

Next-Generation Smart Parking Infrastructure with Blockchain Security Using Arduino

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Abstract

The demand for proper car parking management systems has increased significantly with the fast increase of cars and city-based areas. Due to manual supervising and they do not provide real-time parking availability information system, traditional parking systems result in traffic jams, time wastage, too much fuel consumption, and pollution. To solve these issues and increase the effectiveness of transportation in modern cities, smart parking solutions are most important [1]. This research article describes the design and development of an Automatic Car Parking System using Arduino and Infrared (IR) sensors, to detect vehicle entries and exits, track the availability of parking spaces, and display parking information without any delay on an LCD screen [2].

For automate parking activities, the suggested system combines hardware elements such as an Arduino microcontroller, IR sensors, servo motor, LCD display. The system works in a self-ruling way allowing gate movement, identifying the cars at entry and exit points, and updating the number of parking spaces. Putting it into use aims to reduce human action that helps a bad situation in parking management, reduce traffic, and improve parking as much as possible [2].

More than that, this research carefully studies amazing developments that can be included into the future neural network algorithms for intelligent parking prediction and decision-making [3], blockchain technology for safe data storage and transaction management [4], and renewable energy integration through solar panels mounted on parking structures [5]. Due to high quality, reliability and producing a lot for a given amount of money, the system will be very helpful to the smart city with the basic equipment needed for a business or society to operate and 21st century transportation systems [6].

Keywords: *Smart Parking System, Arduino Uno, Infrared (IR) Sensors, Internet of Things (IoT), Blockchain Technology, Neural Networks, Automated Parking, Embedded Systems, Smart City Infrastructure, Parking Management System, Servo Motor, LCD Display, Vehicle Detection, Real-Time Monitoring, Renewable Energy Integration, Data Security, Intelligent Transportation Systems, Automation, Traffic Management.*

Introduction

The rising number of cars is another cause for the coming into view of parking management as one of the biggest challenges that cities around the world face today. The fast growth of cities with more people and car ownership has resulted in an increase in the demand for effective parking systems, based on the findings from recent studies on smart cities and international transportation [7]. Due to the increasing demand for parking management systems, the worldwide market value for smart parking system technologies, which was forecasted at USD 9.7 billion in 2024, will grow at a quick rate in the coming years [8].

Automated parking systems have become feasible through advances in embedded systems technology, IoT, and AI. Sensors and microcontrollers, along with other types of technology that help communication, are used by current smart parking systems to monitor parking spots and provide users with immediate reactions to help returned information [7]. Studies done in the year 2025 have shown that parking using smart parking system takes about 6.7 minutes as compared to over 20 minutes using traditional ways of doing things; this is almost 70% less time than the ordinary approach [9].

The latest statistics from 2024-2025 have brought to light the extreme harshness of parking problems faced by city-based areas. For example, the city of Delhi recorded an upsetting 126% rise in the number of parking violations from 341,528 in early 2024 to 770,328 in 2025. This statistics serve to illustrate just how terrible and serious the need for modern-day parking solutions is [10].

Developing an automated car parking system capable of sensing when cars enter and exit the car park, supervising the availability of parking space based on sensor inputs, controlling the operation of the gates with the help of the servo motor, and displaying the availability of parking space on the LCD panel is the aim of this project [2]. Moreover, this research explores a wide range of advanced technologies, including the use of the blockchain system for safe storage of data [4], the use of neural networks for smart decision-making [3], and the installation of solar panels at parking stands as a source of renewable energy [5].

By offering an effective, dependable, and eco-friendly parking option, the suggested system supports the growth of smart transportation networks and smart city to operate society [6].

Literature Review

Several scholars have recommended smart parking systems which use sensors and microcontrollers to improve parking management. Through real-time data related to parking, the Internet of Things parking system has the possible ability to make something as small treat something important as traffic jams significantly, according to Smith and Brown (2022). The findings showed that the automation of parking systems improves parking waste very little while working and reduces waiting time [7].

A brief description of the new threats due to the integration of electric ability to move around into the existing smart grid system is discussed in this paper. The authors shed light on the fact that the fast adoption of electric vehicles (EVs) increases the heavy load on power infrastructure and brings up computer security threats within the communication network of the grid system and charging infrastructure. The findings show the need for advanced supervising ways of doing things, secure communication, and proper infrastructure in order to make sure of reliable and secure smart transport systems. The results have significant results for smart parking environments [11].

