Artificial Intelligence-Enabled Smart Parking System

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Abstract The aim of this study is to explore the development and integration of a smart parking system enabled by advanced AI, which relies on Internet of things (IoT) technologies. The intent behind this system is to enhance the utilization of parking spaces while uplifting driver experience, all possible through delivering dynamic updates regarding parking availability. The technical infrastructure employed for building the system revolves around an amalgamation of smart sensors and cameras using IoT interactions to collect data associated with parked vehicles. This information gets subsequently processed by sophisticated AI algorithms that offer up-to-the-minute details about available parking spots stored in a prevalent database. Further, owing primarily to the technology's highly functional characteristics, each occupant status predictably ascertains effective insights into plausible available space during driving, via display boards or mobile-based applications. After conducting a comprehensive review, the suggested smart parking system has been found to surpass traditional parking systems in critical areas such as accuracy, dependability, and efficiency. As a result of this new system being utilized, traffic congestion will significantly decrease, resulting in a noticeably improved parking experience and higher park management revenues. One profound advantage of the proposed system is that it has the capability of collecting real-time data on available parking spaces. The benefit of having access to this data is that car owners are guaranteed shorter searches. This study offers ideas for additional study and development in this field and demonstrates how AI with Internet of things technologies might enhance urban transit networks. By improving parking efficiency and giving drivers a better parking experience, the adoption of an "artificial intelligence-enabled smart parking system" offers an opportunity to revolutionize the parking sector.

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1 Introduction

Conventional parking structures are sometimes faulty and may frequently result in angry motorists circling for what may seem like hours. This issue requires a fix, which prompted the creation of intelligent parking management systems that make the most use of parking spots by using cutting-edge technology like AI and IoT. The automated parking system can deliver precise and current details on the availability of parking by using AI algorithms and immediate information processing. By reducing traffic congestion and improving parking efficiency, this technology will help drivers by making parking easier. Numerous studies have contrasted smart parking systems that make use of AI and IoT technology against conventional parking systems. These studies have demonstrated an unambiguous benefit of intelligent systems over their conventional counterparts in terms of accuracy, reliability, and efficiency.

2 Literature Review

It is clear from reading up on smart parking systems that combining the Internet of things and artificial intelligence may significantly enhance parking management. Many approaches, including predictive analytics, machine learning, and image processing, have been suggested in the study as ways to create these systems. However, current studies possess certain limitations; there still needs to be a holistic solution that integrates all components. Therefore, future research endeavors should prioritize enhancing accuracy and dependability by incorporating various data sources.

