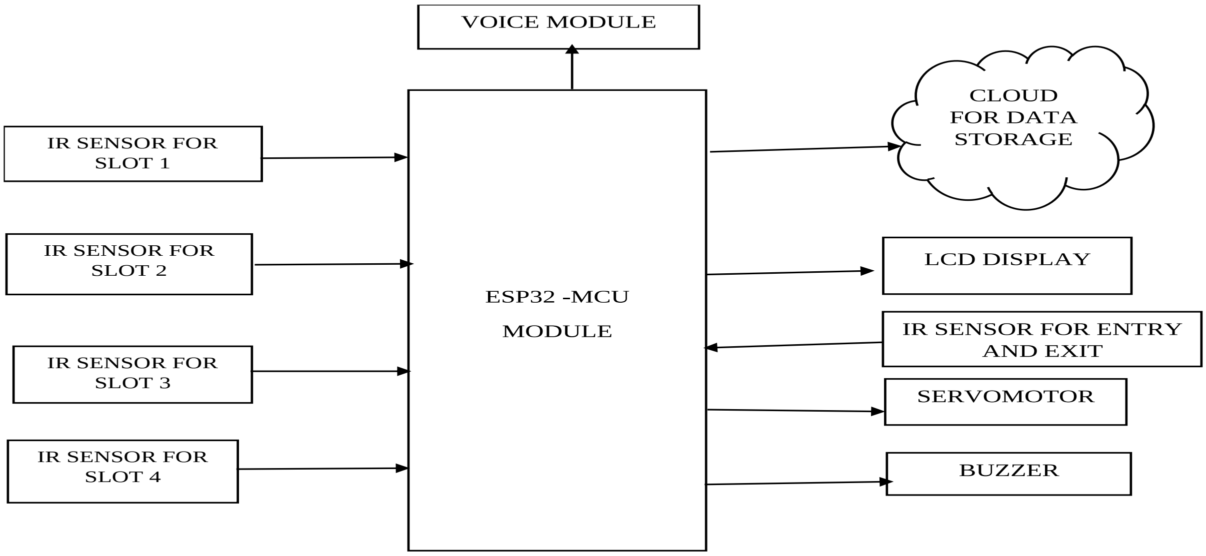

Figure 2: Block Diagram of Real Time Parking Assistance

The system depicted in the block diagram showcases a smart, sensor-based automation framework built around the ESP32 -MCU. This central controller serves as the brain of the setup, interfacing with multiple infrared (IR) sensors that continuously monitor environmental parameters or object presence. These IR sensors, primarily connected on one side of the MCU, provide critical input data used for real-time decision-making. A dedicated IR sensor on the output side likely serves a specialized function, such as triggering an event upon detecting movement or obstruction. The ESP32 also communicates with a voice module, enabling audio alerts or commands, enhancing the interactivity of the system. On the output end, an I2C LCD module visually conveys system statuses or messages, while IoT and MQTT modules ensure seamless connectivity and data exchange with external platforms or cloud services. Additionally, the MCU controls a servo motor and a buzzer, which may be used for mechanical operations and audible notifications respectively. This intelligent integration makes the system highly adaptable for applications like smart surveillance, automation, or interactive systems, blending sensing, control, and communication seamlessly.

V. RESULTS AND DISCUSSIONS

The ESP32 microcontroller was used to create the Real-Time Parking Assistance System, which efficiently tracks and controls parking space availability in real time. The below figure 3 shows real-time parking assistance system shown in the image is built using a combination of IR sensors, a voice playback module, a servo motor, an LCD display, controlled by a central microprocessor, together with a buzzer. Four IR sensors are positioned to detect the presence of vehicles in different parking spots, each providing a digital signal to the microcontroller when a vehicle is detected.

