IOT based Smart Parking System using PIR Sensors

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***Abstract*— This paper presents an advanced parking management system employing Arduino and infrared sensor technology to automate parking slot allocation and monitoring. The proposed system enhances operational efficiency and user experience by utilizing Arduino as the central control unit, integrated with infrared sensors for vehicle detection. Upon detecting a vehicle, the system activates a servo motor to open the barrier for entry. When the vehicle departs, the system detects this and closes the barrier, indicating slot availability. This automation minimizes human intervention, reduces errors, and ensures seamless operation. Additionally, real-time monitoring provides administrators with insights into parking occupancy trends, facilitating data-driven decision-making. The implementation of this system optimizes space utilization and offers a user-friendly experience for both drivers and parking facility managers.**

Keywords*— *Arduino, infrared sensors, parking management, automation, real-time monitoring, occupancy trends.

I. INTRODUCTION

The invention of the automobile in the late 19th century marked a significant turning point in human history. Pioneers like Karl Benz and Henry Ford revolutionized transportation by making cars accessible to the general public. Benz's creation of the first practical automobile in 1885 and Ford's introduction of the Model T in 1908 were monumental steps that transformed how people traveled and lived. As cars became more popular, cities and towns had to adapt to this new mode of transport, leading to the development of early car parking systems.

In the early days of automobiles, parking was a relatively straightforward affair. There were fewer cars on the road, and people could often park wherever there was space, such as on streets or in vacant lots. However, as car ownership grew, especially in urban areas, the demand for organized parking systems became apparent. By the mid-20th century, cities began to implement structured parking solutions, including parking meters and dedicated parking lots, to manage the increasing number of vehicles. Parking meters, introduced in the 1930s, were among the first attempts to regulate parking by charging for the time a vehicle occupied a space. Multi-story parking garages soon followed, providing more efficient use of space in densely populated areas.

Today, the number of cars on the road is staggering. According to recent statistics, global car sales have continued to rise, with millions of new vehicles being sold each year. In 2023 alone, over 80 million cars were sold worldwide, reflecting the sustained demand for personal transportation. This surge in car ownership, driven by factors such as population growth, urbanization, and economic development, has put immense pressure on existing parking infrastructure.

The rapid increase in car ownership has highlighted the need for more efficient parking systems. Traditional parking methods often fall short in meeting the demands of modern urban environments. Problems such as traffic congestion, inadequate parking space, and inefficient parking management are common in many cities. These issues not only frustrate drivers but also have broader implications for urban mobility and environmental sustainability. For instance, the time spent searching for parking contributes significantly to traffic congestion and increased fuel consumption, exacerbating air pollution and greenhouse gas emissions.

Efficient parking management systems are essential to address these challenges. Modern technology offers promising solutions to optimize parking processes and enhance the user experience. Automated parking systems, which leverage advancements in sensors, microcontrollers, and real-time data processing, can significantly improve how parking facilities operate.

In this paper, we introduce an advanced parking management system that utilizes Arduino and infrared sensor technology. Our system is designed to automate parking slot allocation and monitoring, providing a more efficient and user-friendly parking experience. Arduino, a popular open-source microcontroller platform, serves as the central control unit for our system. It is known for its versatility and ease of integration with various sensors and actuators, making it an ideal choice for this application.

Infrared sensors are strategically placed at entry and exit points of the parking facility to detect the presence of vehicles. When a vehicle approaches the entrance, the first sensor detects it, and the Arduino processes this data to trigger a servo motor that opens the barrier, allowing the vehicle to enter. Once the vehicle has passed through and parked, another sensor confirms its entry, and the barrier closes automatically. Similarly, when a vehicle exits the facility, the departure is detected, and the barrier is closed again, updating the availability of the parking slot.

This automated system minimizes human intervention, reducing the potential for errors and improving the overall efficiency of parking operations. Manual parking management often leads to mistakes, such as incorrect ticketing or failure to update slot availability. By automating these processes, our system ensures accurate and reliable parking management.

