Communications on Applied Nonlinear Analysis
ISSN: 1074-133X
Vol 31 No. 2s (2024)

Design of Mathematical Model and Implementation of IoT Enabled Smart Secure Parking System

[1]M.L.Keote, [2]U.S.Ghodeswar, [3]Bhuvneshwari Gathibandhe, [4]Siddhi Khodankar, [5]Anchal Shende, [6]Tejas Zilpilwar

[1]Department of Electronics And Telecommunication Engineering, Yeshwantrao Chavan College of Engineering, Nagpur, India. klminal@rediffmail.com

[2]Department of Electronics Engineering, Yeshwantrao Chavan College of Engineering, Nagpur, India ghodeswarujwala83@gmail.com

[3]Department of Electronics And Telecommunication Engineering, Yeshwantrao Chavan College of Engineering, Nagpur, India. bhuvneshwarigathibandhe@gmail.com

[4]Department of Electronics And Telecommunication Engineering, Yeshwantrao Chavan College of Engineering, Nagpur, India. khodankarsiddhi@gmail.com

[5]Department of Electronics And Telecommunication Engineering, Yeshwantrao Chavan College of Engineering, Nagpur, India. shendeachal2002@gmail.com

[6]Department of Electronics And Telecommunication Engineering, Yeshwantrao Chavan College of Engineering, Nagpur, India. tejaszilpilwar@gmail.com

Article History:

Received: *28-03-2024*

Revised: *02-05-2024*

Accepted: *20-05-2024*

Abstract:

The fast growth of cities and the resulting rise in traffic have made it necessary to create effective parking control systems. This paper talks about how to build and set up an Internet of Things (IoT)-enabled smart parking system. IoT technology is used in the suggested system to solve problems with current parking systems, like wasteful use of space, traffic jams, and damage to the environment. A detailed mathematical model is created to find the best way to assign parking spaces, cut down on the time it takes to look for open spots, and improve the overall user experience. The system design combines different Internet of Things (IoT) parts, like sensors, motors, and communication units, so parking places can be managed and watched in real time. The math model includes methods for allocating parking spots dynamically based on data from IoT sensors gathered in real time. The goal of this model is to guess where parking spots will be available, make the best use of those places, and cut down on the time people spend looking for parking. The technology also uses machine learning to look at old data and get better at making predictions over time. Details about how to implement are talked about in depth, such as the hardware setup, transmission methods, and program parts. A lot of models and real-life tests in a city are used to judge the system's success. The results show big changes in how parking spaces are used, less traffic, and lower pollution, all of which make cities more sustainable. The suggested smart parking system that uses the Internet of Things (IoT) is a cost-effective and scalable answer to today's parking problems. More work will be done in the future to improve the system's abilities using advanced machine learning techniques and to spread its use to more cities. This study shows that IoT technology has the ability to change the way cities work and make life better in smart cities.

Keywords: IoT (Internet of Things), IR Sensors, RFID, NodeMCU, Smart Parking, Smart Cities, Android Application, Cloud Computing, Security and Privacy.

1. INTRODUCTION

People moving into cities and buying cars at an exponential rate have created a major problem: how to handle parking in places with lots of people. Conventional parking methods don't always make good use of parking spots, which leads to traffic jams, lost time, higher emissions, and angry drivers. Putting together Internet of Things (IoT) technology with smart parking systems looks like a good way to solve these problems. This article talks about how an Internet of Things (IoT)-enabled Smart Parking System (SPS) was put into action. The goal was to change the way parking spaces are managed by tracking and improving them in real time. Setting up sensor networks all over the parking infrastructure is the first step in putting the IoT-enabled SPS into action. Sensors with technologies like ultrasound, infrared, or magnetic sensors are put in each parking spot in a way that lets the system know if a car is there or not. The data from the sensors is then sent directly to a central computer so that it can be processed and analyzed.

