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IOT BASED SMART PARKING SYSTEM

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Abstract: Due to the proliferation in the number of vehicles on the road, traffic problems are bound to exist. This is due to the fact that the current transportation infrastructure and car park facility developed are unable to cope with the influx of vehicles on the road. To alleviate the aforementioned problems, the smart parking system has been developed. With the implementation of the smart parking system, patrons can easily locate and secure a vacant parking space at any car park deemed convenient to them. Vehicle ingress and egress are also made more convenient with the implementation of hassle free payment mechanism. With vehicle detection sensors aplenty on the market, the choices made may defer due to the different requirements in addition to the its pros and cons. Subsequently, the various sensor systems used in developing the systems in addition to the recent research and commercial system on the market are examined as vehicle detection plays a crucial role in the smart parking system.

Keywords: Car park system, intelligent transportation system, parking technology, smart parking system

I. INTRODUCTION

In the year 2006, 458,293 new registered vehicles were reported compared to the year 1999 where there were only 296,716 new registered vehicles, which makes it a rough estimate of 54.5% increase in a span of 7 years (Malaysian Ministry of Transportation, 2007). Referring to the aforesaid statistics provided by the Malaysian Ministry of Transportation, the current transportation infrastructure and car park facilities are deemed insufficient in sustaining the influx of vehicles on the road. Therefore, problems such as traffic congestion and insufficient parking space inevitably crops up. In Asia, the situation are made worse by the fact that the roads are significantly narrower compared to the West (Inaba et al., 2001). Various measures have been taken in the attempt to overcome the traffic problems. Although, the problem can be addressed via many methods, the paper focuses on the car park management system introduced, which is the smart parking system. This study will review the evolution of vehicle detection technologies as well as the detection systems developed over the years. By enabling smart parking system offers several key advantages:

- Reduction in traffic congestion by enabling drivers to identify and navigate directly to available parking spaces, thereby minimizing unnecessary vehicle circulation and easing pressure on urban road networks
- Enhancement of time efficiency through real-time data acquisition and communication, allowing users to quickly locate vacant slots and significantly reducing delays in high-density areas
- Minimization of fuel consumption as vehicles spend less time idling or moving slowly in search of parking, resulting in direct economic benefits for users and improved energy efficiency
- Improvement in environmental sustainability by lowering greenhouse gas emissions and air pollutants, contributing to cleaner urban environments and supporting eco-friendly transportation initiatives
- Provision of real-time monitoring and centralized management using IoT sensors and cloud platforms, enabling authorities to track occupancy status and respond promptly to changing conditions
- Increase in user convenience through mobile and web-based applications that provide live updates, navigation assistance, and advance booking features, thereby enhancing the overall parking experience
- Optimization of parking space utilization by ensuring that all available slots are effectively used, reducing instances of both overcrowding and underutilization in parking facilities
- Reduction in human intervention by automating parking operations such as detection, allocation, and billing, which decreases dependency on manual labor and minimizes operational errors
- Enhancement of security through the integration of surveillance cameras, sensors, and alert systems that help detect unauthorized access, prevent vehicle theft, and ensure safer parking environments

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- Facilitation of seamless and contactless payment systems by integrating digital payment technologies, enabling users to complete transactions quickly and securely without physical interaction
- Enablement of data collection and advanced analytics by continuously gathering information on parking usage patterns, peak hours, and user behavior, which can support informed decision-making and urban planning
- Support for scalability and flexibility as IoT-based systems can be easily expanded or modified to accommodate growing urban demands and can be deployed across various environments such as malls, airports, and smart cities
- Reduction in parking violations through automated monitoring, alerts, and enforcement mechanisms that ensure compliance with parking regulations and improve overall discipline
- Improvement in revenue management by providing accurate tracking of parking occupancy and duration, reducing leakage, and ensuring transparent and efficient billing processes
- Integration with broader smart city infrastructure, allowing interoperability with traffic management systems, public transportation networks, and other IoT-enabled services for holistic urban development
- Enhancement of decision-making capabilities for authorities by providing real-time dashboards and historical insights, enabling better planning, policy formulation, and infrastructure development