Furthermore, the system offers real-time monitoring capabilities. Data on parking occupancy can be transmitted to a central monitoring system, providing valuable insights into parking trends, such as peak usage times and average parking durations. This information helps facility administrators

make informed decisions about resource allocation, pricing strategies, and future infrastructure developments.
An additional advantage of our system is the potential for integration with other smart city initiatives. As urban areas increasingly adopt smart technologies to improve services and quality of life, our parking management system can be a key component. For instance, integrating with traffic management systems can help reduce congestion by guiding drivers to available parking spots, and combining with payment systems can streamline the billing process for a seamless user experience.
Moreover, the environmental benefits of an efficient parking system should not be overlooked. By reducing the time spent searching for parking, our system helps lower vehicle emissions, contributing to cleaner air and a healthier urban environment. This aligns with broader sustainability goals and the push for greener cities.
In conclusion, our advanced parking management system, utilizing Arduino and infrared sensor technology, addresses the pressing need for efficient parking solutions in modern urban environments. By automating key processes and providing real-time monitoring, our system optimizes space utilization, enhances operational efficiency, and delivers a seamless user experience. This paper will detail the design, implementation, and benefits of our proposed system, demonstrating its potential to revolutionize parking management in cities worldwide.

II. LITERATURE SURVEY

In today's world, population growth has led to more cars on the road, causing traffic and parking shortages. Illegal parking poses security risks. This paper [1] introduces an Intelligent Prepaid Car Parking system using RFID technology. It aims to solve parking space and vacancy issues while ensuring car safety. The system reduces manual work, making it more efficient. Tested on Xilinx Vivado 15.4, it uses minimal resources: 0.07% LUT, 0.03% Flip flops, 14.5% IO's, and 3.2% buffers.

This paper [2] presents an IoT-based smart parking system as a solution to the shortcomings of traditional parking systems. It consists of parking management and user applications, along with an IoT platform deployed at both parking slot and parking lot levels. Using IoT hardware, the system tracks slot availability and vehicle movements. Crowdsensing from users and staff helps minimize sensor usage. Implemented at X University, the system receives high usability scores of 91 from staff and 80.14 from users, indicating its effectiveness and user-friendliness.

This paper [3] introduces an automated parking system to alleviate the challenges of manual parking methods. Drivers can now easily identify vacant parking spots and their numbers before entering, thanks to monitor screens at entry gates. Only authorized individuals with RFID tags are granted access based on parking space availability. Moreover, a convenient parking fee management system allows payments through the same RFID tag, functioning as a rechargeable parking credit card.

The paper [4] addresses the costly stage of waste collection and transportation in waste management programs. It discusses existing solutions and proposes a new IoT-based approach. This method involves using infrared sensors to collect real-time data from waste bins and Raspberry Pi2Development Board to relay this information to waste managers. With this data, managers can optimize collection scheduling and routing processes efficiently.

An innovative approach to traffic management using IoT is proposed in this paper[5], Infrared sensors, and Image Processing for greater efficiency. Unlike traditional systems, our solution dynamically adjusts traffic signal timings based on real-time data from IR sensors. Implemented at a single junction as a Proof-of-Concept, the system utilizes Wi-Fi transmission to relay sensor data to a Raspberry Pi controller, which orchestrates signal operations. Users receive signal status updates on their mobile devices, enhancing overall traffic flow management.

This paper [6] addresses the pressing issue of traffic congestion in Dhaka city due to inadequate parking systems. We aim to mitigate this problem by developing a smartphone-based car parking model. Our prototype reservation-based system helps users locate available parking spots nearby. Additionally, we've created a Java SE application to manage parking details for different users. This solution aims to minimize traffic jams and provide efficient parking facilities in Dhaka city.

This paper [7] addresses the significant problem of limited parking spots in urban areas by introducing an IoT-based smart parking system for large parking lots. The system efficiently manages parking by providing real-time information on available parking slots via a mobile application, reducing congestion for parking seekers. Utilizing Internet of Things (IoT) technology, a cloud-based solution guides users to the nearest available parking spot, enhancing overall parking system management.

