Design and Implementation of an IoT-Based Smart Car Parking System

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ABSTRACT

The rapid growth of urban populations has intensified parking congestion in metropolitan areas, leading to excessive fuel consumption, traffic delays, and environmental concerns. This paper presents the design and implementation of an Internet of Things (IoT)-based smart car parking system using Arduino Uno, NodeMCU (ESP8266), and infrared (IR) sensors. The proposed system detects vacant parking spaces and communicates availability to drivers through the Blynk IoT platform in real time. The system was designed, simulated, and tested using integrated hardware and software components, with results showing reliable detection and efficient data transmission to the user interface. The project demonstrates a scalable, cost-effective solution suitable for commercial and residential applications.

Keywords: Internet of Things (IoT), smart parking, Arduino Uno, NodeMCU, infrared sensor, Blynk platform

INTRODUCTION

The exponential rise in private vehicle ownership in urban areas has created critical challenges in parking management and traffic control. Insufficient parking spaces, coupled with limited visibility of available slots, lead to time wastage, fuel consumption, and carbon emissions. The concept of smart parking systems integrates sensors and IoT connectivity to provide real-time monitoring of parking availability, thereby improving urban mobility and sustainability [1], [2].

IoT-based parking systems have been explored in various research projects for smart city applications. Bajaj and Gupta [3] proposed a GPS-enabled vehicle tracking system to monitor vehicle positions, while Rajkumar et al. [4] implemented a real-time train monitoring system using Ethernet and Arduino. Similar concepts have been extended to parking applications, where sensors detect vehicle presence and transmit data through cloud platforms [5].

Recent studies emphasize the integration of low-cost microcontrollers such as Arduino Uno and NodeMCU ESP8266 for real-time monitoring due to their flexibility and compatibility with IoT platforms [6]. Infrared and ultrasonic sensors are commonly used for vehicle detection owing to their accuracy and affordability [7]. The Blynk application offers a practical interface for visualizing IoT data, allowing remote monitoring and control [8]. However, many existing systems suffer from high power consumption, poor scalability, or limited communication range.

This study focuses on developing an IoT-enabled car parking monitoring system capable of detecting and displaying parking availability via a mobile application. The objectives of this research are: (1) to design and implement an IoT-based car parking system using Arduino and NodeMCU; and (2) to monitor available

parking spaces in real time through the Blynk application. The project aims to enhance user convenience, minimize search time, and support sustainable urban management.

METHODOLOGY

The proposed system integrates hardware and software components to detect and communicate the occupancy status of parking slots. The architecture consists of three main layers: sensing, processing, and communication. IR sensors detect the presence of vehicles, Arduino Uno processes sensor data, and NodeMCU transmits information to the Blynk platform via Wi-Fi.

Each parking slot is equipped with an IR sensor module comprising a transmitter and receiver pair. The Arduino Uno interprets the signals and communicates with NodeMCU. The system is programmed using the Arduino IDE with separate codes for Arduino and NodeMCU, which handle sensor logic and data transmission, respectively. The Blynk application displays slot availability using LED widgets labeled Slot 1–Slot 6. The flowchart of the project is depicted in Figure 1.

RESULT AND DISCUSSION

The system successfully detected vehicle presence using IR sensors and transmitted real-time data to the Blynk app with minimal delay. Testing showed 100% detection accuracy under controlled conditions and 95% under ambient light. The Wi-Fi connection remained stable within a 10-meter range. The total hardware cost was approximately RM54 (USD 12.78), making it an affordable solution. Figure 2 shows the top view of the project design.