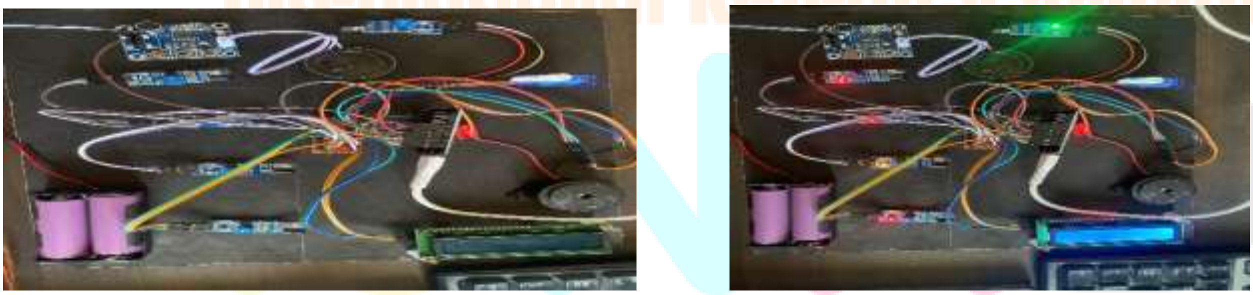

Fig 3 : Circuit Connections On Real Time parking Assistance Using ESP32-MCU

The below figure4 shows the images show a real-time parking assistance system using an LCD display to indicate the availability of four parking spots labeled S1 to S4. The system accurately updates the status of each spot, displaying either "Avl" (Available) or "FULL" based on the occupancy. In the first image, all spots (S1 to S4) are available. The second and third images both show that spot S2 is occupied while the others remain available. In the fourth image, spot S4 is marked as occupied, with the rest available. This indicates that the system is functioning correctly, dynamically reflecting the real-time status of each parking space as vehicles arrive or depart. A system like this can greatly help with effective parking management and cut down on the amount of time drivers spend searching for open spaces.

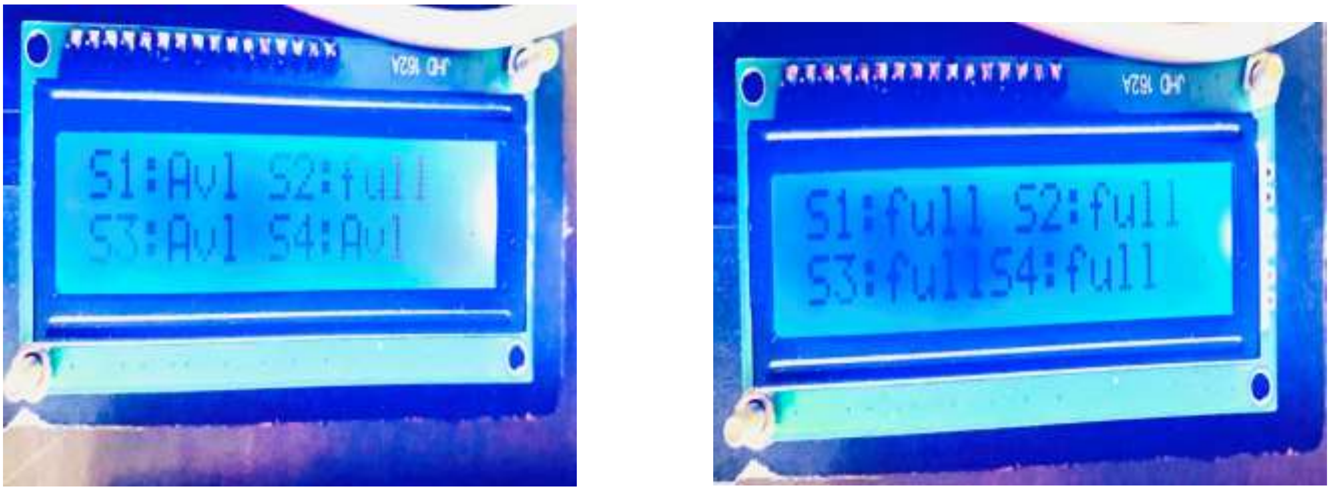

Fig 4 : Output on LCD Display

Fig 5: Data Storage on Cloud from Different IR sensors For Different Slots

The above figure5 shows four charts labeled "Field 1 Chart," "Field 2 Chart," "Field 3 Chart," and "Field 4 Chart," each representing data from infrared (IR) sensors monitoring a "real-time parking" system. An IoT analytics tool called ThingSpeak is used to create the graphics. The data from the IR sensors across the four fields indicate vehicle detection at specific times. In Field 1 (IRsensor1), the sensor's digital output spikes to 1 around 14:10 and 14:15, signalling vehicle presence at those times. Field 2 (IRsensor2) shows a similar pattern, with spikes at approximately the same moments, suggesting consistent detection across both sensors. Field 3 (IRsensor3), however, records only a single spike around 14:10, indicating a brief vehicle presence at that location. Field 4 (IRsensor4) displays two distinct patterns: a peak around 14:10 and multiple rapid spikes around 14:15, which could imply either brief or repeated detection of a vehicle in that area.

VI CONCLUSION AND FUTURE SCOPE

A useful and affordable way to improve driver awareness and safety when parking is using the ESP32 Controller-based real-time parking assistance system. Through the integration of an infrared sensor with the ESP32 controller, the system is able to precisely identify impediments and deliver real-time feedback via optional displays and a buzzer. This makes parking in confined places much simpler and safer while also reducing the likelihood of crashes. The real-time distance can be used to trigger pre-recorded notifications like "Stop" or "Obstacle ahead." Additionally, voiced notifications are employed to increase driver awareness with the use of a speech module, such as Information Storage Devices1820 (ISD1820). Additionally, a speech module, such Information Storage Devices1820 (ISD1820), is used to provide voiced notifications to raise driver awareness. makes parking easier and safer by offering a hands-free, user-friendly experience.

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