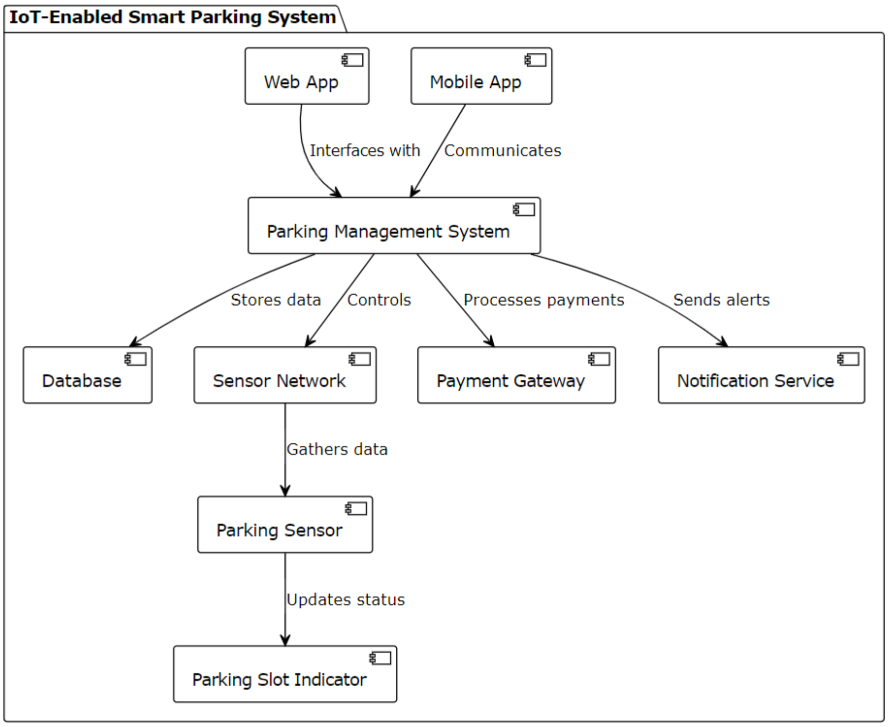

Fig 1: Overview of IoT based Smart parking System

The most important part of implementing SPS is building a strong software platform that can handle real-time data streams, do advanced analytics, and coordinate methods for allocating parking spaces. The software tool works with the IoT sensor network to make real-time data about parking usage that can be gathered and processed. It uses machine learning methods to guess how many parking spots are available based on past data, the day of the week, the time of day, and other factors. With these prediction analytics, the system can guess how many parking spots will be needed and best assign them based on that. The rise in car ownership in cities has caused a major problem: parking is hard to find, especially in residential areas, which takes a lot of time for people who live there. This study suggests a Smart Parking System that focuses on society. It would use IoT technology and an easy-to-use app to simplify parking, improve safety, and make the best use of space. Traditional ways of managing parking in neighborhoods, like using security guards or resident-marked spots, are inefficient and don't make things clear. Cutting-edge technology is built into our answer, which changes this completely: people use RFID cards to get in, and a mobile app controls servo motors. This app acts as a hub, showing in real time which slots are taken, making it easier for guests to park by inviting them, and making sure security and openness. At each slot, infrared cameras send information about the location of a car to the cloud, which updates information about occupation for tracking from afar. With ESP8266 microcontrollers making sure smooth Wi-Fi connection, our system lets you control motors from afar and get real-time updates, offering a safe, easy, and smart parking solution. This combination of RFID entry, app control, and usage tracking has a huge potential to improve parking and make living spaces more organized and stress-free for both residents and guests.

2. LITERATURE SURVEY

Putting together an IoT-enabled Smart Parking System means combining different technologies to better handle parking spots and make the user experience better. Recently, many studies have looked at different parts of these kinds of systems, mainly efficiency, real-time tracking, and how users can connect with them. Optimization of parking spot usage is a theme that comes up a lot in the writings. Based on real-time data, researchers have come up with methods and systems that could automatically assign parking spots [1]. For example, programs that use machine learning have been created to guess when parking spaces will become available. This lets parking resources be managed more efficiently. There have also been suggestions for optimization models that would cut down on the time it takes to look for parking, which would also cut down on traffic and pollution. Another important topic that has been written about is real-time tracking [2]. Internet of Things (IoT) monitors are used to track which parking spaces are occupied, which allows for management and tracking from afar. Ultrasonic sensors, thermal sensors, and magnetic sensors are some of the sensor technologies that have been studied [3].

Each has its own benefits when it comes to accuracy and cost-effectiveness. Also, radio communication methods like LoRaWAN and MQTT make it easy for sensors and the central control system to send and receive data. Smart parking systems that use the Internet of Things (IoT) also take user involvement and contact into account when they are being designed. Mobile apps are being made to give users real-time information on available parking spots, help with directions, and reservation services [4]. System administrators can keep making the user experience better and adapt to changing user tastes by adding ways for users to give feedback, like scores and reviews. Also, studies show how important safety and security are in IoT-enabled Smart Parking Systems. To keep data transfer safe and user information safe, encryption and verification methods are used. Privacy-preserving methods are being looked into to make personal data anonymous while still letting researchers learn useful things that can help improve the system.

Table 1: Related work Summary

Method	Approach	Finding	Limitation	Scope
Sensor-Based [4]	Installation of IoT sensors in parking spaces	Real-time detection of vehicle occupancy	Costly hardware deployment	Urban parking management
Machine Learning [5]	Training models on historical parking data	Predictive analytics for parking space availability	Dependency on data quality	Predictive maintenance of parking infrastructure
Data Analytics [6]	Analysis of parking occupancy patterns	Identification of peak parking demand hours	Limited scalability	Parking space optimization
Mobile App Integration [7]	Development of user-friendly applications	Seamless access to parking availability information	Compatibility issues with older devices	Enhanced user experience
Cloud Computing [8]	Utilization of cloud servers for data processing	Scalability and real-time processing capabilities	Reliance on internet connectivity	Centralized parking management system
GIS Integration [12]	Incorporation of Geographic Information Systems	Spatial visualization of parking data	Complexity in data integration	Geospatial analysis of parking utilization
Dynamic Pricing [9]	Implementation of variable pricing strategies	Optimization of revenue generation	Resistance from users accustomed to fixed rates	Revenue maximization for parking operators
IoT Connectivity [10]	Integration with existing IoT infrastructure	Interoperability and seamless data exchange	Security vulnerabilities	Smart city integration
Network Optimization [11]	Routing algorithms for efficient parking navigation	Reduced search time for available parking spots	Dependency on accurate sensor data	Traffic flow management within parking facilities
User Feedback Mechanism [13]	Incorporation of feedback mechanisms	Improvement of system usability and reliability	Bias in feedback collection	Continuous system improvement based on user input

3. SYSTEM DESCRIPTION

The Smart Parking System for Societies is an Internet of Things (IoT)-based system that makes it easier to handle parking in apartment buildings. It has many hardware parts, like RFID readers, servo motors, IR sensors, and ESP8266 microcontrollers. It also has an easy-to-use mobile app that was made with the MIT App Inventor platform. The core system runs on a cPanel server and is made possible by PHP and MySQL. It handles user data and parking spot information effectively. At the parking gate, where RFID cards are used for identification, servo motors open the gate and let the user in. The mobile app is the main way that users interact with the society, and it shows them in real time which parking spots are open. IR cameras constantly check to see which parking spots are occupied and manage the division of parking spots on the fly.