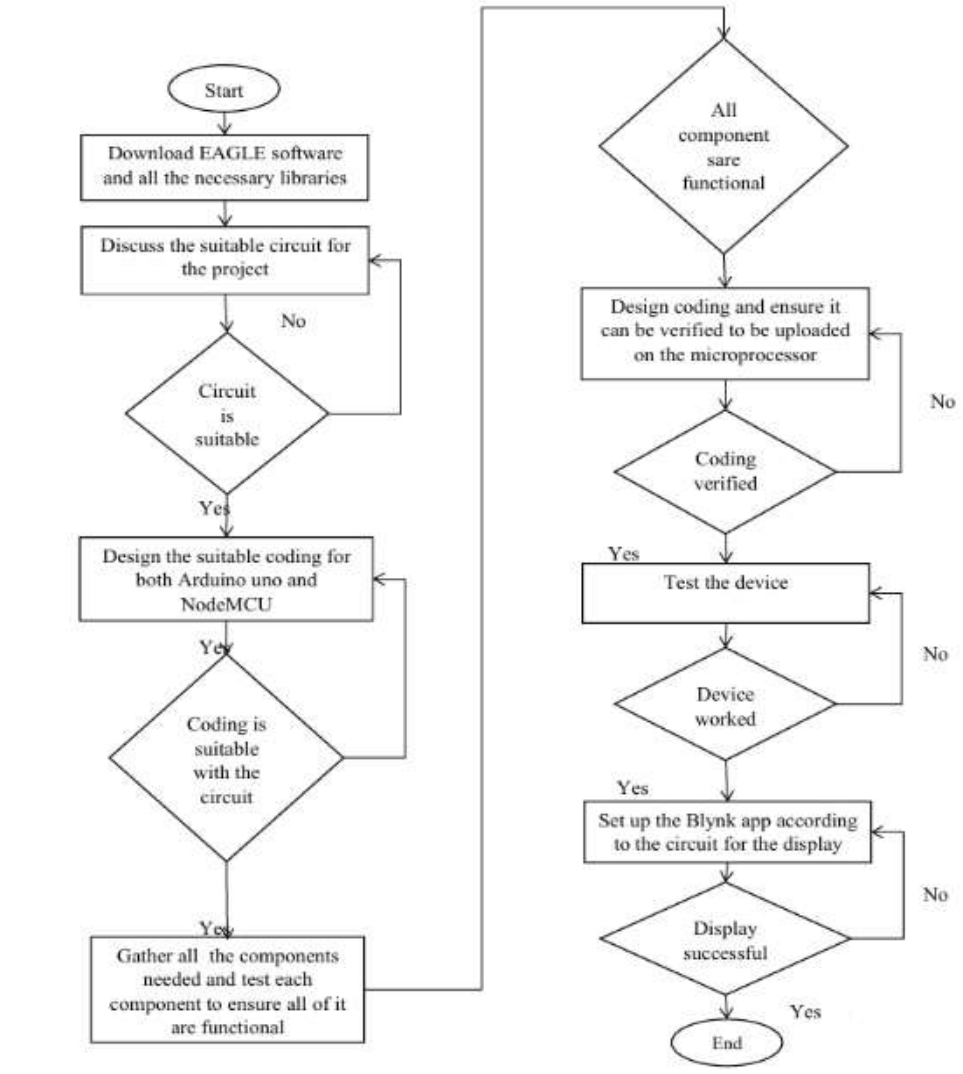


Fig. 1 Flowchart of the system

