IoT Based Electric Vehicle Charging Slot Reservation System

Kotha Vennala[1], Arram Raju Akshitha[2], Arja Jitendra Sai[3], Dr. S. Ravikumar [4]
[1,2,3] UG Scholar, Dept. of ECE, St. Martin's Engineering College, Secunderabad, Telangana, India, 500100
[4]Associate Professor, Dept. of ECE, St. Martin's Engineering College, Secunderabad, Telangana, India, 500100
vennalareddy1626@gmail.com

Abstract:

The Immense growth in the implementation of Electric vehicles (EVs), has established a path in the advancements of charging system. Connecting the charging stations to a common server is essential for future EV adoption. So, there is an issue with the charging time if someone is charging their vehicle at the station, it takes time to charge, so it is not possible to wait. Which leads to the unavailability of slots in charging stations. To overcome this problem an IoT based slot registration in EVs charging station is proposed. The existing charging stations have not implemented charging slot availability and time scheduling. Our paper is proposed to share real-time information about the availability to reserve slots at charging stations. This system uses Real Time Clock (RTC) for the real time traffic database to estimate the shortest path to reach the charging station. An IoT module is used to monitor and signalize the state of availability of each slot in the charging station. The system leverages the Internet of Things (IoT) to facilitate secure reservations via a mobile or web application. It consists of smart charging stations equipped with sensors and microcontrollers that communicate with a cloud-based server. Users can make reservations, and receive notifications through the application. The aim of this paper is to ease the scheduling of the charging the EVs at charging stations by not to be interrupted by another Vehicle. The proposed system will result in a reduction in waiting time with good accuracy. In this we have used both hardware and software components. The hardware is GSM, IoT, RPS, ESP32 microcontroller, buzzer and RTC and the software is Embedded C.

Keywords: ESP32 Microcontroller, GSM, IoT, RTC, RPS, Buzzer, Keypad, EV Charging point.

1.INTRODUCTION

A charging station, also known as an electric powered automobile charging station, an electric powered recharging factor, a charging factor, a price point, a digital charging station (ECS), or an electric powered automobile supply equipment (EVSE), is a device that supplies electric power to charge plug-in electric vehicles such as cars, neighbourhood electric vehicles, vans, buses, and other types of vehicles. On-board converters in certain electric vehicles hook into a conventional electric socket or a higher voltage outlet. Others rely on their own charging stations. Connectors that meet a variety of specifications are available at charging stations. Chargers are provided with a handful of adapters, including blended Charging Machine (CCS), and AC fast charging, for typical direct current fast charging. Avenue charging stations, as well as retail shopping centres, government offices, and parking lots, are common places to find public charging stations. Multiple charging era standards have been established to allow interoperability among carriers. Nomenclature, energy, and connectors all have standards. Tesla has evolved proprietary technology in these areas, which is significant. AC Type 1 / Type 2 plugs are utilized even when charging. A vehicle that transports the charger to the car is required for cell charging.

Inductive charging mats that rate without a connected connection is used in Wi Fi charging and can be implanted in parking stalls or even on motorways. A battery switching station allows cars to replace a drained battery with a charged one, removing the cost of the c programmer language period. A battery switching station is a location where an electric car may drive over and an automatic (or perhaps even manual) system can open the bottom of the vehicle, remove the exhaust battery, and replace it with a fully charged battery. To implement this era, the car must be made so that it can be stretched out using a chamber on the bottom and by unexpectedly starting up the bolts beneath the car. The following advantages are claimed: battery swapping takes less than five minutes, refuelling takes less than five minutes, the driver can stay in the car while the battery is switched, and spare batteries could participate in vehicle to grid electricity transfers. Car charging cables, like cell phone charging cords, usually have two connectors: one that goes into the car socket and the other that plugs into the fee element itself. The type of connector you'll require depends on the vehicle and the rate point's strength score ("speed"). A type 2 socket is found in the majority of the slow/fast rate factors. As an alternative, they will occasionally have a cable connected. A cable with a CHAdeMO and a CCS connector is commonly attached to all DC rapid charging stations.