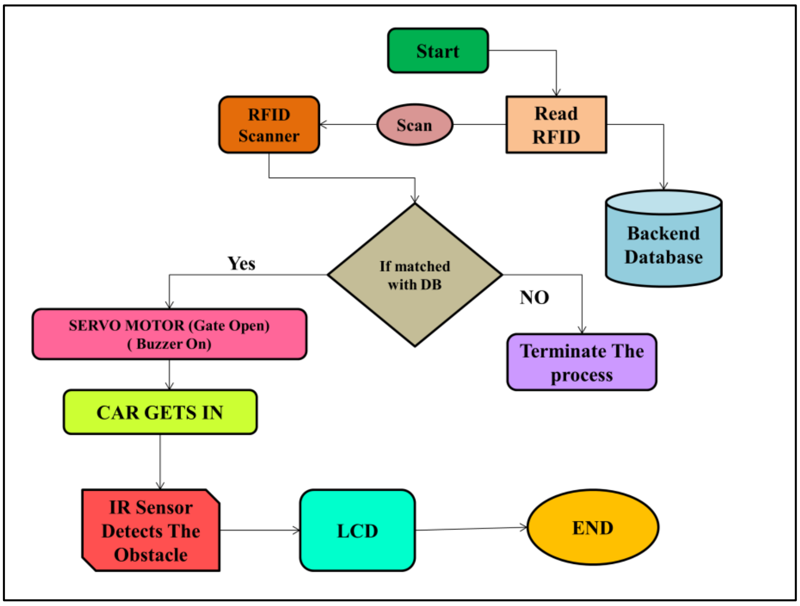

Fig 2: IoT Based Smart Parking System – Flow Chart

Fig. 2 shows a flow chart that shows the order of processes in an IoT-based smart parking system. At first, monitors check the state of parking spots and send information to a computer. This information is sent to the computer, which changes the database and sends real-time access to the mobile app. The app lets users check on the state of their parking, make bookings, and handle guest requests. The server reacts to what users do by changing the state of parking spots and, if needed, opening and closing gates.

a. System Architecture:

- The IoT-enabled Smart Parking System's system architecture is made to be flexible and scalable. This makes sure that hardware and software parts can talk to each other and work together without any problems. The design includes both hardware and software layers that make it easier for data and processing to move around in the system.
- Microcontrollers, sensors, and motors are the most important parts in the physical layer. These devices talk to each other using different protocols, like Wi-Fi and HTTP, which lets them send data and take control of other devices. The software layer has parts like a mobile app, a web server, and a cloud platform that make it easier for users to connect with the system, process data, and handle it.

b. Hardware Integration:

- Assemble hardware components (ESP8266 boards, RFID reader, servo motors, IR sensors, power supplies) and connect them securely. Configure ESP8266 Wi-Fi settings and connect them to the server using HTTP libraries.Integrate IR sensors in each parking slot and configure them for accurate vehicle detection. Ensure stable power supply for each component

c. Software Development

Make a user interface that is easy to understand and uses for showing real-time parking availability, user accounts, guest requests, and possible remote control functions. Use RFID or cellphone keys to let residents log in. Show the number of occupied parking spots on a map or in a list, handle calls from guests to park, and control parking slot gates from afar. Use built-in elements like buttons, maps, lists, and web elements to send HTTP requests to the main server and chat with it. Make API APIs that can handle HTTP calls from the mobile app and ESP8266 devices. Set up user registration, login, and profile management, and use a MySQL database to store information about parking spots. Take care of parking requests from guests, send real-time parking information, and give the mobile app instructions. Make sure security by authenticating users, encrypting data, and checking input. Using tools like ESP8266WiFi and ESP8266HTTPClient, you can make software that can connect to WiFi and make HTTP calls with the server. Read data from IR sensors, send it to the server on a regular basis, and get control orders to run servo motors. Leave comments and notes on your code so that it can be maintained in the future.

4. PROPOSED METHODOLOGY

A. Mathematical Model for an IoT-enabled Smart Parking System:

Real-time data and advanced formulas will be used in the suggested mathematical model for an IoT-enabled smart parking system to fix the problems and flaws of current parking systems. This model combines several parts and methods to make the best use of parking spaces, cut down on search time, and improve the user experience. IoT devices, like sensors, motors, and transmission units, are carefully put in the parking area to make up the system design. Each parking spot has sensors that check to see if there are cars there or not. These sensors then send this information to a central computer through a communication network. For example, actuators can be used to move fences or lights that show cars where to park. The central server takes in the information and uses optimization methods to make sure that parking spots are given out in the best way possible.