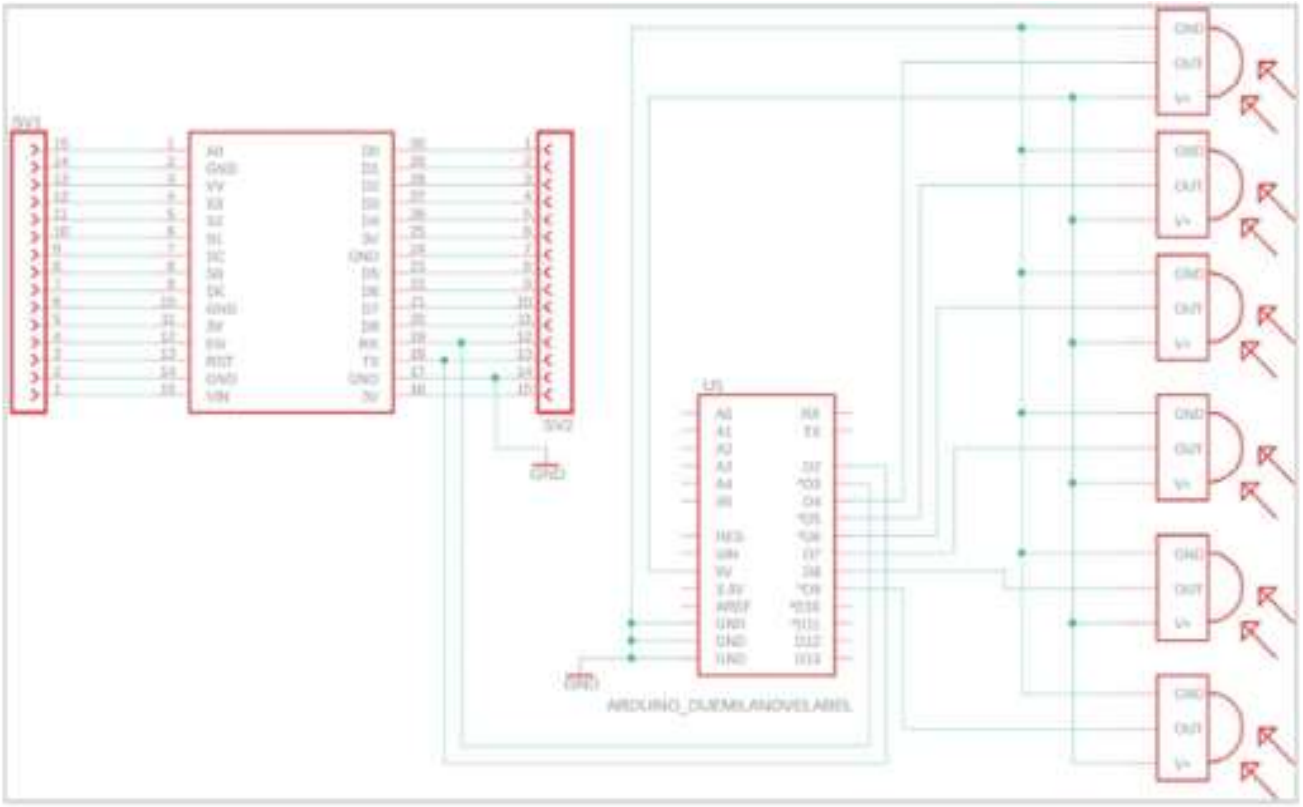