The research introduces a novel smart parking algorithm that considers driver behavior as well as parking traffic predictions. The authors begin by reviewing the existing literature on smart parking algorithms, emphasizing the shortcomings of present techniques. They then discuss their proposed system, which employs machine learning techniques to forecast parking behavior using historical data and real-time traffic statistics. The method is tested with simulations, and the findings reveal that it surpasses previous algorithms in terms of parking success rate, waiting time, and journey time. This paper contributes significantly to the advancement of efficient and sustainable smart parking systems [17]. The paper describes a power management method for EV parking lots. The authors conduct a literature study on EV power management algorithms and emphasize the shortcomings of current techniques. They present a new method that optimizes charging schedules depending on user preferences and electricity pricing by using fuzzy logic inference. The method is tested using simulation tests, and the findings suggest that it can lower charging costs while also increasing user satisfaction. This research contributes significantly to the creation of long-term and cost-effective EV charging infrastructure [14]. The study proposes a cloud-based smart parking system based on Internet of things (IoT) technology. The authors conduct a literature study on smart parking systems and identify the shortcomings of existing techniques. They propose a novel system that monitors parking places with IoT sensors and analyzes and processes parking data in the cloud. In addition, the system includes a smartphone application that allows users to find available parking spaces in real time. Experiments are used to evaluate the system, and the findings suggest that it can increase parking efficiency and user happiness. This work contributes significantly to the advancement of smart city infrastructure [21]. The study describes a novel approach to smart parking based on fog computing. The authors review the existing research on smart parking systems and fog computing, stressing the limitations of present techniques. They propose a new system that uses fog computing to handle parking data in real-time and reduce latency. The system also contains machine learning techniques for predicting parking behavior and optimizing parking space distribution [25]. The impact of public transportation on parking behavior, the possible benefits of a new public transportation line in reducing parking demand, and a methodology for measuring its impact are discussed [11]. Parking structures and administration, parking problems in smart towns, and possible advantages of intelligent parking systems are all explored. The research places a strong emphasis on the requirement of integrating parking options with other initiatives related to smart cities, including automated parking structures and real-time data on parking systems, in addition to alternative methods of designing and managing parking facilities [23]. The challenges involved in charging electric cars (EVs) in intelligent parking structures, as well as the possible advantages of ideal charging regulation. The study discusses several strategies for optimum charge control, including algorithmic heuristics and model prediction oversight, and highlights the relevance of incorporating charging management into other intelligent parking solutions [2]. A theoretical framework for a more effective and automated smart vehicle parking solution using IoT-enabled networks is provided after discussing the limitations of current smart parking systems [24]. For intelligent parking management systems, the Sampark protocol is put up as a simple and secure replacement for the drawbacks of the current methods of communication and safety precautions [16]. The most current developments in the area of smart parking are examined in-depth in this study. The authors look at a number of technological solutions that have been proposed to address parking-related issues, including detectors, smartphone applications, and data analytics. The study addresses the advantages and disadvantages of every approach, as well as possible future fields of inquiry in the subject of intelligent parking. Practitioners and researchers engaged in creating environmentally friendly and effective parking systems may find the paper to be a helpful tool [7]. The concept of smart parking is first introduced, along with some of its potential advantages, including reducing traffic congestion, enhancing the user experience, and generating income for parking operators. The report then discusses the key technologies used in innovative parking systems, including sensors, networks for communication, cloud computing, mobile apps, statistical analysis, machine learning, AI, and blockchains. The authors draw the following conclusion: intelligent parking structures have the ability to revolutionize parking management and enhance the parking experience overall, but effective implementation and acceptance depend on careful evaluation of technical, social, economic, and policy factors [18]. The authors present a full overview of various technologies and their roles in optimizing parking management. The authors include technical details on the implementation of various applications, such as sensor location, communication protocols, data processing algorithms, and user interfaces. Technical obstacles related to the adoption of smart parking systems were also noted, such as sensor accuracy, communication dependability, data privacy and security, and system scalability. The use of enhanced sensors, the creation of secure communication protocols, the application of authentication and encryption protocols, and the usage of cloud-based architectures are only a few of the options suggested by the authors as answers to these problems [10]. Using surveillance camera video streams, the authors provide a deep learning-based technique for forecasting parking spot availability. The suggested method classifies photos as either occupied or unoccupied parking spots using convolutional neural networks (CNNs). A publicly accessible dataset was used to train the CNN model, which produced results with high accuracy along with low false-positive rates. The authors also suggest an IoT-based architecture for a smart parking system, which includes sensors for detecting vehicle presence, communication networks for transmitting sensor data, and cloud-based platforms for data processing and storage. The authors emphasize the advantages of this design, such as real-time monitoring, automatic billing, and remote management. The report includes a case study of the proposed system in action at a shopping mall parking lot. The authors assess the system's effectiveness in terms of parking space availability, detection accuracy, and response time. The results show that the suggested system can detect parking space availability and offer real-time information to users [3]. The report provides useful insights into the potential problems of smart parking system design and implementation. The authors highlight the value of careful planning, stakeholder engagement, and comprehensive testing in the success of a smart parking system. In addition to ongoing evaluation and improvement, the study emphasizes the necessity of a user-centered approach to system design. Analytics and optimization of data: Smart parking systems generate enormous amounts of data that may be utilized for analysis and these processes. Prediction analytics, algorithms for machine learning, and optimization models are a few of the strategies that have been suggested in numerous research to improve parking management. These actions can improve parking use, speed up search times, and lessen traffic congestion. Artificial intelligence (AI): To improve parking management's precision and effectiveness, smart parking systems make use of AI tools like image recognition and the processing of natural languages. These technologies enable automatic vehicle identification, license plate recognition, and chatbot dialogue with users [22]. The paper describes a method for creating smart parking systems that rely on fog computing and decentralized architectures. The authors describe an approach for building such systems, which includes deterministic propagation modeling and practical deployment considerations. The report also analyzes the advantages and disadvantages of adopting fog computing in smart parking systems [9]. The research compares several policies for managing parking lots that accommodate electric vehicles. The authors present a simulation model for testing and comparing different policies depending on characteristics such as charging demand, battery capacity, and parking length. The study provides insights into the development of efficient regulations for managing parking lots for electric vehicles [5]. The study presents a novel smart auto parking system that uses dynamic resource allocation and pricing to optimize the utilization of parking spaces. The authors present a simulation-based approach for evaluating system performance, which incorporates elements such as real-time data collecting and analysis. The study offers insights into the construction of efficient and effective smart parking systems [15]. The study describes a smart parking smartphone application that uses deep learning algorithms to analyze parking lot photos and deliver real-time information on available parking spaces. The authors detail the application's architecture and implementation, as well as the usage of convolutional neural networks for picture processing. The research delves into the use of deep learning in the development of intelligent parking systems [8]. The study provides an in-depth examination of science and technology parks (STPs) and their role in stimulating innovation and economic growth. The writers go on the major features of STPs, such as their physical infrastructure, management approaches, and support services. The report also looks at the future of STPs in light of developing technologies like artificial intelligence and blockchain. The document contains useful information about the design and operation of STPs [19]. In order to achieve smart city status, the study provides a framework for deploying urban computing in Saudi cities. The authors assess the current state of urban computing in Saudi Arabia and make recommendations for the creation and implementation of a complete urban computing framework. The study provides useful information about the possible benefits of urban computing in the context of smart city development [4]. The research examines the distribution and readiness of artificial intelligence (AI) applications in global mobility projects. The authors explore the current level of artificial intelligence in mobility initiatives and identify characteristics that contribute to AI application suitability in this context. The report gives useful insights into worldwide trends and problems in the development and application of artificial intelligence in mobility projects [20]. The research compares two types of sensors often found in smart parking systems: proximity sensors and light sensors. The performance of these sensors is evaluated by the authors based on parameters such as accuracy, response time, and cost. The report gives useful insights into sensor selection and application in the design of functional smart parking systems [6]. The research uses cluster analysis to examine parking behavior in Munich, Germany. The authors employ clustering techniques to detect various patterns of parking behavior by analyzing parking data acquired from sensors. The research delves into the possible application of cluster analysis as a technique for understanding and managing parking behavior in metropolitan environments [12]. The study describes a decision support system for regulating roadside parking in metropolitan settings. Utilizing current data from parking sensors, the tool helps automobiles locate parking places by providing information about available spaces. The system's development and use are described by the authors, along with any possible advantages it could have for easing traffic congestion and boosting urban mobility. Insightful information about the creation of decision support systems for intelligent parking is provided by the research [13]. Based on IoT technology, the paper outlines a smart parking system. The authors propose a sensor-based intelligent parking structure that uses real-time data to provide cars with information and uses sensors to identify available parking places. The article discusses the system's implementation, design, and possible advantages for enhancing urban mobility and alleviating traffic congestion. The study provides useful insights into the use of IoT technologies in smart parking systems [1].