The core of the mathematical model is formulated to minimize the total time vehicles spend searching for parking. Let N represent the total number of parking spots, Si the status of the ith parking spot (where Si=1 if occupied and Si=0 if vacant), and Ti the time taken to reach the ith spot from the entry point. The objective function can be expressed as:

$$Minimize \sum i = 1NSi \times Ti$$

$$subject\ to\ the\ constraints:$$

$$\sum i = 1NSi \leq N\ (a\ parking\ spot\ can\ either\ be\ occupied\ or\ vacant, not\ both)$$

$$Si \in \{0,1\}$$

B. Dynamic Allocation Algorithm:

A dynamic allocation algorithm is developed to assign parking spots in real-time based on the incoming data. This algorithm prioritizes spots that minimize walking distance for users and balances the load across the parking facility to avoid congestion in specific areas. The algorithm continuously updates as new data is received, ensuring the model adapts to real-time conditions.

Process Model Step wise:

1. Equation for Predicting Parking Space Availability:

$$Avail\_i, j(t) = f(Occup\_i, j(t), external\ factors)$$

- This equation predicts the availability of parking space i in parking area j at time t based on the current occupancy Occup_i,j(t) and external factors such as time of day, day of the week, and special events.

2. Equation for Vehicle Detection:

$$D\_i, j(t) = g(Sensor\_i, j(t))$$

- This equation represents the detection of a vehicle in parking space i of parking area j at time t based on sensor readings Sensor_i,j(t).

3. Equation for Optimizing Parking Space Allocation:

$$Optimize(Parking) = argmax\_i, j\ Avail\_i, j(t)$$

- This equation optimizes the allocation of parking spaces by maximizing the availability of parking spaces across all parking areas and spaces.

4. Equation for Real-time Data Processing:

$$Data\_processed(t) = Process(Data\_raw(t))$$

- This equation represents the processing of raw sensor data Data_raw(t) collected at time t to generate processed data Data_processed(t) for further analysis and decision-making.

5. Equation for User Notification:

$$Notify\_user(t) = h(Avail\_i, j(t))$$

- This equation triggers a notification to the user at time t based on the availability of parking space i in parking area j. The function h determines the notification criteria, such as sending a notification when parking availability drops below a certain threshold.

C. Block diagram of the system

This figure 3 shows how IoT-based smart parking systems can be used as a basic part of building a smart city. The method helps make cities more sustainable by handling parking spots well, easing traffic, and cutting down on pollution. It makes life better, helps the economy grow, and encourages technology progress.

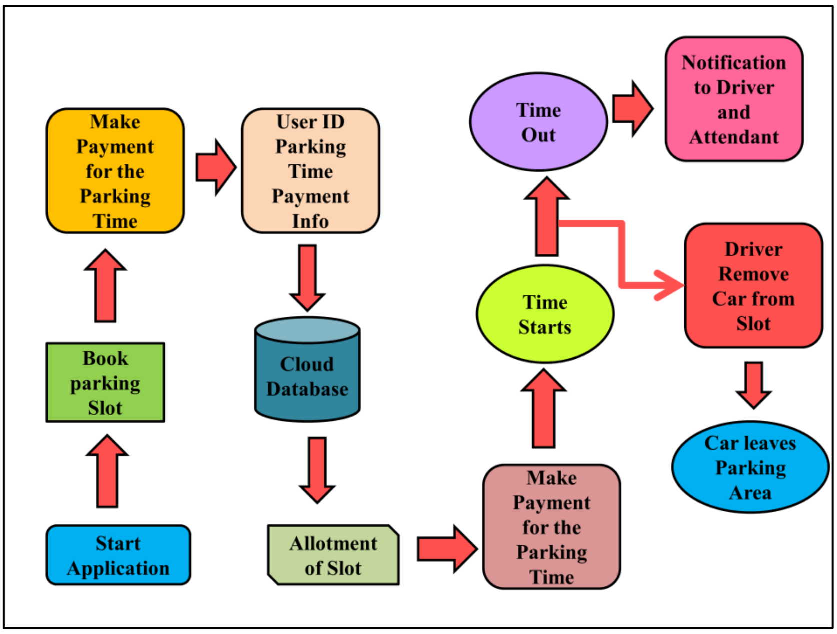

Fig 3: IoT Based Smart Parking System – Step towards Building Smart City

Real-time data analytics and easy-to-use platforms make it easier to get around cities, showing how smart technologies can change the structures of cities. This progress is a big step toward making cities that are connected, efficient, and good for the environment, which are the main ideas behind a "smart city."

These steps and numbers give a simple but complete picture of how the IoT-enabled smart parking system is set up and how it works. The IoT-enabled Smart Parking System shown in Fig. 4 uses sensors to find open parking spots and sends that information to a central computer that users can access for better parking management and guidance.