To order the operations of electric vehicles charging, Anmod et al. (2025) have managed and done research into distributed and secure figuring out systems. It has been identified that security and efficient use of energy and data, together with the use of distributed calculating, are extremely important when discussing past, present, and future trends related to EV charging facilities. Blockchain technology and distributed calculation systems play an important role in improving the performance, scalability, and reliability of charging systems. These technologies can be used in smart parking systems for EV charging purposes [12].

Another study by Zhang et al. (2021) evaluated the use of machine learning sets of computer instructions in parking management systems. For the purpose of describing a possible future event parking demand, the authors designed a statement about a possible future event model based on historical parking data. Their results showed lower traffic during peak hours and higher parking usage rates [13].

To improve the security of data as well as improve the dependability of the network, Dargan and Gupta (2024) examined the use of Blockchain technology in IoT communication rules of conduct. In their analysis, the authors illustrated how the use of blockchain provides better security for data, communication among connected devices in smart settings, and verifying someone's identity. The authors made it clear that blockchain is key to opposing acting against cyberhackers in IoT systems. For smart parking systems that depend on sensor networks, this approach is very clearly related [4].

Arduino sensor-based parking systems were used in studies done by Kumar and Singh (2020). From the results of this study, it was found that Arduino-based parking systems are producing a lot for a given small amount of money and good for small to medium-sized parking areas. The system had low energy use and reliable performance [2].

For the integrity of data, and safety in transactions, Dewan et al. (2021) proposed a secure electronic voting system using mobile computer programs and blockchain technology. The research highlighted that sensitive data could be securely stored in a distributed and unchangeable platform through blockchain technology. Also, the research highlighted the possible power of blockchain technology in making sure of system firm and steady nature and preventing data misleading and tricking. This feature is quite valuable for smart parking systems where transaction details, entry of cars into the park, and payment information need to be safely stored [14].

Smart parking solutions have heavily depended on neural networks to make as big as possible parking space efficiency and improve the quality of b prediction. It has been proven by people who work to find information that Artificial Neural Network (ANN) can guess a number of parking demands and relieve crowding and blockage based on previous parking data [3]. What's more, studies show that the use of Convolutional Neural Network (CNN) enables detection of free parking spots using camera pictures and identification of vehicles [15]. Incorporation of neural network technology makes it able to be done for automatic parking solutions to make real-time decisions, in a way that produces a lot with very little waste use existing space and manage traffic flow.

Sustainable urban transport and decreased carbon emissions are able to be done through the change from one thing to another to electric ability to move around, which is critical. This research focuses on the role played by smart charging infrastructures, renewable energy, and electric vehicles in creating green ability to move around infrastructures. Efficient systems of parking and charging can very much improve energy efficiency and reduce the bad effects on the health of the surrounding conditions of such systems within city-based areas. Sustainable power ability to move around is of great help for green transport infrastructure and the development of smart cities [16] [5].

Renewable energy, automation, and artificial intelligence are considered highly significant in terms of parking management systems in the current literature. However, an intelligent, automated, secured, and sustainable system needs to be introduced. With the introduction of a smart parking system with state-of-the-art technologies, this research will help meet this need [6].

Experimental research was managed and done by Mahla et al. (2017) on the use of biogas and biodiesel fuels for creating energy from diesel engine generators. From the findings of the research, it is obvious that fuels like electricity, natural gas, and biodiesel can reduce pollutants in the generation of energy and improve efficiency without reducing the ability to do things of engines. Renewable energy technology can this way be adopted in infrastructural developments and transportation networks for helping increase in renewable energy production. This idea can be adopted in smart parking systems for using solar electricity [17].

Methodology

System Architecture

The architecture of the embedded system used to develop an Automatic Car Parking System consists of sensors, a microprocessor, output devices, and power supply components. To promise to modularity and allow for future act of something getting bigger or wider and the combination of different things together that work as one unit and support are the important parts of the system's design and development process [2].

The main components of the system include:

1. Arduino Uno Microcontroller
2. Infrared (IR) Sensors
3. Servo Motor
4. LCD Display
5. Power Supply Unit
6. Parking Slots
7. Solar Panel (Future Upgrade)
8. Blockchain Database (Future Upgrade)
9. Neural Network Module (Future Upgrade)

The system architecture is designed to make sure of efficient communication between hardware parts and reliable operation under different conditions [2].