3 Methodology

Smart parking systems have emerged as a viable alternative for managing parking lots in urban settings. The approach for creating and implementing a smart parking system utilizing artificial intelligence is presented in this research study. The system employs the OpenCV library to integrate a variety of technologies, including a Raspberry Pi board, ultrasonic sound sensors, light-emitting diode, resistors, and a camera module, to create the ideal smart parking environment for automobile parking.

3.1 Designing the System Architecture

The first stage in designing a smart parking system is to define the system architecture. Identifying the system's hardware and software requirements falls under this. The main controller for this project will be the Raspberry Pi board, which will oversee the numerous sensors and cameras. Additionally, a camera module that recognizes number plates will employ OpenCV as an open-source computer vision library, ultrasonic sensors, LEDs, resistors, and various other components. The first step in creating a smart parking structure utilizing artificial intelligence is to create a system design that details all of the hardware components and how they will be connected. The software architecture which will be employed in the project is also defined at this stage. Key software modules required to create a smart parking system are identified.

3.2 Developing the Hardware Components

The second phase in constructing the smart parking system is to create the hardware components. Hardware for this project will mostly consist of the Raspberry Pi. A robust and reasonably priced microprocessor called the Raspberry Pi has become easily adaptable to a wide range of sensors and modules. To do this, many sensors and gadgets must be built and connected to the Raspberry Pi device. To determine if

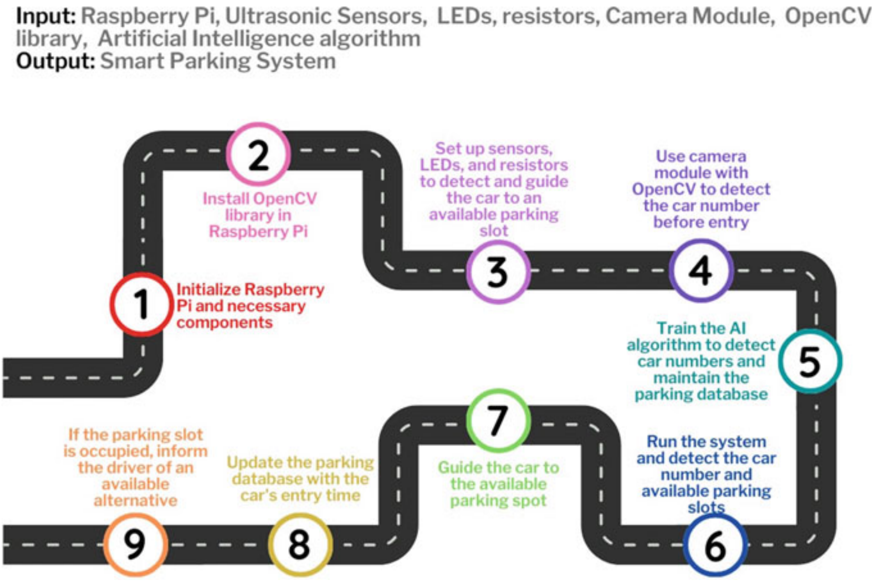


Fig. 1 Flow diagram for hardware implementation

a car is present in a parking space, we shall employ ultrasonic sensors in this project. In order to alert drivers about parking place availability, resistors, and LED lights will be used. The camera module will be used to photograph the parked vehicle's license plate (Fig. 1).