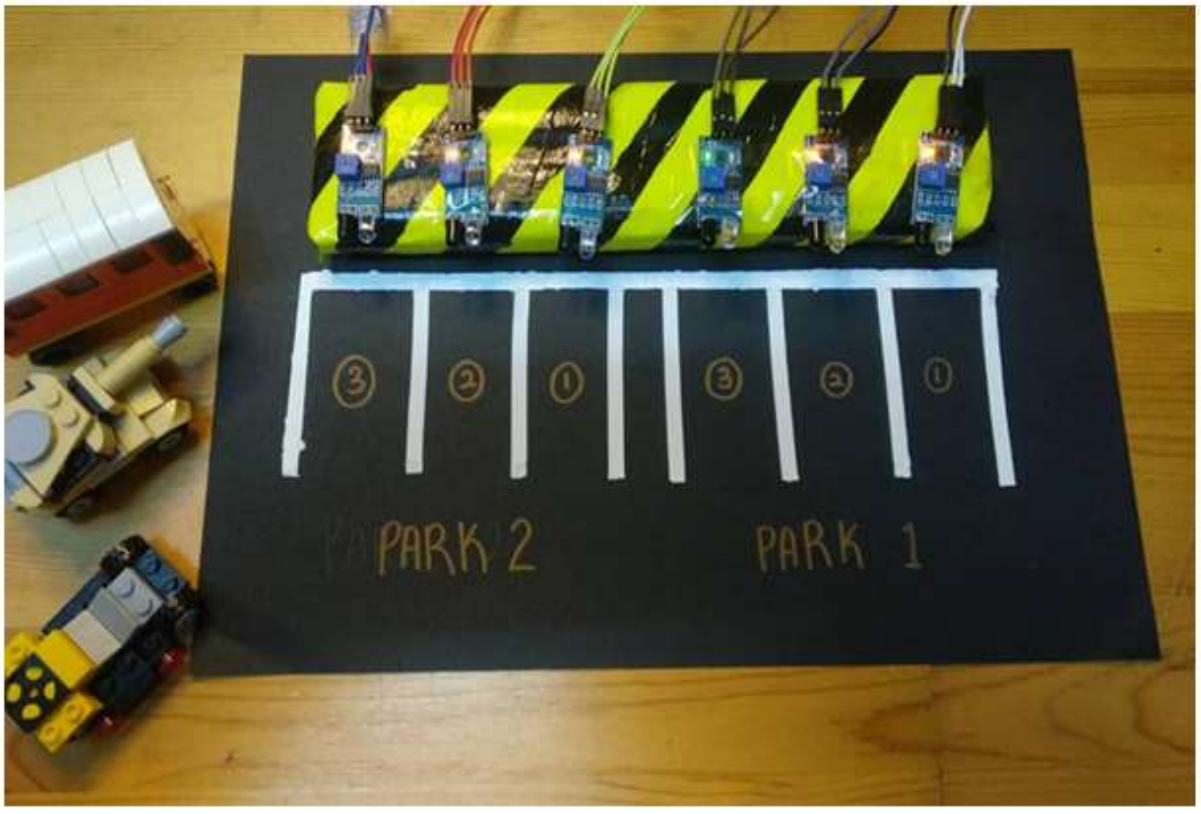
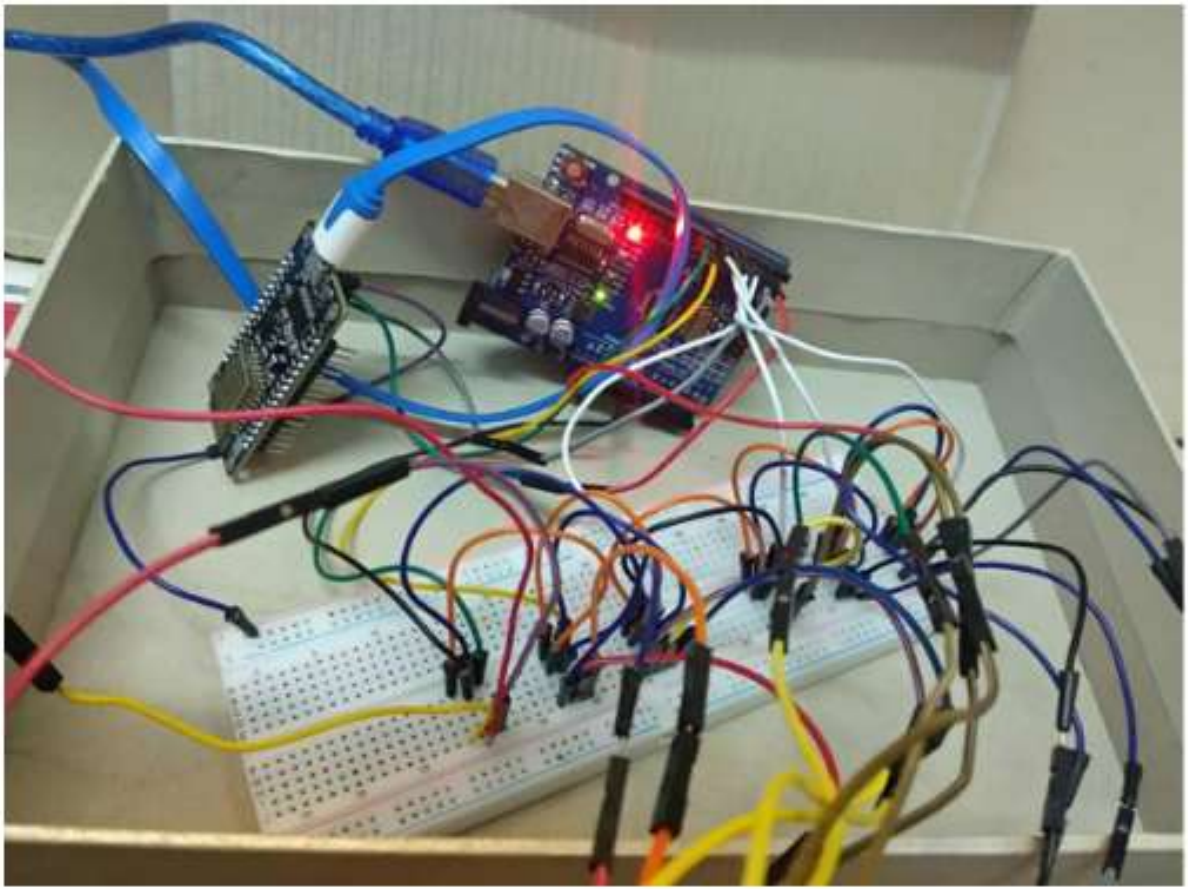