II. PROPOSED SYSTEM

1. System Architecture:

The proposed Smart Parking System utilizes IoT technology, a web application, and OTP-based authentication to ensure efficient and secure parking management. Users start by accessing the system's web application, where new users can register by providing basic details, while existing users can log in directly. After logging in, users can view available parking locations and select their desired slot. They then enter booking details, such as vehicle and contact information, and proceed to payment by clicking the “Pay” button. Once payment is successful, the system sends a confirmation email containing a One-Time Password (OTP) for verification at the parking gate. Upon arrival at the parking gate, the user provides the OTP to the admin or attendant. The admin verifies the OTP, granting parking access if correct or denying it if incorrect. Once the OTP is successfully verified, the system updates the slot status in real time on both the web application using ThingSpeak and the LCD display via Arduino. This ensures users and administrators can monitor parking slot availability accurately. The system offers convenience, enhances security, and provides real-time updates for a seamless parking experience.

2. Hardware Implementation:

The hardware implementation of the Smart Parking System uses an Arduino Uno as the main microcontroller, interfaced with essential components such as IR sensors, an LCD display, and a NodeMCU (ESP8266) for IoT connectivity. The system employs four IR sensors (IR-1 to IR-4), each positioned at a designated parking slot to detect whether a car is present or not.These sensors are connected to the Arduino’s digital pins, allowing it to monitor parking slot occupancy in real time. The status of these slots—whether occupied or vacant—is displayed locally using a 16x2 I2C LCD, which reduces wiring complexity by using just the SDA and SCL lines. There is Servo motor present for gate controlling. To enable remote monitoring, the Arduino communicates with a NodeMCU module via serial UART using TX (pin 1) and RX (pin 0). The NodeMCU sends parking data to the ThingSpeak cloud platform, where it is visualized on a webpage for users and administrators. A custom PCB is used specifically to provide a common VCC and GND connection to all components, ensuring reliable power distribution and reducing loose wiring.

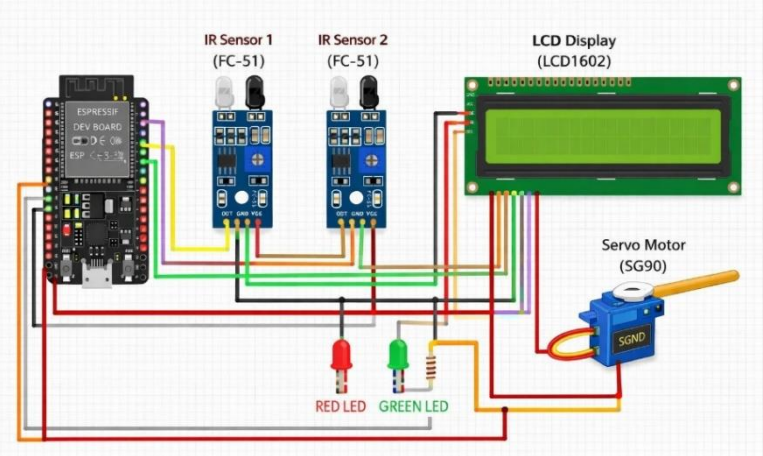

Fig1: Hardware Arrangement

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3. Testing & Results

To ensure the reliability and accuracy of the Smart Parking System, various levels of testing were conducted. The unit testing phase involved verifying individual hardware components—each IR sensor was tested for accurate detection of vehicles, and the LCD display was tested to ensure it correctly reflected the status of parking slots. The Arduino code was uploaded and debugged using the Arduino IDE, ensuring correct readings and serial communication with the NodeMCU. For the web application, the Django backend was tested by creating multiple user accounts, logging in, booking slots, and verifying if the OTP generation and email functionality worked as expected. The frontend was tested across different devices and screen sizes to ensure a responsive design using HTML, CSS, and JavaScript. Integration testing was performed to check the end-to-end flow—from booking a parking slot on the web app, receiving the OTP, arriving at the gate, entering the OTP, and finally updating the slot status on both the webpage and LCD. The ThingSpeak platform was also tested for consistent data transmission and visualization from the NodeMCU. Edge cases like entering an incorrect OTP, rebooking an already booked slot, or accessing the gate without a valid booking were handled and verified. Overall, the system successfully passed all major test cases and demonstrated stable performance under real-time conditions.