Raspberry Pi Through the use of Internet of things (IoT) gadgets and AI, the artificial intelligence (or AI)-enabled intelligent parking system aims to effectively oversee and track spots for parking. In this project, the ultrasonic detectors, LEDs, resistors, and camera parts that are employed to determine and monitor parking spot availability are controlled and communicated with by the Raspberry Pi. Additionally, the Raspberry Pi gathers information from cameras and sensors and connects with an artificial intelligence algorithm to make choices about the availability of parking spaces and traffic flow. This project uses a Raspberry Pi, which makes the system affordable, reliable, and readily scalable. It provides a strong platform for building IoT applications that can be readily expanded to cover bigger lot sizes or even whole towns. Because of its flexibility and agility, it serves as a vital piece of an "AI-enabled smart parking system" as a useful tool for creating one-of-a-kind IoT applications.

Ultrasonic Sensors Ultrasonic sensors are used to detect the presence of automobiles in the parking lot. To detect car presence, we will use four ultrasonic sensors, two for each parking place. These sensors will be attached to the Raspberry Pi's GPIO pins (Figs. 2 and 3).

Infrared Sensor Detecting vehicle entrance and departure in the parking area is done with the use of infrared sensors. An adjacent item reflects the infrared sensor's released beam of energy back to the device. The infrared beam is blocked when a

Fig. 2 Raspberry Pi

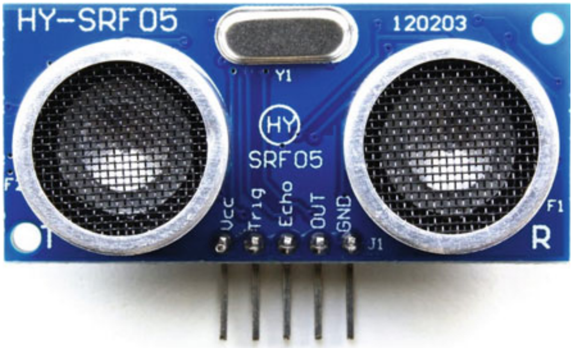


Fig. 3 Ultrasonic sensor

car enters or quits a parking place, prompting the detector to detect the vehicle's presence or absence. Due to its capacity to provide real-time information on the state of occupancy of parking spots, infrared sensors enhance the system's precision and dependability. The AI algorithm then makes use of this data to forecast parking space availability and direct vehicles to the closest place that is easily accessible.

LED Indicators We will use LEDs to indicate the availability of parking places. Green LEDs will show available parking spaces, while red LEDs will indicate occupied parking spaces. The LEDs will also be linked to the Raspberry Pi's GPIO ports.

Servo Motor Servo motors can be utilized in the artificial intelligence-enabled smart parking system to regulate the movement of physical barriers that restrict access to parking spaces. Depending on whether a parking space is available, the gadget may autonomously move these barriers. This can assist in assure that only authorized cars are allowed entry to the lot and can help avoid unauthorized parking. Additionally, the use of servomotors enables precise and precise control of the obstacles, enhancing the system's overall dependability and efficiency (Figs. 4 and 5).

Camera Module The camera module will be used to capture photos of vehicles entering and exiting the parking area. These photos will be analyzed with OpenCV

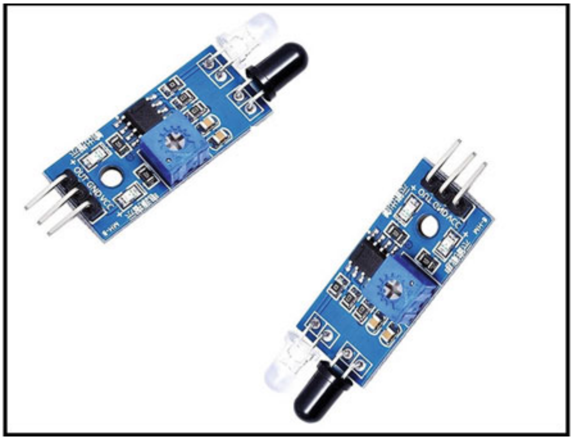


Fig. 4 Infrared sensor

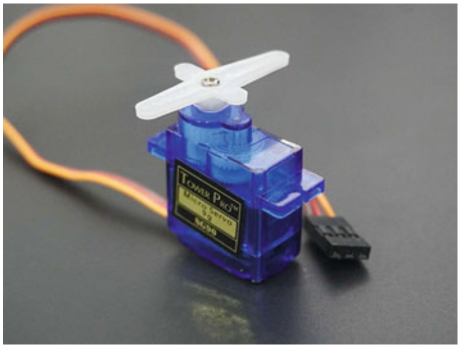


Fig. 5 Servo motor

to retrieve the vehicle's license plate. The camera module will be linked to Raspberry Pi's camera module interface (CSI) port.