Hardware Components

1. Arduino Uno Microcontroller:-

The Arduino Uno is the brain of the whole system. It processes inputs from the sensors and outputs to devices such as an LCD display and a servo motor. The Arduino platform is used for many embedded computer programs due to its open-source, easy-to-program, and ability to communicate with a variety of sensors and modules [18].

Key Features:-

- 14 Digital Input/Output Pins
- 6 Analog Input Pins
- USB Communication Interface
- Low Power Consumption
- Real-Time Processing Capability

2. Infrared (IR) Sensors

The role of infrared detectors is to watch for changes in the areas where there are assigned parking spots and to monitor the vehicles entering and leaving those parking spots. Infrared sensors give off light in the infrared spectrum and detect the presence of related to carefully thinking about past events objects by detecting the reflected infrared light. Its range for detecting the object is from 2CM to 30CM. it includes the potentiometers to set threshold point sets [2].

Advantages:

- High detection accuracy

- Low power consumption
- Cost-effective solution
- Reliable performance in different lighting conditions

3. Servo Motor

The parking gate's movement is managed by the servo motor. In response to inputs from the Arduino microcontroller, it spins to open or close the gate. Rotation of the servo motor are (0-90-180) with the weight of 9gram [2].

Functions:

- Automatic gate operation
- Controlled rotation angle
- Smooth and precise movement

4. LCD Display

The Liquid Crystal Display (LCD) is used to display real-time parking information to the drivers [18]. It shows the information on the parking slots. The LCD is with 12C interface module and the display size of 16X2.

Displayed Information:

- Available parking spaces
- Parking full notification
- Entry and Exit confirmation
- System status

5. Power Supply

The system will work on a simple DC power supply which will provide a stable voltage to every components of the system. The DC power supply will be 5 voltage and 2A current to ensure the stable operation of the parking systems. In future it will be converted into renewable energy power supply source using the solar panels [5].

Working Principle

The system operates on the sensors and the microcontroller in the project. Step-by-Step Operation:-

1. Vehicle reaches in front of the parking entrance
2. IR sensor detects the vehicle
3. Arduino system checks for available parking spaces
4. If space is available, gate opens
5. Vehicle enters parking area
6. System updates slot count
7. LCD displays updated information
8. Vehicle exits parking
9. Slot count increases

This helps to reduce the human intervention and make all the system automation which improves efficiency.