A prototype module to simplify the experience of finding free parking spaces for drivers is proposed in this study [8]. It integrates Arduino Uno, Ultrasonic sensor, LCD display, servo motors, push buttons, and an Android application. The Ultrasonic sensor detects free or occupied parking spaces by measuring object distance and motion. This information is transferred to the Android app via Bluetooth, allowing users to find available parking slots before arrival, reducing congestion and optimizing parking efficiency.

This paper [9] highlights the need for a smart outdoor parking system in urban areas due to increasing population and vehicle dependency. Existing manual parking systems cause congestion and accidents. The proposed solution utilizes IoT and weighbridge load sensors to create an organized, timely, flexible, and safe parking system for public places like malls and parks. This innovation aims to reduce traffic and enhance the parking experience in smart cities.

This paper [10] introduces a car parking detection mechanism using ultrasonic sensors integrated with Internet of Things (IoT) technology. It enables real-time monitoring of parking slot status, allowing users worldwide to access information on available parking spaces. Data from the ultrasonic sensor is transmitted via Wi-Fi module (ESP8266) to an IoT platform like thingspeak.com using HTTP, facilitating easy data visualization and accessibility for users.

This paper [11] highlights the growing importance of smart car parking technology in both developing and developed countries. It emphasizes the significance of leveraging the Internet of Things (IoT) to connect and automate data collection from various devices, enabling efficient smart parking systems. The proposed innovative algorithm enhances the efficiency of existing cloud-based smart parking systems and introduces a network architecture based on IoT. This structure utilizes users' Global Positioning System (GPS) to automatically find free parking spaces, reducing waiting times and increasing the probability of successful parking.

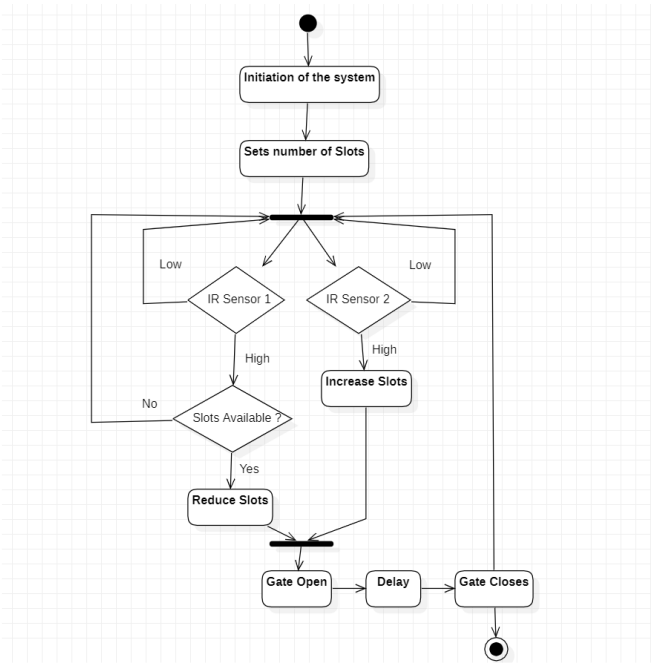
This paper [12] addresses the inefficiencies of traditional parking systems by proposing a Smart Parking & Energy Management solution for multi-storied office parking areas. Leveraging Internet of Things (IoT) technology and advanced sensors from Honeywell, the system streamlines parking processes. Unoccupied spaces are indicated using lamps, guiding users to available spots without the need for manual searching. Occupied spaces are stored in the cloud, directing incoming vehicles to empty spots. Automated light control reduces energy usage and enhances aesthetics, improving user convenience and time efficiency.

This paper [13] delves into the architecture and design of an Arduino-based car parking system. The fundamental rule is the authorization of the driver or user, which is facilitated through an authorization card containing vehicle details. If the user is authorized and parking space is available, the parking gate opens, granting access. Conversely, unauthorized users are denied entry. Upon successful parking, a mobile notification is sent to the user. This system addresses urban parking challenges, enhances vehicle security, and facilitates parking in multi-floored structures by indicating free space availability on each floor.