OpenCV The camera module's pictures will be processed using the computer vision library OpenCV. We will apply number plate recognition algorithms from OpenCV to identify a license plate in the vehicle's picture.

Database Data will be stored in a database for the camera module and ultrasonic sensors. The information will be kept in a database created with MySQL (Figs. 6 and 7).

Web Application An internet application will be created to give consumers real-time information on parking availability. The PHP-written web application will be hosted by the Raspberry Pi-based website server. The web application will make use of the information stored in the database created by MySQL to give users the most recent information regarding parking availability.

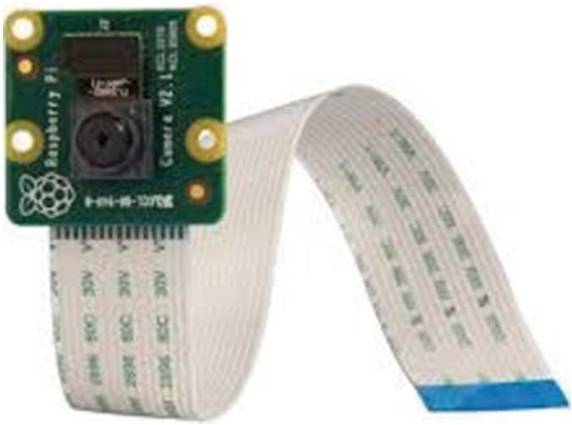


Fig. 6 Camera module in Raspberry Pi

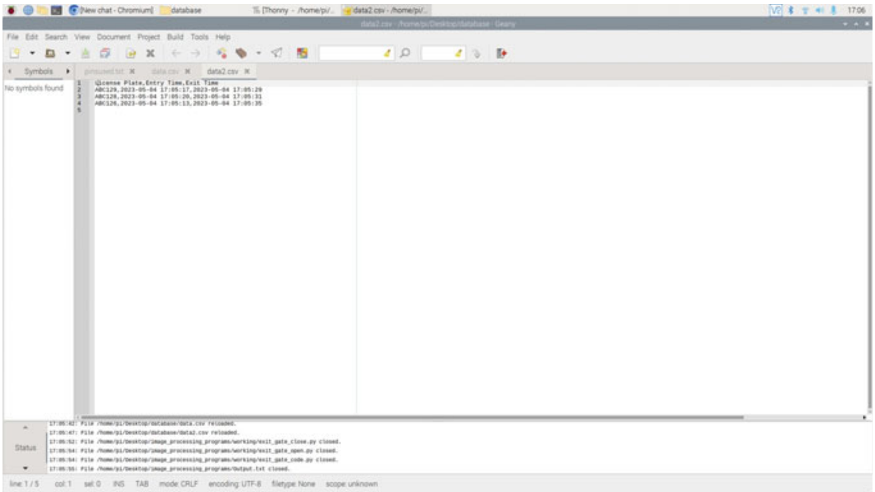


Fig. 7 Data collection

3.3 Developing the Software Components

The creation of the software components is the third stage in the construction of the smart parking system. The myriad sensors and gadgets linked with the Raspberry Pi boards need to be programmed in order to do this. We will be employing OpenCV in this project to take and process images of license plate frames. In order to identify the license plate of the parked car and verify it, the information gathered will be processed using machine learning algorithms (Fig. 8).

