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Research Article

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Efficient Parking Management through QR Technology

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Abstract Parking is an under-appreciated issue that requires considerable consideration. Here, we propose the concept of developing a parking system to lessen the need for labor. Each Android-compatible smartphone has the capacity to read QR codes and scan them to retrieve a wealth of data. Quick Response code is referred to as a QR code. Due to their uniqueness, QR codes are utilized to assign spaces in real-time. The system authorizes the vehicle by scanning the code of the one that is going to enter. After scanning, a space will be assigned to the user depending on availability and empty as soon as the vehicle exits the slot. By doing so, we will essentially use less complex technology and software to decrease human labor. This system will oversee authorization and spot selection. An online parking system that makes use of the ESP8266. A parking system is developed, this website allows the user to check vacancy spots. The device also assists in storing the user's information in a database, allowing for quick parking access, and thereby decreasing traffic congestion. The hardware is built with an ESP8266 and an infrared sensor. Furthermore, the system is managed by a website, which allows the user to keep track of changes regarding available parking spaces. To speak, a scalable and accurate database may be developed and hosted on a real-time application for data storage. Technology is an ideal companion for customers who want to check parking vacancy spots from faraway areas without wasting time and avoiding traffic congestion.

Keywords Parking Management, QR Technology

1. Introduction

In the world, rising traffic congestion has created a slew of issues, including a scarcity of parking spots and increased concern among drivers. In the face of a burgeoning population and the consequent surge in vehicle ownership, personal vehicles have become indispensable for navigating the demands of a fast-paced lifestyle. The increasing affordability of vehicles has led to a substantial rise in demand globally. Consequently, the need for adequate parking spaces has become more pronounced. However, despite the existence of sufficient parking infrastructure in large cities, challenges persist due to the scarcity of available spaces during peak hours. This often prompts individuals to hastily park their vehicles in nearby spaces, contributing to inconveniences and traffic congestion. Embracing technological solutions is pivotal in mitigating these challenges. The advent of IoT (Internet of Things) technology has revolutionized traffic management systems, particularly in the realm of car parking. IoT facilitates real-time connectivity between parking spaces and users through internet-enabled communication devices, addressing the evolving needs of urban spaces grappling with an influx of vehicles [6]. The integration of IoT in car parking management not only streamlines the detection of available spaces but also alleviates the chaotic practice of haphazard parking, thereby reducing traffic disruptions. As our world undergoes continuous modernization and socio-economic development, the application of IoT emerges as a crucial tool in enhancing the efficiency of parking infrastructure and ensuring a smoother urban mobility