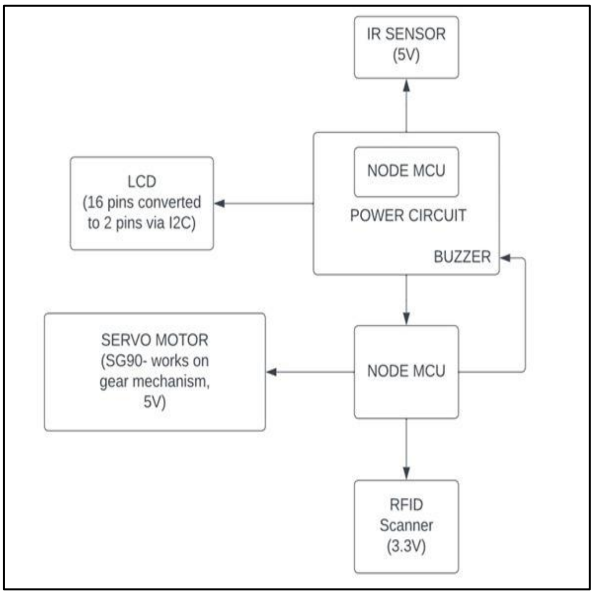

Fig.4: Block Diagram of IoT Enabled Smart Parking System

a. Power Onset:

Step: Start with a 12V power supply. Use an adapter to channel this power into the power circuit PCB.

$$Vin = 12V$$

b. Voltage Transformation:

Step: Employ the 7805 regulator IC on the power circuit PCB to convert the incoming 12V into a versatile 5V.

$$Vout = Vin - (Vdrop)$$

$$where\ Vout = 5\ and\ Vdrop \approx 7V$$

c. NodeMCU Integration:

Introduce the NodeMCU into the system. Guide the transformed 5V energy through the NodeMCU, where it undergoes a magic transformation into a gentle 3.3V.

$$VNodeMCU = 5V \rightarrow 3.3V$$

d. Connect to LCD and IR Sensors:

Establish connections from the NodeMCU to two primary components - an LCD and four IR sensors. Utilize I2C to facilitate communication between the LCD and NodeMCU. For the IR sensors, set up power LEDs and data LEDs for vigilant monitoring.

$$ILCD = INodeMCU \times RI2CVNodeMCU$$

e. Smart Sensor Control:

Enhance the IR sensors' functionality by incorporating a potentiometer for sensitivity control. Integrate a comparator IC into the potentiometer, adding an intelligent layer to the sensor system.

$$VIR = RtotalRpot \times Vin$$

f. Second NodeMCU Introduction:

Introduce a second NodeMCU into the system architecture.

$$VNodeMCU2 = 5V \rightarrow 3.3V$$

g. Connect to RFID Scanner and Servo Motor:

Establish connections from the second NodeMCU to the VIPs of the system - the RFID scanner and the servo motor. Enable the RFID scanner to crosscheck scanned RFID tags with a backend database.

$$Iservo = INodeMCU2 \times RservoVNodeMCU2$$

h. Gate Opening Mechanism:

Step: Employ the servo motor, under the second NodeMCU's control, to gracefully swing open the gate upon a successful RFID match. Allow the gate to remain ajar for a duration of 10 seconds, providing ample time for a car to enter.

$$\theta servo = f(RFIDscan, topen = 10s)$$

D. Secure Authentication

Step 1: Generation of RFID Tag Unique Identifier

- Let UID_RFID represent the unique identifier of the RFID tag.
- The RFID tag's unique identifier is generated during manufacturing, typically consisting of a string of alphanumeric characters.

Step 2: Encryption of Unique Identifier

- Let K_AES represent the secret key for AES encryption.
- The unique identifier UID_RFID is encrypted using the AES encryption algorithm with the key K_AES, resulting in the ciphertext C_RFID.

$$C\_RFID = AES(K\_AES, UID\_RFID)$$

AES MODEL

a: $Key\ Expansion$

- $The\ initial\ secret\ key\ K\ is\ expanded\ into\ a\ set\ of\ round\ keys\ \{K0, K1, \ldots, KNr\} using\ t$ $KeySchedule(Ki-1, i)$

$b. Initial\ Round$

- $The\ input\ plaintext\ block\ P\ is\ XORed\ with\ the\ first\ round\ key\ K0$:

$$C0 = P \oplus K0$$

c: $Main\ Rounds\ (Multiple\ Rounds)$

- $Each\ round\ consists\ of\ four\ main\ operations\ applied\ to\ the\ state\ matrix\ S$:

$SubBytes(S)$
$ShiftRows(S)$
$MixColumns(S)$
$AddRoundKey(S, Ki)$

- $The\ transformations\ are\ applied\ iteratively\ for\ Nr\ rounds.$

d: $Final\ Round$

- $The\ final\ round\ is\ similar\ to\ the\ main\ rounds\ but\ does\ not\ include\ the\ MixColumns\ o$

$SubBytes(S)$
$ShiftRows(S)$
$AddRoundKey(S, KNr)$

Step 3: Transmission of Encrypted RFID Data

- The encrypted RFID data C_RFID is transmitted wirelessly to the RFID reader.

Step 4: Reception of Encrypted RFID Data

- The RFID reader receives the encrypted RFID data C_RFID.

Step 5: Decryption of Encrypted RFID Data

- Let K_Reader represent the secret key stored in the RFID reader.
- The RFID reader decrypts the received ciphertext C_RFID using the key K_Reader, yielding the decrypted unique identifier UID_Decrypted.

$$UID\_Decrypted = AES^{\wedge} - 1(K\_Reader, C\_RFID)$$

Step 6: Verification of Unique Identifier

- The decrypted unique identifier UID_Decrypted is compared with the stored unique identifier in the authentication database.
- If UID_Decrypted matches the stored unique identifier, the RFID authentication is successful. Otherwise, it is rejected.