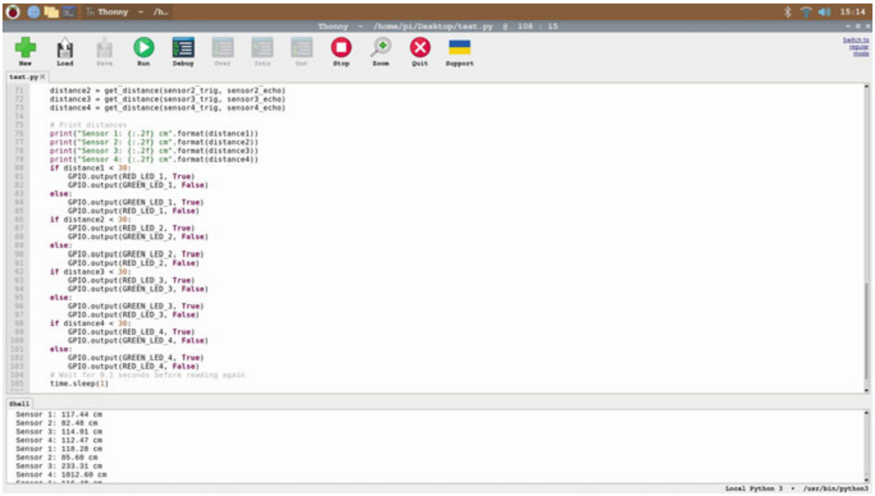
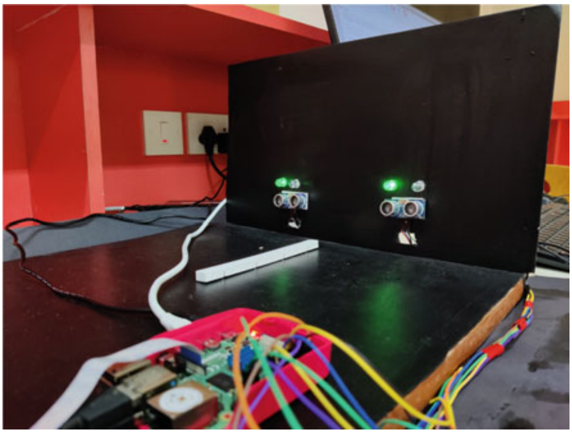


Fig. 8 Raspberry Pi code of ultrasonic sensors for vehicle detection

3.4 *Testing and Evaluation*

Testing and outcome review is the fourth step in developing the smart parking system. Run tests to make sure that it is dependable and satisfies the standards it requires as a component of this procedure. In this study, we will assess the system's reliability while communicating with the database, accuracy in recognizing license plates, and effectiveness in handling parking spots (Figs. 9, 10, 11, and 12).

Fig. 9 Setup when the vehicle is not present



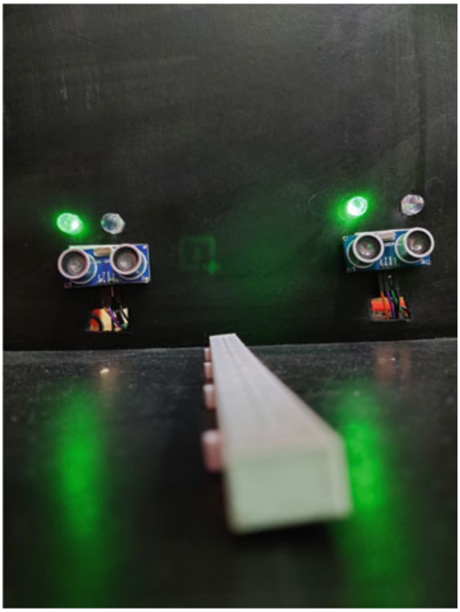


Fig. 10 Indiaction of vacant space using LEDs for parking

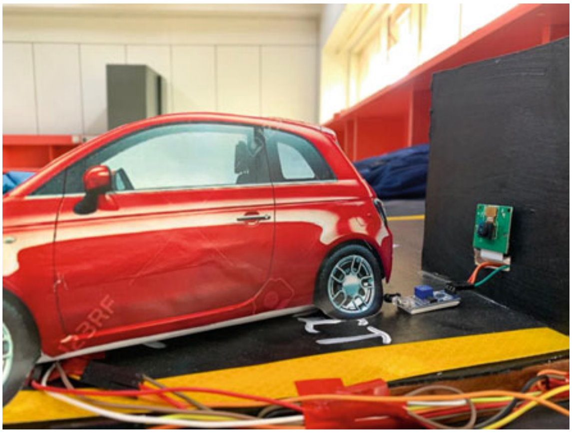


Fig. 11 Setup when the vehicle is present

3.5 Deployment and Monitoring

The smart parking system’s final phase in development is to deploy it in a real-world context and monitor its performance. This includes setting up the hardware at a parking lot and maintaining the database. The device is installed in lots of parking, and the data gathered by the machine learning algorithm is used to optimize parking lot utilization. Parking lot operators receive data to assist them to optimize their parking facilities while users are provided with current details on the number of