This paper [14] aims to introduce a simple automatic car parking allocation system utilizing basic components like microcontrollers to address parking allocation challenges. Traditionally, manual supervision is required in shopping complexes and multi-store buildings, leading to complex parking processes. The proposed system integrates IR sensors at parking spaces to detect vehicle presence, LED notification boards to display available slots, and displays to direct drivers, streamlining the parking process and reducing congestion at entry points. Additionally, a gate with a servomotor controls vehicle access based on information from IR sensors at entrances and parking slots.

This paper [15] introduces a smart parking system using IoT technology. It aims to enhance parking efficiency by determining slot availability for registered or reserved vehicles. The system employs various sensors, including ultrasonic and IR sensors, controlled by an Arduino microcontroller and connected to a cloud server. Through a mobile app, users can locate parking spaces in real-time. The system dynamically allocates parking slots, optimizing vehicle parking without rigidity.

III. PROPOSED MODEL



A. ARDUINO:

Arduino is an open-source electronics platform based on easy-to-use hardware and software. It consists of a microcontroller, which is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. The platform is designed to be accessible to everyone, from beginners to advanced users, allowing them to create interactive projects with ease.

Arduino boards can read inputs – such as light on a sensor, a finger on a button, or a Twitter message – and turn them into outputs – like activating a motor, turning on an LED, or publishing something online. Users write a set of instructions for the microcontroller to follow using the Arduino programming language (based on Wiring) and the Arduino Software (IDE) based on Processing.

Arduino is chosen for its user-friendly platform, flexibility, and cost-effectiveness. It seamlessly interfaces with sensors and actuators, facilitating the development of the automated parking system. With its open-source nature and extensive community support, Arduino accelerates project development and innovation. It enables real-time data processing, essential for dynamic management of parking slots. Overall, Arduino serves as the central control unit, streamlining the integration of components and ensuring efficient operation of the parking system.

B. SENSOR:

A Passive Infrared (PIR) sensor is a widely used electronic sensor that detects motion by measuring changes in infrared (IR) radiation levels emitted by objects in its field

of view. Infrared radiation is a form of electromagnetic radiation with wavelengths longer than visible light, typically emitted by warm objects such as humans and vehicles. PIR sensors are called "passive" because they do not emit any energy themselves but instead detect the infrared radiation naturally emitted by objects.

PIR sensors consist of two main components: the pyroelectric sensor and a Fresnel lens. The pyroelectric sensor can detect changes in infrared radiation levels, while the Fresnel lens focuses the infrared radiation onto the sensor to improve its sensitivity. When a warm object moves within the sensor's field of view, the amount of infrared radiation changes, causing the sensor to generate a small electrical signal. This signal is then processed to determine whether there has been motion in the area.

In this paper, we incorporate two PIR sensors to effectively manage the availability of parking slots. The first PIR sensor is strategically placed at the entrance of the parking area. Its primary function is to detect the entry of vehicles into the parking lot. Upon detecting an entering vehicle, this sensor sends a signal to the Arduino microcontroller, which then decrements the count of available parking slots by one. This mechanism ensures accurate tracking of occupied slots.

The second PIR sensor is positioned at the exit of the parking area. Its role is to detect vehicles leaving the parking lot. When an exiting vehicle is detected, the sensor transmits a signal to the Arduino, which increments the count of available parking slots by one, reflecting the newly freed space.

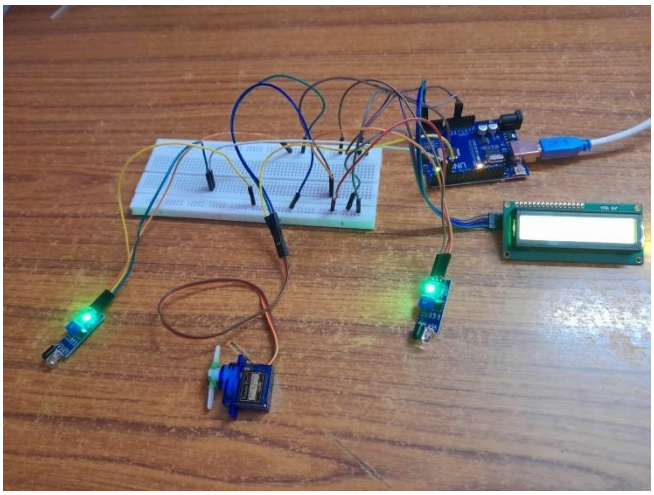
The integration of these PIR sensors ensures efficient management of parking slot availability. The sensor at the entrance continuously monitors for incoming vehicles, and when a vehicle is detected, it signals the Arduino to reduce the count of available slots. Conversely, the sensor at the exit monitors for departing vehicles, and upon detection, signals the Arduino to increase the count of available slots. This dynamic adjustment helps in maintaining an accurate count of available parking spaces, ensuring that drivers have real-time information about parking availability.