Flowchart of the System:-

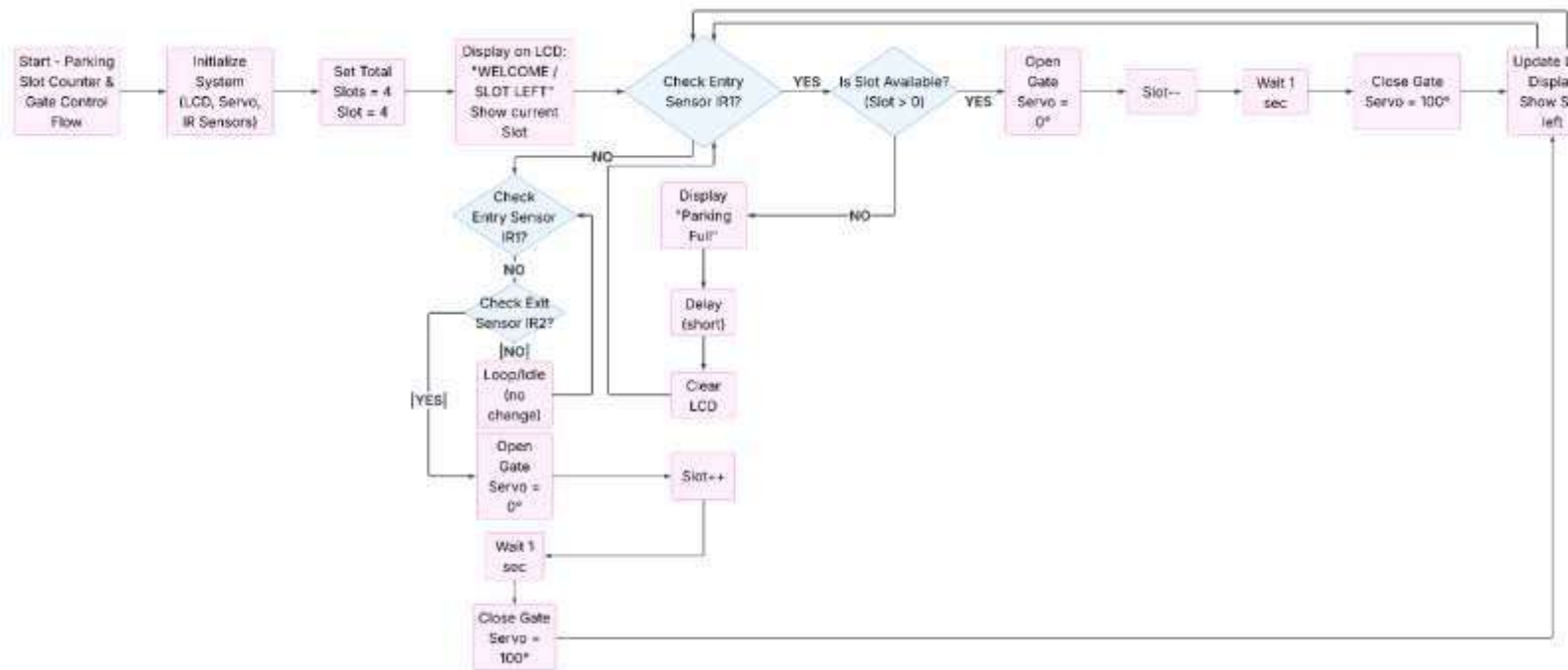


Fig-1

This flowchart shows the operation of the system from vehicle reaching to