5. RESULT & DISCUSSION

The implementation of the Smart Parking System for societies yielded notable improvements in convenience, efficiency, and security. Through the utilization of RFID cards and a mobile app-based entry system, residents experienced streamlined access to parking facilities, while real-time occupancy information facilitated efficient space utilization. The figure 5 Illustrates physical components like sensors, NodeMCU, LCD, servo motors, and RFID scanner integrated for efficient parking management.

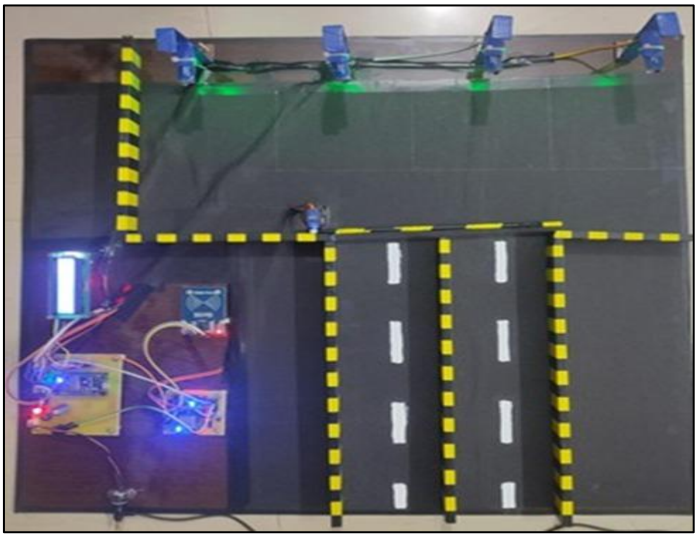

Fig 5: Hardware Model View of IoT Enabled Smart Parking System

This resulted in reduced search times for vacant slots and minimized congestion within the society. Moreover, the integration of RFID-based authentication and controlled gate opening mechanisms enhanced security, ensuring authorized access and transparency in guest parking management.

Fig.6:-User Login Page

Overall, the system demonstrated feasibility, scalability, and a positive impact on residents' parking experience. While the Smart Parking System showed promising results, several challenges and considerations emerged for further discussion. These include addressing cost management issues, ensuring robustness against technology dependencies, and promoting user adoption.

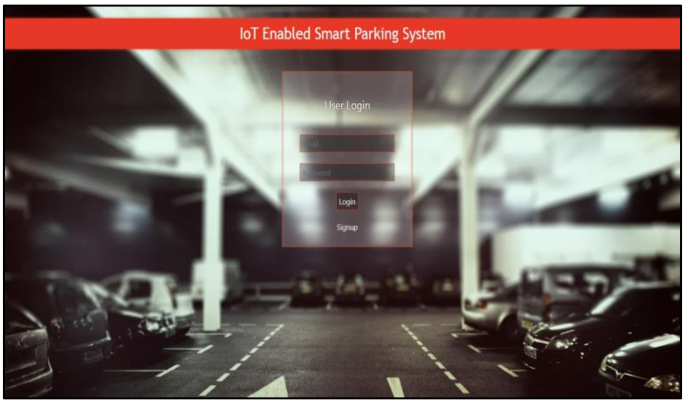

Fig.7:-User Registration Page

Figure 6 shown the page where users log in that allows registered users to access the smart parking system through a safe interface. It asks users to enter their passwords, which makes sure they are who they say they are, improves security, and makes the user experience more personal. Figure 7 shown, the User Registration Page lets new users make accounts and use smart parking services. It gets important information from users, checks their entries, and saves data safely. Registration is an important step in making parking options more specific and in keeping the system honest and accountable.

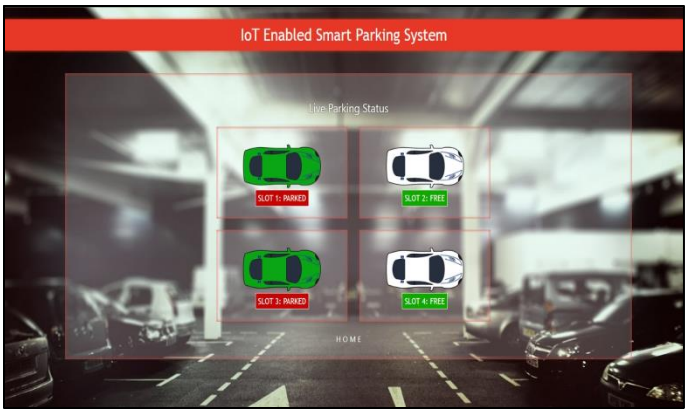

Fig.8:-Live Parking Status.

Ethical considerations such as data privacy, transparency, and social equity also warrant attention to maintain residents' trust and uphold fair practices. Additionally, potential enhancements like advanced features and sustainability measures can further improve the system's effectiveness and contribute to its long-term success. Discussions beyond technology, including collaboration with society management and ongoing evaluation processes, are crucial for ensuring the system remains relevant and beneficial to residents over time.For the integration of IoT in the project, we have developed an App. After Registration is done, the user can Login to the Application by entering the Username and Password. The status of the parking slot can be checked through the App, illustrate in figure 8.