experience. The disparity in the number of automobiles and available parking spaces has exacerbated traffic congestion and pollution. Many communities are attempting to address this issue by expanding parking spots, which are frequently located in parks and vacant lots. However, there is a scarcity of safe and up-to-date information on drivers who park in these places. To address these issues, a parking system is required. A system like this would make it easier for vehicles to find vacant parking spaces, decreasing traffic congestion and emissions. QR codes have emerged as a viable alternative since they can hold more information than regular barcodes. QR codes are two-dimensional matrix barcodes with a character limit of 7089. Mobile phones scan them, allowing users to access information or make transactions (Zhou & Li, 2014) [5]. Users of the planned parking system may use a website on their phones to determine the exact location of available parking spaces. Users can speed up the procedure when they arrive at the parking facility by going through the website. The QR code helps in getting user information and cross-referencing it with the database to enable quick access to available parking places. This simplified technique saves time and reduces parking hassles (Alsafery et al., 2018) [1]. Overall, implementing a parking system with QR codes decreases traffic congestion, enables simple access to parking spots, and minimizes time-consuming procedures connected with traditional parking techniques (Shaikh et al., 2016) [4]. A vast interconnected network facilitates the seamless communication of devices across diverse environments, allowing them to collect and share data during their operations. Devices, ranging from traffic lights to mobile phones, are equipped with embedded sensors, enabling them to carry out their functions effectively. The proliferation of IoT platforms ensures that sensors emit substantial amounts of data, fostering easy communication between devices. These IoT platforms serve as central hubs that accumulate and analyze the data, extracting valuable insights based on predefined instructions. The outcomes of these analyses are subsequently shared among devices to enhance user experiences. Notably, this entire system operates and manages itself within IoT platforms, requiring minimal to no human intervention, highlighting the self-sufficiency and efficiency achieved through IoT technologies [6]. This paper delves into the development of a cost-effective IoT-driven car parking management system, aiming to establish seamless communication between car owners and parking facilities. The research encompasses an examination of the economic feasibility for the urban populace, considering the affordability factor for a broad demographic. Additionally, the study scrutinizes energy consumption patterns throughout the year, providing a comprehensive analysis of the proposed IoT-based system's sustainability and efficiency. By exploring the intersection of technological innovation, economic accessibility, and energy considerations, this research contributes valuable insights to the realm of urban infrastructure management, particularly in addressing the challenges associated with parking solutions in city areas. Ullah and colleagues (2023) and (2024) eloquently present insights in four separate papers addressing manufacturing excellence, operational scheduling, and equipment efficiency. These contributions are crucial considerations for barcode pairing activities during device production [20,22,24,30]. Rahman et al. (2023) delves into the significance of cryptocurrency systems, particularly in the electronics sector, influencing the selection of devices extensively used in barcode pairing within plant operations [17,30]. Fayshal et al. (2023) emphasize environmental factors and safety risk assessments, significantly influencing considerations for a vehicle tracking system through barcodes [25,32]. Kamal et al. (2019) showcase evidence of RFID technology for warehouse management through an Android application, highlighting its profound impact on the electronics industry, especially in barcode tracking on the road [12]. Shakil et al. (2013) offer an informative process flow chart for a jute mill, enriching industry data and aiding barcode tracking research for parking facilities [21]. Hossain et al. (2023) discuss electricity generation from moving vehicles, proposing its potential application for ensuring machine continuity in a factory, aligning with the objectives of tracking and barcode management [16]. Molla et al. (2023) & (2024) underscore the importance of medical textiles with plantable and implantable options, serving as a focal point for future barcode technology research [31,37,39]. Mustaquim (2024) applies in two different papers regarding the remote sensing methods in land surface interpretation, contributing to the arrangement of barcode PCB boards and associated risk prediction [27,38]. So, everybody tries in different ways, but no one does in the way that we have implemented in this research.

2. Methodology:

Frequently, internet users are prompted to log in to websites using publicly shared devices, which inherently pose security risks due to potential malware infections or compromises like key-logger spyware. Users entering

their login details on such unsecure devices face the imminent threat of unauthorized access to their credentials. Consequently, there is a growing necessity for users to access websites without the need to input sensitive information on insecure devices. Even on secure devices, challenges may arise in manually entering credentials, especially on devices with limited input capabilities. The proposal advocates for the real-time identification of available parking zones in the vicinity and recommends QR code-based authentication through a mobile application, leveraging the widespread availability of smartphones. Upon scanning the QR code at the entrance, data will be transmitted to Google Firebase [8], where authentication will undergo verification, and sensor data will be systematically updated based on the car's engagement and disengagement status. This approach aims to streamline the parking process, enhance security through QR code authentication, and maintain an updated record of sensor data, fostering an efficient and technologically advanced parking management system. While secure authentication systems have been proposed, many require specialized hardware such as biometric readers or near field communication (NFC) devices. Moreover, even NFC devices may be vulnerable to compromise, exposing sensitive information. In efforts to enhance security, some websites implement secondary authentication mechanisms, like requiring users to utilize fobs or other second-factor devices. However, these devices often prove inconvenient for users to carry. Parvez et al. (2022) engage in a comprehensive discussion on ergonomic factors influencing worker efficiency in electronics plants and impacting vehicle tracking systems, where visualization systems have specific requirements [13,14]. Rahman (2015) explores the impact of supplier selection on the electronics sector, recognizing its significant role in product procurement for road transport tracking systems [11]. Rahman and colleagues (2023) implement machine learning algorithms, particularly focusing on predicting performance in the healthcare operations sector, especially in scenarios involving substantial amounts of big data. This study is deemed highly beneficial, laying a foundation for potential expansions in future research endeavors [18,19]. Molla et al. (2024) provide substantial insights into COVID data in the United States and globally, offering valuable information for adhering to COVID protocols in the development and maintenance of rules and regulations for barcode tracking in parking systems [23]. Noman et al. (2020) conduct a noteworthy project on data retrieval approaches, with coding technology playing a pivotal role in our research, specifically when adjusting barcode technology [28,29]. Ullah et al. (2024) utilize value stream mapping with a robust mathematical process, offering utility in research, especially in scenarios where extensive vehicle production is essential for parking and tracking systems [15]. Bazgir et al. (2023) interprets security system and Iot in cloud system which is utilized in our paper [35,36].