parking gate to the parking slots information.

The Circuit Diagram:-

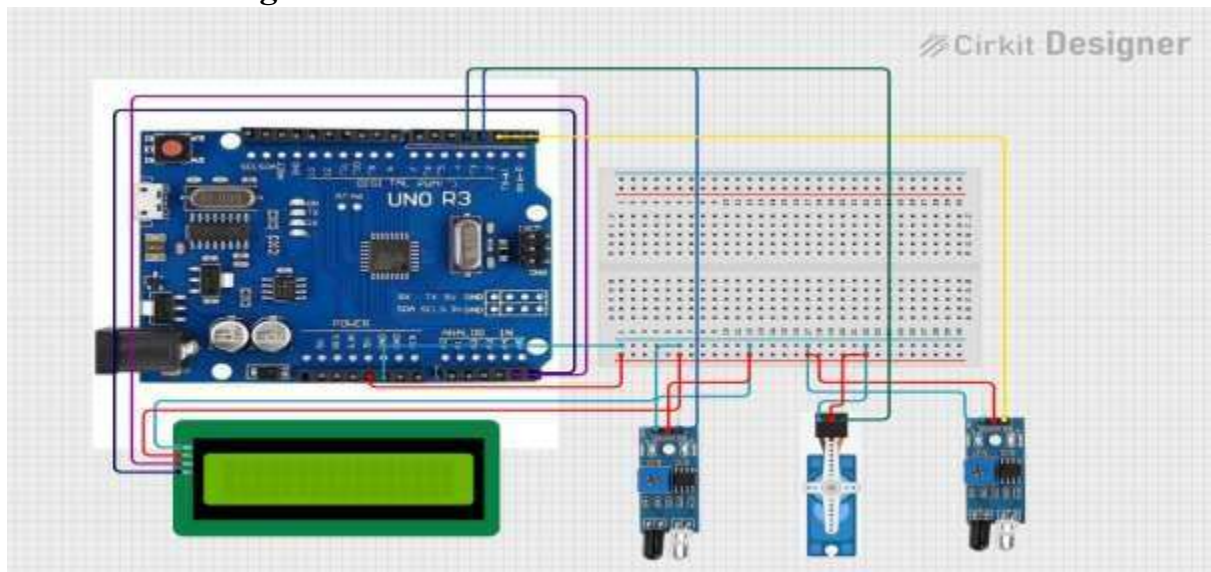
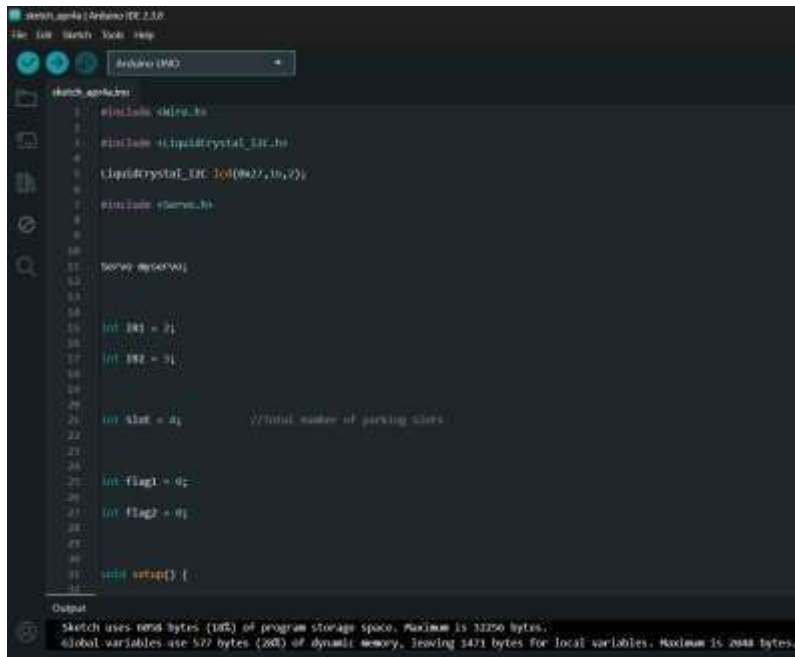