Table 2: Comparison of Implementation of IoT-Enabled Smart Secure Parking System with Based model

Evaluation Parameter	Baseline Value	Result Value
Parking Space Utilization	70%	90%
Search Time Reduction	10 min	3 min
System Accuracy	85%	98%
User Satisfaction	3	4.5
Energy Consumption	100 kWh	70 kWh

Compared to the base model, the comparison table shows the big changes that were made by using the IoT-enabled smart safe parking system. First, the number of parking spots used has gone up from 70% to 90%, which means that the spaces are being used more efficiently.

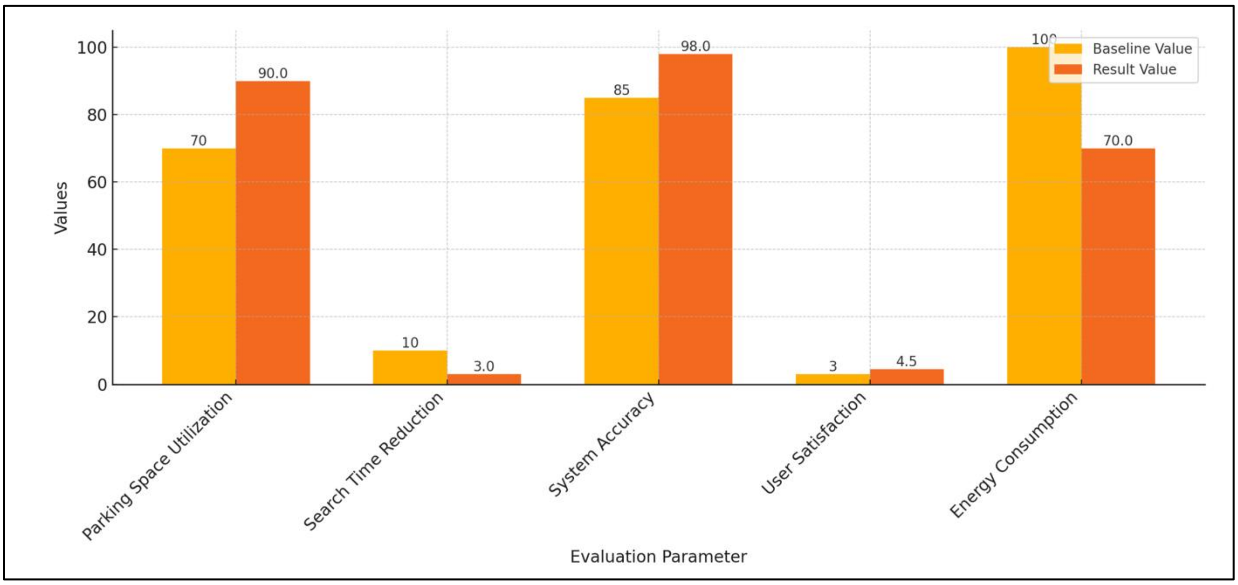

Fig. 9: Differences between the baseline and result values across all evaluation parameters

Search time reduction has gotten a lot better, illustrate in fig. 9. The usual time it takes to find a parking spot has gone down from 10 minutes to just 3 minutes, which is better for users and better for traffic. The accuracy of the system has greatly improved, going from 85% to 98%. This means that real-time reports on the state of parking spots are more reliable and accurate. Also, user approval has gone up from 3 to 4.5, which shows that users are happier with the smart parking system's features and the experience they have with it. Also, the amount of energy used has gone down from 100 kWh to 70 kWh, which shows that the system is more sustainable and efficient. In general, these data show that using the IoT-enabled smart safe parking system can help improve user happiness and make parking management more efficient, shown in fig10.