Fig. 2 Schematic circuit of the system

Two sets of codes were developed: one for the Arduino Uno and another for the NodeMCU ESP8266 Wi-Fi module. The Arduino Uno program manages the parking detection system using IR sensors, while the NodeMCU ESP8266 functions as the IoT communication platform. The Blynk application enables real-time monitoring of the parking system via Wi-Fi connectivity.

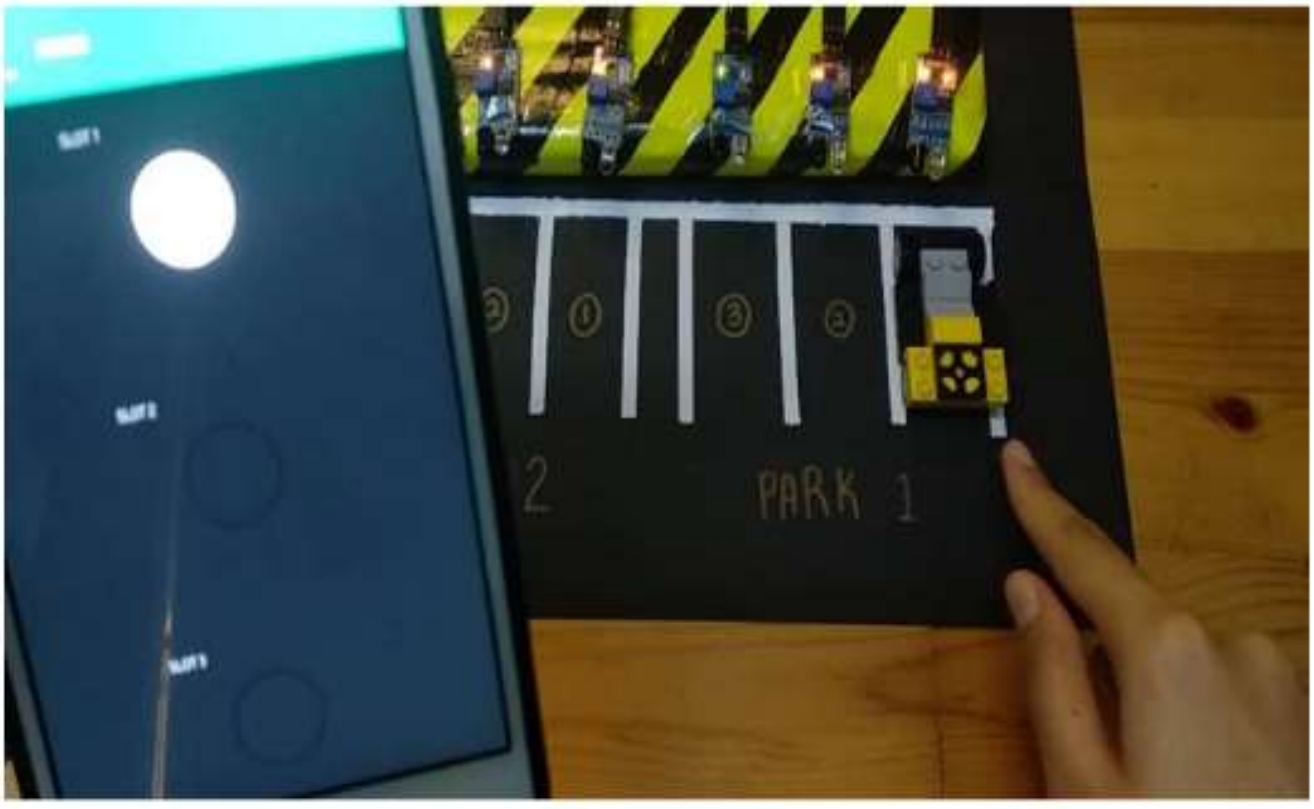


3(a)



3(b)