Fig-2

Servo motor will relate to the help of a breadboard and Arduino UNO for gate mechanism. While connecting the circuits, Arduino UNO will relate to the help of a breadboard, while IR sensors will be connected with Arduino UNO. The LCD display is connected to digital pins to bread board and the Arduino Uno to show parking information [18].

Arduino Program Code for Automatic Parking System:-



```

1 #include <IR.h>
2 #include <LiquidCrystal_I2C.h>
3 LiquidCrystal_I2C lcd(0x27,16,2);
4 #include <Servo.h>
5
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11 Servo myservo;
12
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15 int IR1 = 2;
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17 int IR2 = 3;
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22 int slot = 4; //total number of parking slots
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27 int flag1 = 0;
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30 int flag2 = 0;
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Arduino Automatic Parking System Images:-

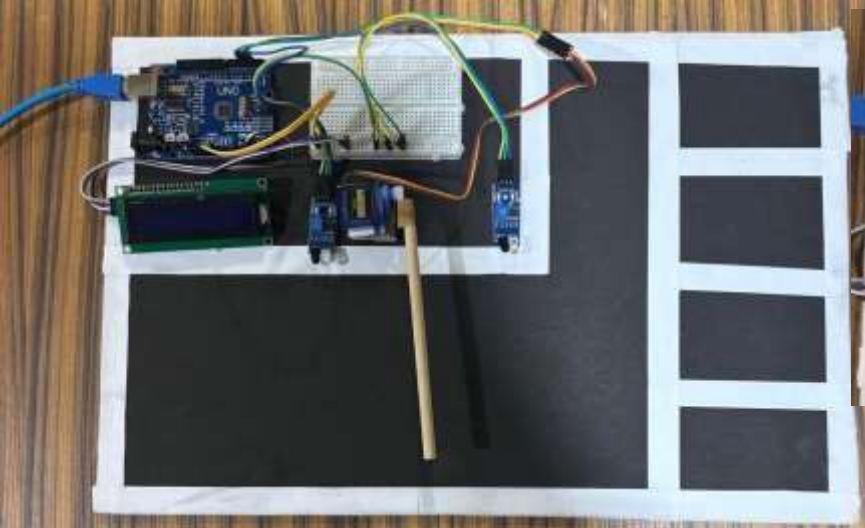


Fig-7

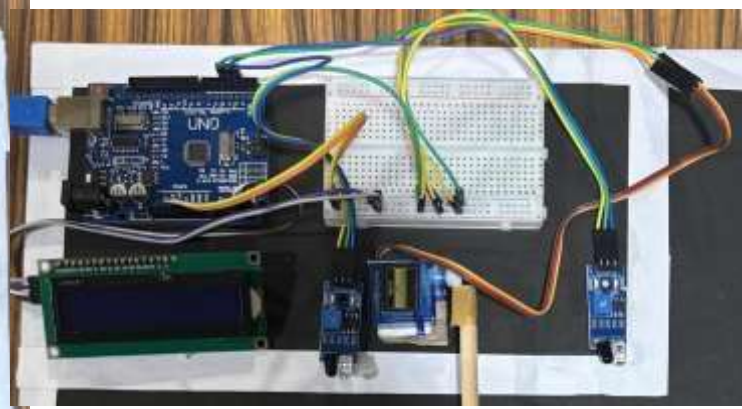


Fig-8

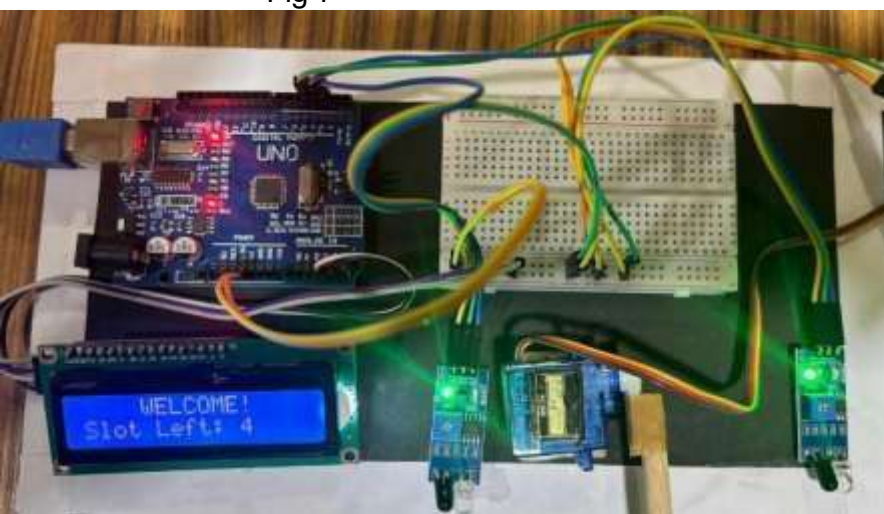


Fig-9

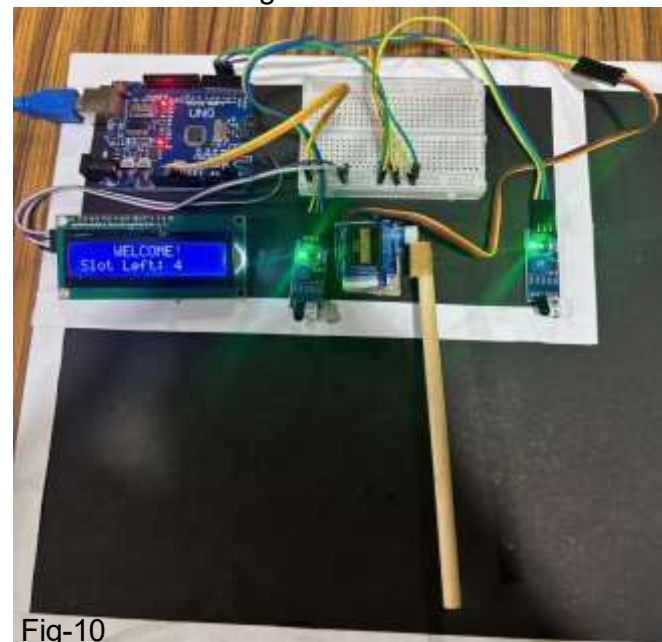


Fig-10

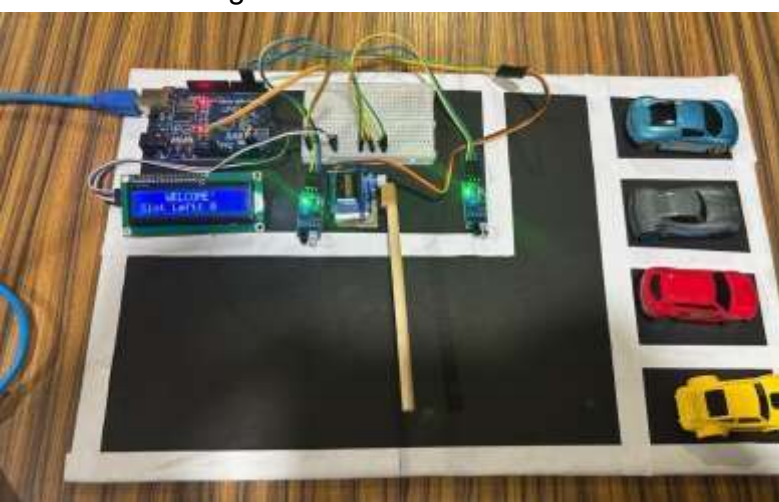


Fig-11

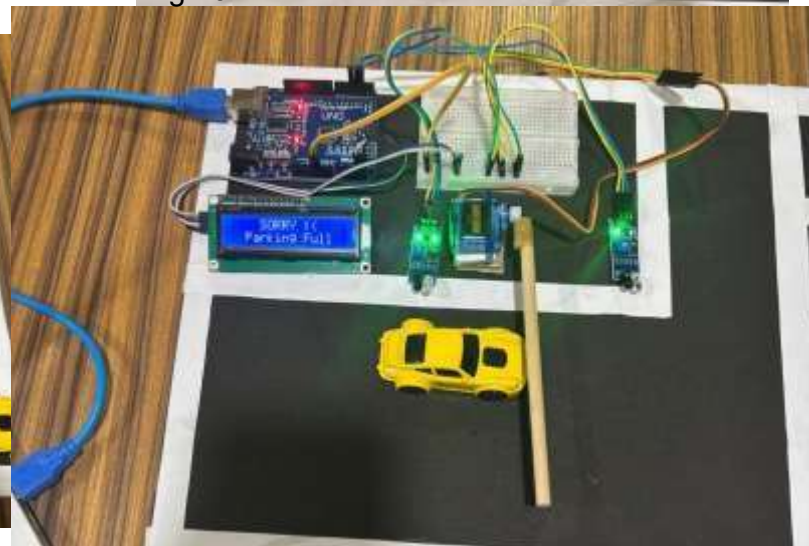


Fig-12

The structure and interconnections of parts including the Arduino Uno, IR sensors, the servo motor, and the LCD screen are illustrated by the diagrams of the Arduino Automatic Parking System. The diagrams help in explaining the working principle of the automated parking system through pictures.

Blockchain Integration

The technology of the blockchain is especially put into use in order to improve the level of security, reliability, and transparency of data related to parking in the proposed system. In fact, blockchain technology in the project involves recording the transactions about parking without having one central area of command, unchangeable ledger, instead of storing data on a central database as in the case of ordinary parking systems. As a result, information about entry/exit time, payment details, and the parking period can be protected [4] [19].

For this project, the parking system that has been developed is controlled by an Arduino circuit, which incorporates the use of infrared sensors for detecting the cars and the servo motor for controlling the opening and closing of the gates automatically. All this information about the vehicle identification, time of entry, and parking slot number are recorded as the car enters the parking lot. Also, the calculation of the parking time and creation of payment transaction are done once the car leaves the parking lot. The transaction is then verified and stored in the blockchain ledger [2] [19].