Hence, there is a desire to offer users secure, convenient, and efficient means to log in to websites. The IR Sensor detects whether a vehicle is inserted into the slot as shown in Figure 1. ESP8266 collects all sensor readings and sends them to the Wi-Fi module. Wi- Fi Modules get string data, which is then uploaded to the server. Thingspeek retrieves data from the system and displays it on a graph (Chatterjee et al., 2018) [2]. The proposed system is given below (Figure 1):

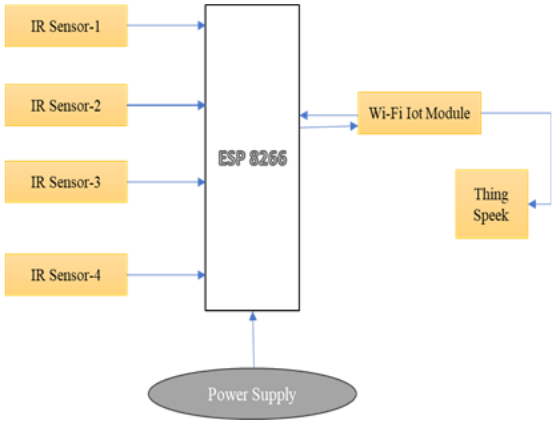

Figure 1: Block Diagram

The concept of "Online Parking with QR Code" leverages QR codes to streamline the parking procedure. Users log into the system's website and receive a unique QR code representing their allocated parking spaces. Upon entering the parking facility, users scan their QR code, prompting the system to retrieve their details.

Subsequently, users are directed to a suitable parking spot based on current availability. This efficient solution eliminates the need for manual interventions, saving time and enhancing the overall parking experience for users, as depicted in Figure 2.

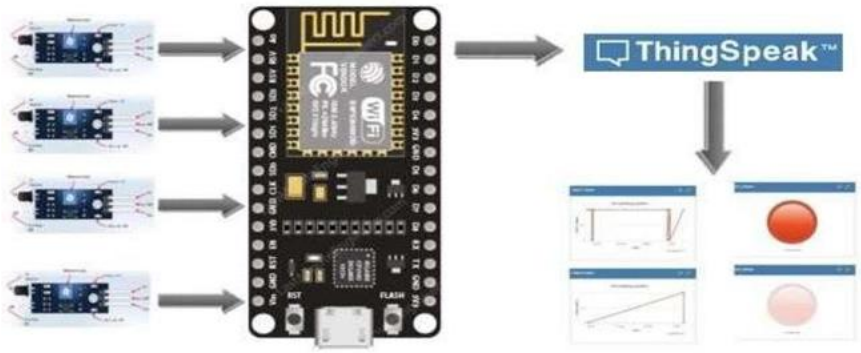

Figure 2: System Design & Architecture.