C. SERVO MOTOR:

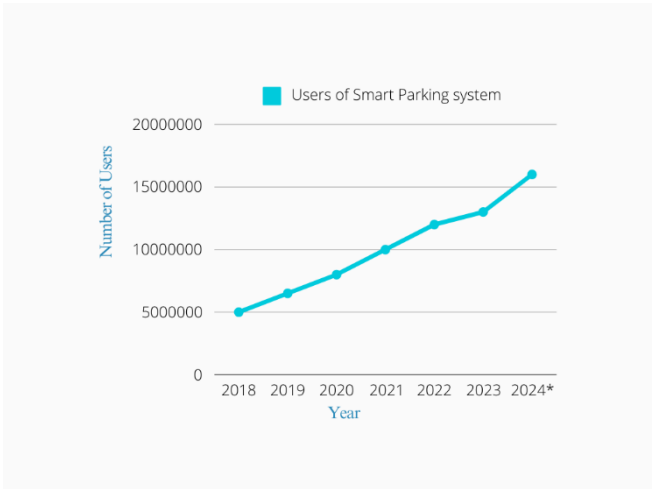
A servo motor is a rotary actuator that allows for precise control of angular position, velocity, and acceleration. It consists of a motor coupled with a feedback mechanism, typically a potentiometer or an encoder, which provides positional feedback to the control system. Servo motors are widely used in various applications requiring accurate and controlled movement, such as robotics, industrial automation, and model aircraft.

In this project, a servo motor is employed to control the barrier or gate mechanism that regulates access to the parking area. Its precise control capability ensures smooth and accurate movement of the barrier, allowing for efficient management of parking slot availability. By integrating the servo motor into the automated parking system, the project achieves dynamic control over entry and exit points, enhancing user experience and optimizing space utilization.

IV. RESULT



Upon successful connection, light will be light up in the LCD module and one out of the two lights in the IR sensors will light up denoting power supply and successful connection. In the figure(see 7.1) if the left most IR sensor, detects motion of any vehicle, it will activate the servo motor and will in turn reduce the number of parking slots available. When the number of parking slots reduce to 0, the servo motor will not activate even if the first infrared sensor detects an object. The second infrared sensor helps in increasing the number of slots available as each time this sensor detects an object, it will increase the number of parking slots available thereby activating the servo motor.



The tabulated data illustrates a significant upward trend in the adoption of smart parking systems globally from 2018 to 2024. Starting with an estimated 50 million users in 2018, the number of users steadily increased, reaching approximately 160 million by 2024. This growth reflects the increasing recognition and adoption of smart parking solutions to address the challenges posed by urbanization, traffic congestion, and parking space shortages. The continuous rise in the number of users underscores the effectiveness and popularity of smart parking systems in optimizing parking management, reducing search times, and enhancing the overall urban mobility experience.

V.CONCLUSION

In conclusion, the smart car parking system provides a best alternative solution for the manual car parking systems using cost effective measures and ensuring that the system works for perfection. This also have the capabilities to fulfil the requirements of great smart cities in general on the basis of parking. Implementing this system won't require much maintenance.

For future enhancements, the system for parking could be enlarged to multistorey parking. Each storeys's gateway can have a microcontroller along with sensors to multiply the original use of the system, The second feature to be added will be usage of RFID tags to allow only authorized cars or employing a payment system based on RFID within the cars. The next feature includes using a camera sensor to identify tags plastered on the car's windshield like fast tags to maintain pay and park systems.

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