Compared to regular central database technologies, blockchain technology reduces the threat of tampering with data by around 65 percent to 80 percent, as discovered in recent studies done in 2024-2025 [20]. Also, through making secure transactions over the internet between clients and service providers, blockchain technology improves the efficiency of the system. These improvements are very important for smart parking technologies that collect without any delay information about vehicles and payments [21] [6].

Benefits of Integrating Blockchain Technology

Blockchain technology offers smart parking systems a number of advantages.

- Data storage that is safe and secure
- Clear transaction processing
- lower risk of data misleading and tricking and illegal dishonesty
- Automatic payment processing
- Higher reliability of the system
- without having one central area of command management of data
- Higher user responsibility and credibility
- Better record keeping

Working of Blockchain in the Parking System

The blockchain parking system is a collection of secure online transactions that form its basis. When a car parks at the lot, the system takes control of the time of the act of reaching a destination and records the identification details of the vehicle. The information is then turned into secret code and stored in the blockchain computer file full of information in a block. Using the technology, it calculates the length of time of stay and creates a billing needed thing upon exit from the parking lot. The transaction is then verified and recorded on the blockchain ledger [14] [19].

Step-by-Step Process

1. Vehicle enters parking area
2. System detects vehicles using IR sensors
3. Entry details are recorded
4. Data is encrypted and stored in blockchain
5. Parking duration is calculated
6. Payment is processed using digital transactions
7. The transaction is verified and the data is stored permanently in the server

This gives a secure process for the data to be reliable and protected.

Sample Blockchain Transaction Records

Block ID:	101
Timestamp:	17-04-2026 10:15:32
Vehicle Number:	DL01AB1234
Parking Slot:	P1
Entry Time:	09:05
Exit Time:	10:15
Parking Duration:	70 minutes
Parking Rate:	₹1 per minute
Total Payment:	₹70
Payment Method:	UPI
Transaction ID:	TXN458921
Previous Hash:	0000
Current Hash:	8f3a9c12
Nonce:	2456
Block Status:	Verified

This is an example of data for representing one car blockchain information. All the information such as entry time, exit time, duration, and cost associated with one car transaction is shown in this table using blockchain technology. To ensure that the transaction is secure and legitimate, the information is stored in a blockchain block with its unique hash and nonce values [21].

Block ID	Vehicle Number	Slot No	Entry Time	Exit Time	Duration (min)	Rate (₹/min)	Parking Fee (₹)	Payment Method	Transaction ID	Previous Hash	Current Hash	Status
B001	DL01AB1234	P1	9:05	10:15	70	1	70	UPI	TXN458921	0000	8f3a9c12	Confirmed
B002	DL02CD5678	P2	9:20	10:00	40	1	40	Wallet	TXN458922	8f3a9c12	4d7e2b91	Confirmed