The infrared (IR) sensor is deployed within a parking space to ascertain the presence or absence of a parked car in that specific slot. The recorded values from the sensor are transmitted to the ESP8266, as illustrated in Figure 3. The utilization of the IR sensor in the parking slot involves the detection of a car's presence. The gathered data from the sensor is then transmitted to the ESP8266, as depicted in Figure 3. This paper introduces the utilization of NodeMCU ESP32 for sensor integration and data transmission to online databases, opting for its advantages over Raspberry Pi and Arduino Mega, primarily due to its cost-effectiveness and low power consumption. Notably, the ESP32 is preferred over ESP8266, attributed to its multiple AD converters, an additional CPU core, and the inclusion of a power-saving mode feature. The strategic selection of NodeMCU ESP32 for these functionalities enhances the efficiency and affordability of the proposed system, aligning with the pursuit of optimized performance and resource utilization in IoT applications [7]. In the context of parking space monitoring, this IR sensor serves the purpose of determining whether a car is currently occupying the designated slot. The data collected by the sensor is subsequently transmitted to the ESP8266, as showcased in Figure 3.

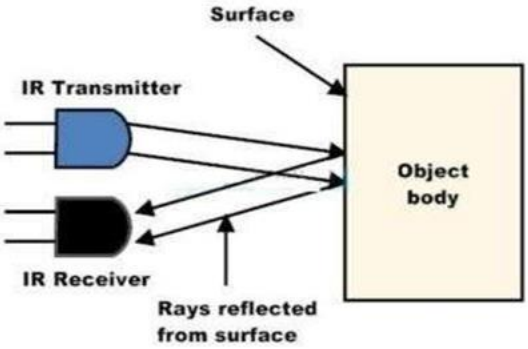

Figure 3: IR Sensor.

The seamless transfer of data from the controller to the server is achieved through the utilization of the Wi-Fi module, a pivotal component depicted in both Figure 4 and Figure 5. This wireless module functions as the conduit, facilitating the transmission of information from the controller to the server in an efficient and reliable manner.

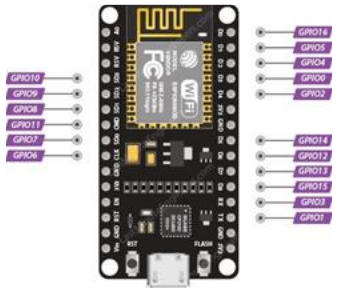

Figure 4: ESP8266 Wi-Fi Module

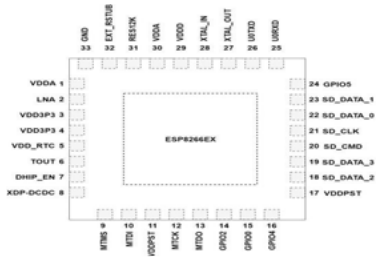

Figure 5: Pin Configuration of ESP8266

The data originating from the parking spot finds its repository on the Thingspeak website, where the stored values are visually represented through a graph. ThingSpeak, serving as an open-source Internet of Things (IoT) application and API, facilitates the storage and retrieval of data from devices through the HTTP protocol over the Internet or a Local Area Network (LAN). ThingSpeak further enables the creation of sensor logging applications, a capability vividly illustrated in Figure 6. This versatile platform empowers users to develop applications for seamless tracking and visualization of sensor data, contributing to the robust functionality of IoT ecosystems.

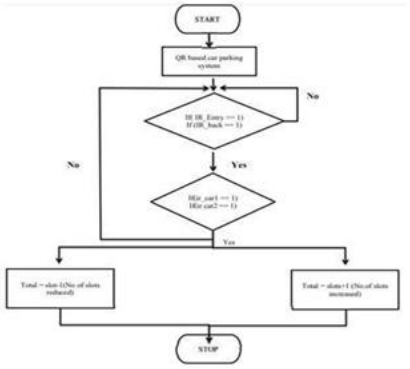

Figure 6: Flowchart for development of sensor in the app

3. Results & Analysis:

This circuit is efficient for parking management utilizing QR code technology. By scanning QR codes, consumers may simply access parking spots, minimizing time- consuming procedures. The renovation increased parking efficiency, decreased traffic congestion, and improved customer experience as shown in Figures 7-9 (Luque- Vega et al., 2020) [3].