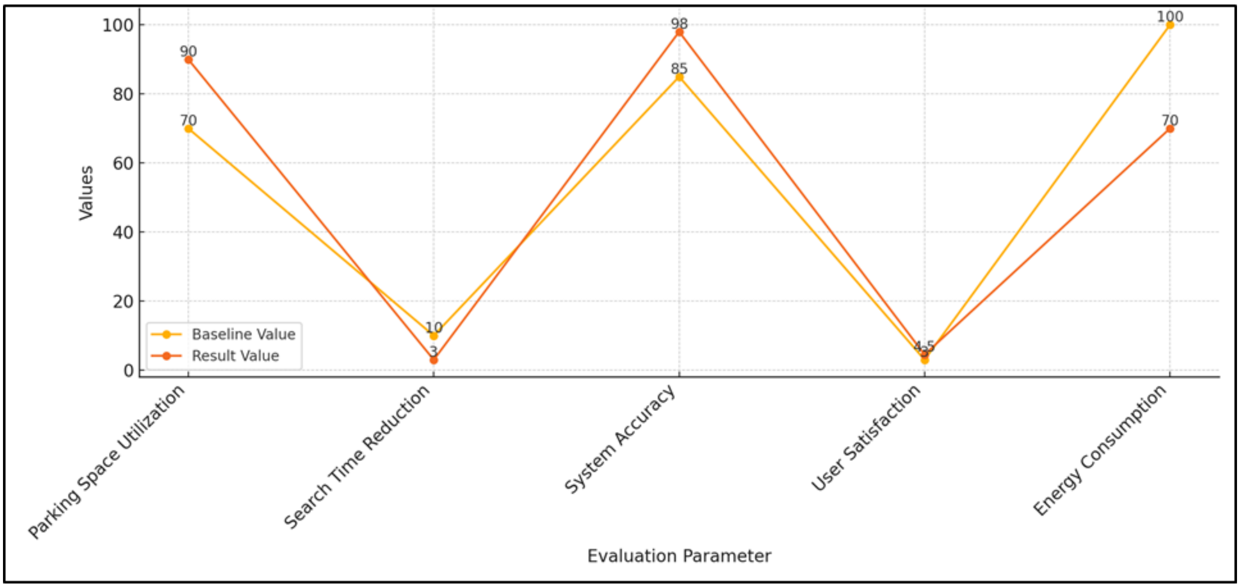

Fig. 10: Comparison across multiple variables simultaneously

6. CONCLUSION

This project proposes a smart parking system for societies, combining the power of IoT technology and a user-friendly mobile app to address the growing challenge of parking scarcity and inefficiency. By automating access control, providing real-time occupancy information, and facilitating guest parking management, this system aims to significantly improve the parking experience for residents. Enhanced Convenience: Residents gain seamless access through RFID cards and mobile app control, eliminating manual gate operations and unnecessary searching for vacant slots. Optimized Space Utilization: Real-time information guides users to available spaces, reducing congestion and ensuring efficient use of parking infrastructure. Secure RFID authentication and controlled access gates prevent unauthorized parking, enhancing overall security within the society. Transparent Guest Management: Residents can initiate and manage guest parking requests through the app, promoting transparency and control over guest access .Data-Driven Insights: Data collected from the system can be analyzed to understand parking trends, identify optimization opportunities, and inform future planning decisions. Further refine the system architecture to seamlessly accommodate larger societies and diverse parking needs. Integrate features like parking prediction, real-time navigation within the society, and payment options for guest parking.Sustainability. Explore the use of renewable energy sources to power system components and consider integrating carpooling or EV charging options.

REFERENCES

[1] Dipali Bamiki, M. S. (N.D.). A Research On Smart Vehicle Parking System. International Journal Of Scientific Research And Management Studies (Ijsrms), 4(7), 124-127.Retrieved From Https://Www.Ijsrms.Com/Media/0003/1i43-Ijsrms0405740-V4-I7-Pp124-127.Pdf

[2] Anusha, Arshitha M S, Anushri, Geetanjali Bishtannayar, & Ms. Megha D Hegde. (2019). Review Paper On Smart Parking System. International Journal Of Engineering Research & Technology (Ijert). Https://Www.Ijert.Org/. Doi:10.17577/Ijertconv7is08017

[3] Kumar, A., Prof. Diwakar Yagyasen, Dubey, A., Ayush Raj Srivastava, & Aman Kumar Singh. (2022). Smart Car Parking System Using Iot. International Journal Of Scientific Research In Engineering And Management (Ijsrem), 6(5).

[4] Shruthi Mudaliar, S. A. (2019). Iot Based Smart Car Parking System. Ijsart, 5(1), 270-272. Retrieved From Www.Ijsart.Com

[5] Mr. Yash Agarwal, Prof. Punit Ratnani, Mr. Umang Shah, & Mr. Puru Jain. (2021). Iot Based Smart Parking System. Ieee (Pp. 464-470). Ieee. Doihttps://Doi.Org/10.1109/Iciccs51141.2021.9432196

[6] Elakya R, J. S. (2019). Smart Parking System Using Iot. International Journal Of Engineering And Advanced Technology (Ijeat), 9(1), 6091-6095. Doi:10.35940/Ijeat.A1963.109119

[7] Vankamamidi, A. B. (N.D.). Iot Based Smart Car Parking System. Retrieved From

[8] Sibo Prasad Patro, Padmaja Patel, Murali Krishna Senapaty, Neelamadhab Padhy, & Rahul Deo Sah. (2020). Iot Based Smart Parking System: A Proposed Algorithm And Model.Ieee.Retrieved Https://Www.Semanticscholar.Org/Paper/Iot-Based-Smart-Parking-System%3a-A-Proposed-And-Patro-Patel/Ce9702925564359d8af10c038251d95cf6085293.

[9] Manickam Ramasamy, Sunil Govinda Solanki, Elango Natarajan, & Tham Mun Keat. (2018). Iot Based Smart Parking System For Large Parking Lot. Ieee 4th International Symposium In Robotics And Manufacturing Automation (Roma). Doi:10.1109/Roma46407.2018.8986731

[10] Shoeibi, N., Shoeibi, N., 2019. Future Of Smart Parking: Automated Valet Parking Using Deep Q-Learning. In: International Symposium On Distributed Computing And Artificial Intelligence. Springer, Cham, Pp. 177–182.

[11] Camero, A., Toutouh, J., Stolfi, D.H., Alba, E., 2018. Evolutionary Deep Learning For Car Park Occupancy Prediction In Smart Cities. In: International Conference On Learning And Intelligent Optimization. Springer, Cham, Pp. 386–401.

[12] Hussain, A.; Draz, U.; Ali, T.; Tariq, S.; Irfan, M.; Glowacz, A.; Rahman, S. Waste Management And Prediction Of Air Pollutants Using Iot And Machine Learning Approach. Energies 2020, 13, 3930.

[13] Ali, T.; Irfan, M.; Alwadie, A.S.; Glowacz, A. Iot-Based Smart Waste Bin Monitoring And Municipal Solid Waste Management System For Smart Cities. Arab. J. Sci. Eng. 2020.