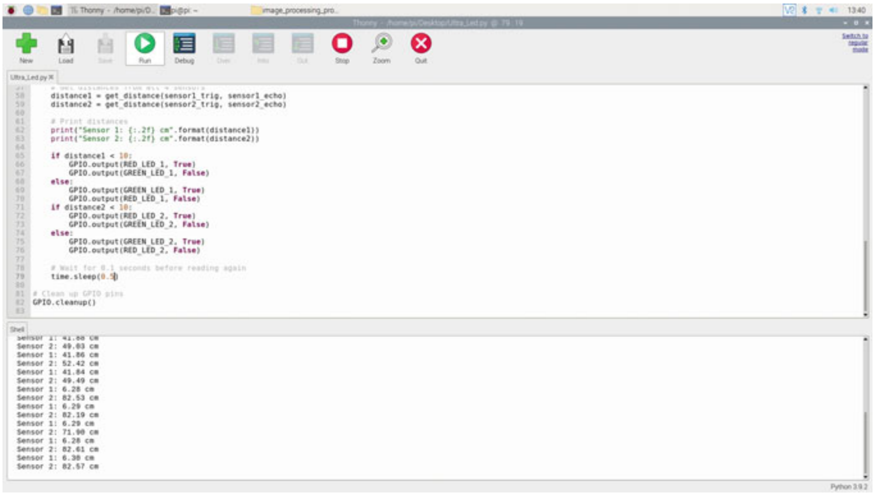
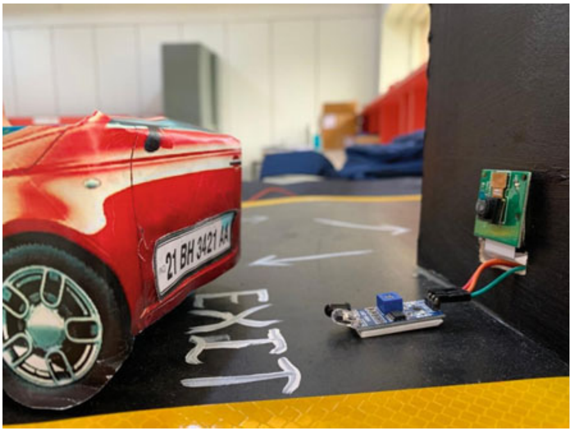


Fig. 12 Raspberry Pi code of infrared sensors for vehicle detection

parking spaces. To suit the requirements of various parking lots, the system may be turned up or down. In summary, the process for the artificial intelligence-enabled smart parking system project entails configuring the hardware components, which include ultrasonic sensors, LEDs, camera modules, and Raspberry Pi. The number plate will be extracted from photos recorded by the camera module using OpenCV. The sensor and camera module data will be stored in a MySQL database hosted on the Raspberry Pi (Fig. 13).

This project uses the Raspberry Pi, ultrasonic detectors, LEDs, resistors, and module cameras to create a smart parking system utilizing the Internet of things (IoT) and artificial intelligence (AI). In order to save time, reduce traffic, and enhance the

Fig. 13 Number plate of the vehicle is getting detected



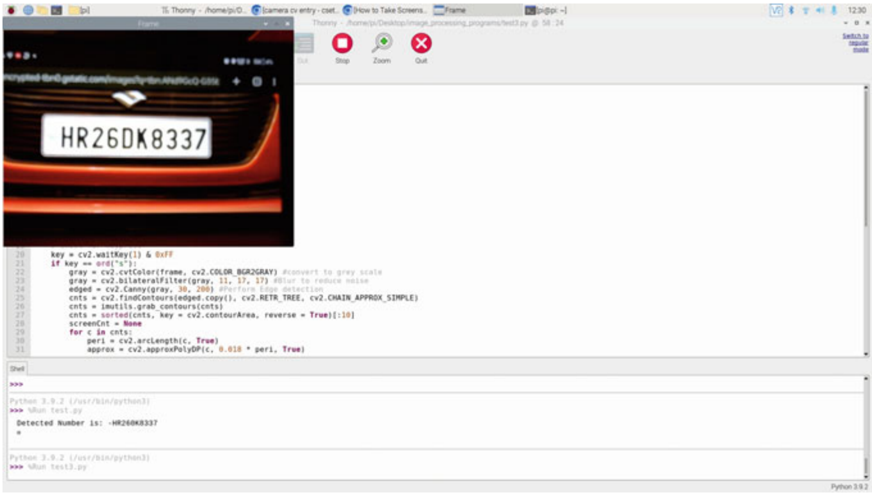


Fig. 14 Code for number plate detection

overall driving experience, the system aims at creating it quick and simple to track and handle parking locations (Fig. 14).

Additionally, the system may be accessed remotely, giving users access to real-time parking data via online or mobile apps. In the near future, machine learning methods may be used to improve the precision of parking space availability projections and to identify infractions. In order to reduce the requirement for parking attendants and to save time and money, automated payment systems might be developed, enabling automobiles to pay for parking places without the need for tangible payment methods.

Additionally, the smart parking system could be integrated into navigation systems to provide drivers with real-time parking information and help them find free parking spots quickly and effectively, easing traffic congestion, and helping to improve traffic flow in general. Data from the smart parking system might potentially be used to identify high-demand parking areas and plan the construction of new parking structures or the conversion of vacant spaces into parking slots.