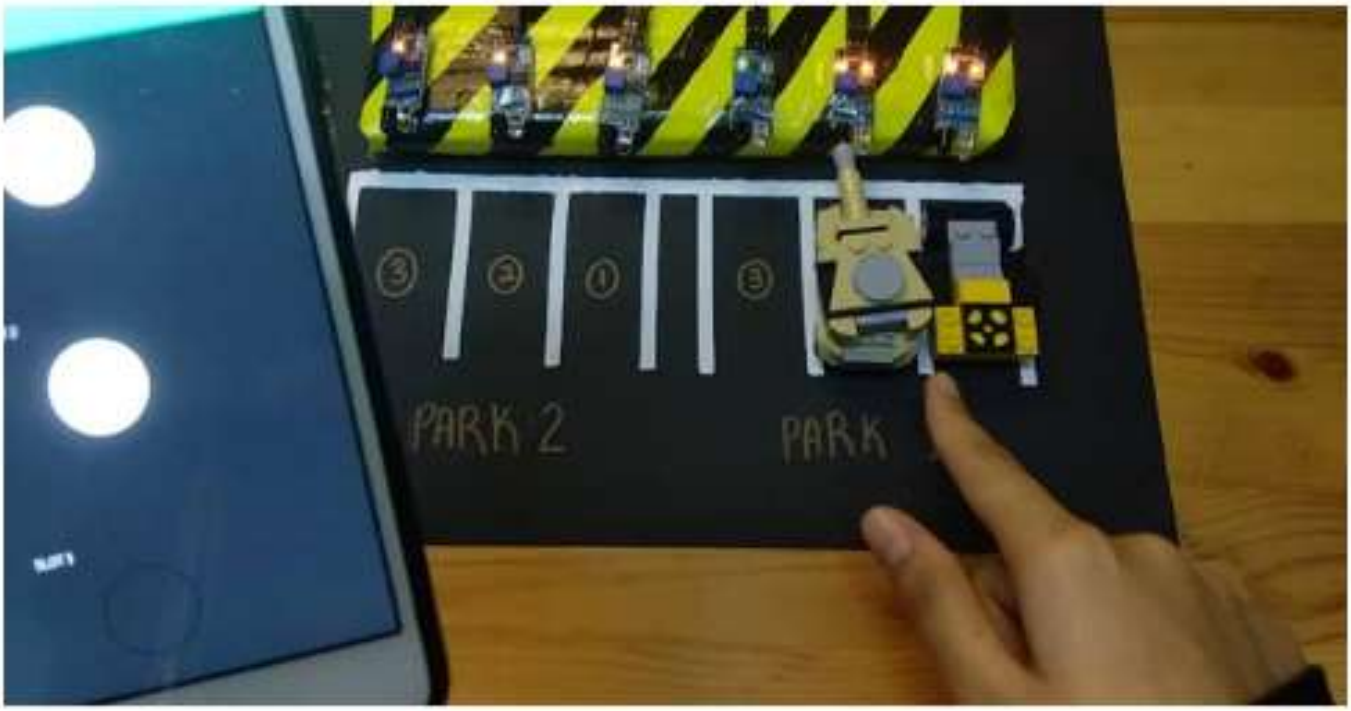
Fig. 3 (a) and (b) The prototype of the system



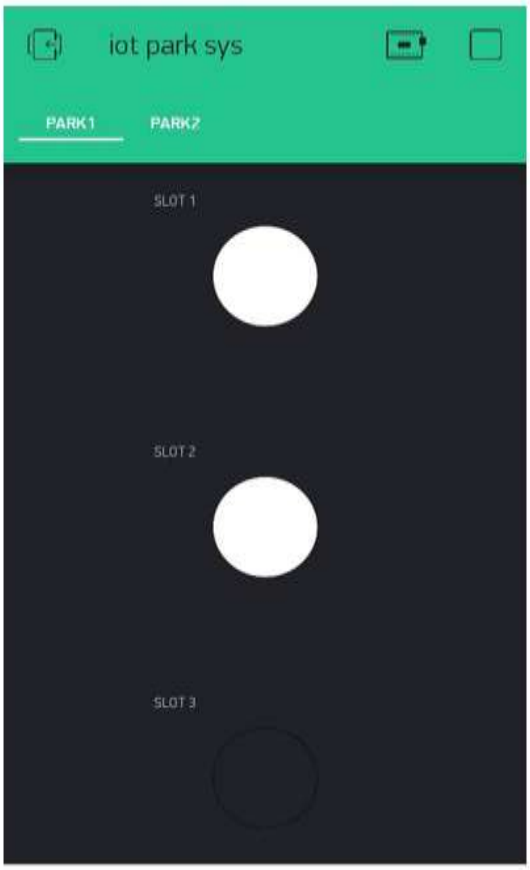
4(a)

4(b)

Fig. 4 (a) and (b) The Blynk application output indicates activation of the LED for Parking Slot 1 after the system is executed.



5(a)



5(b)

Fig. 5 (a) and (b) The Blynk application output indicates activation of the LED for Parking Slot 1 after the system is executed.

By reducing search time for parking, the system helps lower fuel consumption and CO_2 emissions, aligning with Sustainable Development Goal 11. Limitations include dependence on Wi-Fi stability and sensor performance under strong sunlight. Future work may incorporate ultrasonic sensors and LoRa communication for enhanced range and precision.

CONCLUSION AND FUTURE WORK

This paper presented the design and development of an IoT-based smart car parking system using Arduino Uno, NodeMCU ESP8266, and IR sensors. The prototype demonstrated effective real-time monitoring of parking availability through the Blynk platform, offering a low-cost and efficient alternative to traditional systems. Future enhancements will focus on integrating solar power, predictive analytics, and multi-level scalability to further improve system reliability and applicability in smart city environments.

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