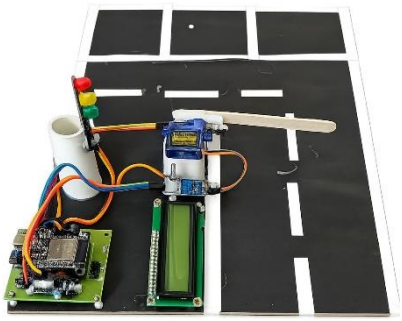

Fig2: Hardware Model

Fig2.1: Hardware Result

III. ADVANTAGES OF THE PROPOSED DESIGN

- Reduction in traffic congestion through efficient parking allocation
- Enhancement of time efficiency with real-time parking information
- Minimization of fuel consumption due to decreased search time
- Improvement in environmental sustainability by lowering emissions
- Provision of real-time monitoring and management capabilities

IV. APPLICATIONS

- IoT-based smart parking systems are widely applied in urban areas to reduce traffic congestion by guiding drivers to available parking spaces, thereby improving overall traffic flow and minimizing delays in densely populated cities.
- The system plays a vital role in smart city development by integrating with intelligent transportation systems,

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enabling efficient resource utilization, real-time monitoring, and data-driven urban planning.

- Smart parking solutions are implemented in malls and commercial centers to enhance customer experience by providing real-time parking availability, reducing search time, and improving operational efficiency.
- These systems are used in large transit hubs to manage high volumes of vehicles efficiently, ensuring smooth parking operations and reducing congestion during peak hours.
- Smart parking helps in providing quick access to parking for patients and emergency vehicles, thereby improving response time and overall service efficiency in critical environments.
- Universities and colleges utilize smart parking systems to manage large parking areas, streamline vehicle movement, and ensure better space allocation for students, staff, and visitors.
- Organizations deploy these systems to manage employee parking efficiently, enable reserved parking, and improve security and access control within office premises.
- Smart parking solutions help in managing resident and visitor parking, enhancing security, and preventing unauthorized vehicle entry.
- Municipalities use IoT-based parking systems in public areas to improve parking management, enforce regulations, and optimize revenue collection.
- During large events such as exhibitions, concerts, or sports activities, smart parking systems assist in handling high vehicle inflow and ensuring organized parking.
- These systems are applied in logistics hubs to manage vehicle entry, parking, and movement efficiently, reducing waiting time and improving operational productivity.
- Smart parking systems are useful in popular tourist spots to manage seasonal traffic, provide guidance to visitors, and reduce congestion in high-demand areas.

V. FUTURE SCOPE AND IMPROVEMENTS

The Smart Parking System has significant potential for future enhancements through the integration of emerging technologies. AI-based slot prediction can be implemented to analyse historical data and forecast parking demand, helping users identify the best times to find available slots. Mobile app integration would enhance user convenience by allowing seamless booking, payment processing, and real-time navigation assistance directly from smartphones. Additionally, voice and chatbot assistance could be integrated to enable users to interact with the system using natural language, simplifying the process of finding and reserving parking spaces. Advanced technologies like Automatic Number Plate Recognition (ANPR) can automate entry by scanning vehicle license plates, eliminating the need for OTP verification. A dynamic pricing system could also be introduced, adjusting parking rates based on peak hours, demand levels, or offering promotional discounts to optimize space usage. Furthermore, IoT-based smart navigation can guide drivers to their exact reserved slot using sensor-driven directions. Finally, AI algorithms can be extended to analyse traffic patterns and suggest the most efficient parking schedules, reducing congestion and improving overall user experience. These advancements would elevate the system into a more intelligent, automated, and user-centric solution.

VI. CONCLUSION

The Smart Parking System based on IoT is a solution to contemporary parking woes in an effective and automated manner through the integration of real-time slot identification, cloud monitoring, and OTP authentication. Using Arduino, NodeMCU, and sensors, the system successfully reduces manual intervention, lessens parking search time, and increases security. The middleware server integration along with a Django-based web application ensures smooth data visualization and easy accessibility for users and administrators alike. Experimental outcomes prove the system's capability to enhance parking efficiency. With possible improvements such as AI-based forecasting, ANPR, and mobile app support, the system can be optimized further for smart city use.

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BIOGRAPHY

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