4 Result

With the use of ultrasonic sensors, LEDs, resistors, and camera modules integrated with OpenCV software onto a Raspberry Pi platform, this innovative system allows city managers to oversee parking spaces more efficiently therefore saving valuable street space for purposes like public transit and making it conducive to traveling by foot or bicycle in populous areas. This automated parking management platform

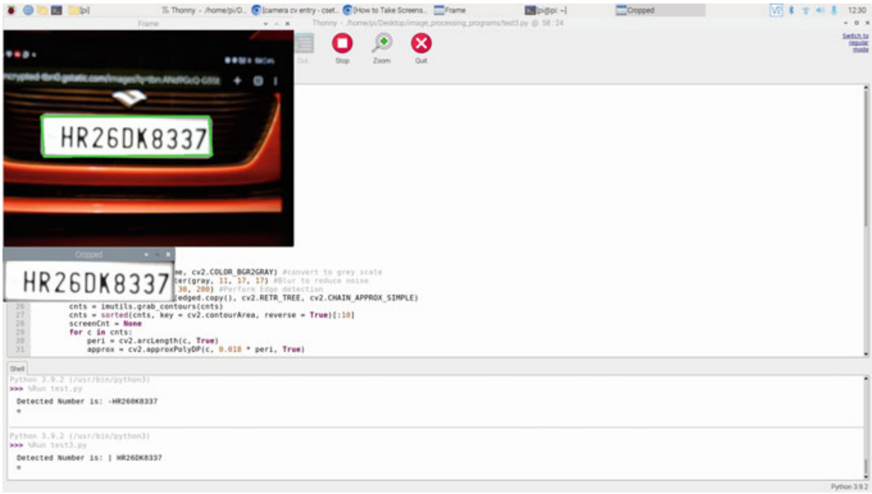


Fig. 15 Code and output for number plate detection

reduces driver wait time searching for a spot which can take up to 20 min per driver on average in cities around the globe (Fig. 15).

By delivering an effective and dependable parking experience, this technology attempts to reduce the challenges associated with traditional parking systems, such as traffic congestion and driver annoyance.

In terms of accuracy, dependability, and efficiency, the study compared the proposed smart parking system to standard parking systems. In all of these areas, the results revealed that the smart parking system based on AI and IoT technology outperformed traditional parking systems. The AI algorithms in the system processed the data acquired from sensors and cameras in real time, sending real-time parking availability information to the database.

The emergence of smart parking technology has allowed drivers to easily find vacant parking spaces, which leads to a more pleasant driving experience and fewer traffic holdups. The utilization of AI and IoT technologies in modern parking systems offers many benefits that traditional methods simply cannot match. For instance, the system engineers can receive live data updates on available spots, resulting in better management as well as more efficient resource usage when it comes to finding vehicles quickly.

5 Future Scope

The "artificial intelligence-enabled smart parking system" project contains various potential future scopes that could improve the system. These are a few examples:

5.1 Implementation of License Plate Recognition Technology

The existing system detects car numbers before entry using cameras, but it may be improved further by using license plate recognition technology. This technique has the potential to improve vehicle detection accuracy while also reducing errors. The technology can also detect authorized and unauthorized cars by recognizing license plates.

5.2 Integration with Mobile Applications

In the future, the system might be coupled with mobile applications to allow cars to reserve parking spots ahead of time. By doing this, you can reduce city traffic congestion and improve driving comfort. The smartphone app additionally provides navigation assistance and real-time parking availability details for drivers.

5.3 Expansion to Multiple Parking Lots

The system can be expanded to cover many parking lots in a city. This can assist enhance parking availability and alleviate traffic congestion. The technology can also be connected with a centralized management system to monitor and administer many parking lots.

5.4 Real-Time Data Analysis and Prediction

The AI model may be enhanced even more by including immediate analysis of data and prediction. This can help forecast parking supply and traffic flow, enabling drivers to make better parking choices. In order to give drivers real-time parking information, this feature may also be connected to navigation systems.

5.5 Integration with Electric Vehicle Charging

The technology can be connected with electric vehicle charging facilities to provide a more comprehensive parking service for electric vehicles. The AI model can also be trained to forecast the availability of charging outlets. This can stimulate the usage of electric vehicles while lowering greenhouse gas emissions.

5.6 Integration with Payment Systems

The system can be connected with payment systems to allow drivers to pay for parking via the mobile application. This can give drivers a more seamless and convenient experience. The payment system can also be coupled with the reservation system, allowing vehicles to purchase parking spaces.

5.7 Integration with Security Systems

To increase the security of parked automobiles, the system can be connected with security systems. Cameras, alarms, and other security systems are examples of this. In addition, the AI model can be trained to detect and identify questionable activity. The security system can also be linked to the reservation system, allowing for secure access to booked parking spots.

Finally, the "artificial intelligence-enabled smart parking system" has enormous development and integration potential in the future. The incorporation of license plate recognition technology, mobile applications, multiple parking lots, real-time data analysis and prediction, electric vehicle charging, payment systems, and security systems can improve the system's functionality and effectiveness, making it a necessary tool for managing parking spaces in urban areas.

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