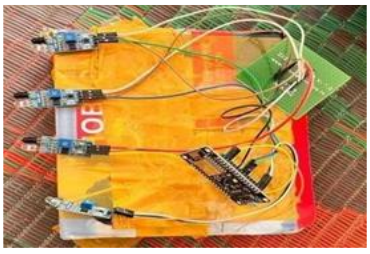

Figure 7: Hardware Demo

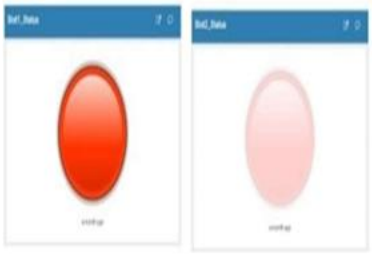

Figure 8: Showing Slot Filled and Occupied.

In this system, QR code pairing is utilized for the monitoring of parking slots through the Internet of Things (IoT). This suggests an innovative approach where QR codes are employed to facilitate and enhance the monitoring process within a parking environment, leveraging the capabilities of IoT for efficient and connected parking slot management.

Create-ID	Entry ID	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6
1/1/2024	1		1 Web App				
1/2/2024	2		0	Web App			
1/3/2024	3					1 Web App	
1/4/2024	4		1 Web App				
1/5/2024	5						
1/6/2024	6		0	Web App			
1/7/2024	7						
1/8/2024	8					0	Web App
1/9/2024	9						
1/10/2024	10						
1/11/2024	11		1 Web App				
1/12/2024	12						
1/13/2024	13		0	Web App		1 Web App	
1/14/2024	14					0	Web App
1/15/2024	15		1 Web App				
1/16/2024	16		1 Web App				
1/17/2024	17						
1/18/2024	18						

Figure 9: Graph Representing Time and Duration of the Vehicle Parked.

4. Conclusion:

The "QR Code-enhanced Online Parking" initiative introduces a user-friendly solution for exploring parking options in specific locations, simplifying the process of finding an appropriate parking space. Utilizing technology, it visually displays the availability of parking spaces, allowing users to swiftly identify their designated area. This eliminates the manual aspects of parking management, making parking facilities more user-friendly. The incorporation of IoT-based automated monitoring adds to the overall efficiency. However, the successful integration of parking solutions requires collaboration among diverse stakeholders, including operators, governmental bodies, payment providers, and technology firms. By addressing both current needs and future challenges, parking can transform into a seamless and empowering experience rather than a cumbersome task. The incorporation of IoT-based automated monitoring further enhances the overall efficiency and effectiveness of parking facilities. This not only meets current demands but also prepares for future challenges in parking management. The initiative's success relies on collaborative efforts from various stakeholders, including operators, governmental bodies, payment providers, and technology firms. This collective approach ensures a holistic and integrated parking solution that caters to the diverse needs of both providers and users. By addressing the complexities associated with parking, this initiative transforms it from a burdensome task into an empowering experience. The user-centric approach, coupled with technological advancements, establishes a foundation for a parking ecosystem that aligns with contemporary expectations. As the "QR Code-enhanced Online Parking" initiative continues to evolve, it holds the potential to reshape urban mobility, making parking not just a necessity but a seamlessly integrated and enhanced aspect of daily life.

5. Future work:

For the future development and enhancement of the "QR Code-enhanced Online Parking" initiative, it is recommended to focus on several key aspects. Firstly, consider collaborating with urban planning authorities and technology providers to integrate smart infrastructure elements, such as sensors and cameras, for real-time data collection and improved accuracy of parking availability information. Expansion to new geographical locations and diverse urban settings should be explored to ensure scalability and relevance. Implementing enhanced security measures, establishing a user feedback mechanism, and fostering collaborations with mobility service providers are crucial for continuous improvement and comprehensive urban transportation experiences. Additionally, ensuring accessibility, launching educational campaigns, and staying abreast of technological advancements contribute to the initiative's success. Sustainability integration, continuous technological upgrades, and strict regulatory compliance will further solidify the initiative's position as a cutting-edge and user-centric solution, optimizing urban parking systems and enhancing the overall urban mobility experience.

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