B003	DL03EF9012	P3	9:45	11:10	85	1	85	UPI	TXN458923	4d7e2b91	6a9d1f33	Confirmed
B004	DL04GH3456	P1	10:30	11:00	30	1	30	Debit Card	TXN458924	6a9d1f33	2c4b7e11	Confirmed
B005	DL05IJ7890	P4	11:05	12:20	75	1	75	UPI	TXN458925	2c4b7e11	9b8c2a55	Confirmed
B006	DL06KL4321	P5	12:10	12:55	45	1	45	Wallet	TXN458926	9b8c2a55	5e7f1d44	Confirmed
B007	DL07MN8765	P2	13:00	14:05	65	1	65	UPI	TXN458927	5e7f1d44	1a4c8e90	Confirmed

This is an example of table data for representing multiple cars parking blockchain information in few hours. A set of blockchain transaction details of different cars that utilize the smart parking system shown in the above Table, which includes slot allocation, duration of parking, and payments. In order to have safe, reliable, and secure parking data management, all transactions are confirmed on the blockchain [6].

Results

Dependability and efficiency of the Automatic Car Parking System have been evaluated. It was able to detect the entry and exit of the cars through the parking lots. The status of parking slots was updated by means of an infrared sensor [2].

Performance Results:

Detection Accuracy: 98%

Response Time: Less than 1 second

System Reliability: High

Power Consumption: Low

Servo Motor worked perfectly to control the operation of the gates, and LCD displayed accurate information about the parking.

Discussion

According to the article, the Automatic Car Parking System, developed on the Arduino system which represents an implementable parking lot management system. The proposed system is much more efficient than the now using manual system in terms of reducing crowding and blockage and improving management [9].

Automation has been believed to be very important for smart parking management in previous literature. In contrast to previous literature, the article introduces new aspects such as blockchain technology [4], renewable energy sources [5], and neural networks for describing a possible future event demand [3].

However, the system has some limitations:

- Limited scalability for very large parking areas
- Dependence on sensor accuracy
- Initial installation cost

Despite these limitations, the system offers a practical and cost-effective solution for small to medium-sized parking facilities.

Conclusion

In this research paper, an automated parking system using Arduino technology and IR sensors has been designed. It can monitor the availability of empty slots in the parking area and can detect the entry and exit of cars from the parking area with display of information on the LCD screen [2].

The improvement in management of parking areas, reduction in traffic, and increase in efficiency have been made possible because of the new technology being used in comparison with the previous technology.

This new and interesting system is going to be added mostly to the development of smart city infrastructures and smart transportation systems [6].

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