2. LITERATURE SURVEY

Electrical vehicles require a charging station similar to current fuel car require a petrol pump and obviously charging takes some time, so it is better to charge the car when it is parked, therefore it is efficient to combine both the charging and parking system which is based on the IoT technology which makes the system user friendly [1]. One can upload information on cloud and simultaneously on smart phones. Car safety while parking is one of the issues faced by people. The internet of things (IoT) is the best platform for monitoring the status of WPT system which is able to provide the wider connectivity, modified sensing, information processing and greater flexibility. [1] talks about "Wireless charging system" and "Inductive Power Transfer". Under wireless charging system, this paper covers various aspects of wireless charging of electric vehicles, fundamental operation of wireless charging system including inductive wireless charging technique. It compares the inductive power transfer for different charging systems. Overall, this paper compares various smart parking, charging and combined charging parking system, which can help to solve various issues related with it. Also, it contains a table of comparison of various research papers. Various types of methods and techniques used for parking and charging are discussed. Various sensors, controllers,

software and cloud servers are available at the market which will help to make system automatic, reliable and user friendly along with development of efficient IoT platform [1].

IoT based Smart Car Parking with Wireless Charging Feature for Electric Car, International Research Journal of Engineering and Technology (IRJET) Volume:07 Issue:08 (Ms. Lekshmi M, Mr. Mayur P, Mr. Manjunatha B, Ms. Kavya U, Mr. Anil Kumar J H) 6 The problem of finding a parking space in metro cities is a herculean task in the fast-moving world. The need for the hour is an IoT backed solution wherein the availability is based on the reservation management facility [2]. This paper talks of employing an app based IoT smart parking system. To prevent long waits at the EV charging station, the parking system is equipped with a wireless charging scheme for electric vehicles. This serves dual advantage of parking vehicles as well as charging electric vehicles [2]. The Wireless charger designed is a Resonant Inductive Power Transfer System employed due to its consumer suitability and its effect on battery performance. The coil coupling and power electronics infrastructure decides the efficiency of the charging system and hence facilitates the charging of Electric Vehicles at the same speed as that of standard AC plug-in chargers.

IoT Based Electric Vehicle Application Using Boosting Algorithm for Smart Cities (Shabana Urooj, Fadwa Alrewas, Yuvaraja Tee Karaman, Hariprasath Manoharan, Ramya Kuppusamy) To overcome all issues in existing vehicles and for protecting the environment, electric vehicles should be introduced by integrating an intellectual device called sensor all over the body of electric vehicle with less cost [3]. Therefore, this paper confers the need for and importance of introducing electric vehicles with IoT based technology which monitors the battery life of electric vehicles. An online monitoring system, which is called Things Speak has been used for monitoring all the vehicles in a continuous manner (day by day). These online results will then be visualized in MATLAB after an effective boosting algorithm is integrated with objective function [3]. It was observed [3] that the cost of implementation is lesser and capacity of electric vehicle is increased to about 74.3% after continuous monitoring with sensors.

IoT Enabled Smart Charging Stations for Electrical Vehicles, Journal of Telecommunication Study Volume: 4 Issue: 2 (Esha Sharma, Bharath S, Adarsh Deva Ramani, Deepti Sr, Saravana Kumar) [4] This paper makes a smart application to know the different tariff rates of the grid by connecting to the grid. The tariff rates include both the power intake rate and also the outgoing power rate. When the user comes to the grid, the application also displays the battery SOC. The main agenda of this paper [4] is to optimize low carbon technologies through one connected platform using rulebased algorithms, helping to decarbonize both the production and consumption of energy. The status of the battery is computed by the Arduino uno (microcontroller), then the computed data is stored in cloud, where the ESP8266 acts as intermediate device between the microcontroller and the network. [4] The stored data is accessed by the cloud using certain applications like Ad fruit, MQTT dashboard etc. Hence the user will get to know about their car's battery status and also they can provide an excess amount of charge to any other applications, by knowing the status of the battery. An article on "PARKPLUS Electric Vehicle Charging for Automated Parking" PARKPLUS Electric Vehicle Charging [5] is an integrated solution to provide paper-specific EV charging capacity to PARKPLUS Automated and Semi-Automated Parking Systems. The PPEVC solution is designed for palette-based parking systems and parking platforms that include power for manual connection when parking. In this, charging power is connected upon manual connection, or when the parking platform arrives at designated parking.

The Smart Charging Slot Reservation and Utilization System for Electric Vehicles operates using IoT technology to provide real-time monitoring and remote booking of charging slots. Users can check slot availability and reserve a charging station through a mobile app or web portal, reducing waiting times and ensuring a hassle-free experience. The system employs sensors and cloud computing to update the status of charging slots dynamically. RFID, OTP verification, or mobile authentication is used to ensure secure access to reserved slots. Dynamic load management distributes power efficiently, preventing grid overload and optimizing energy consumption. The system also integrates with renewable energy sources, such as solar and wind power, for sustainable charging solutions. However, the system faces limitations, including high initial setup costs, making widespread adoption challenging. Connectivity issues in remote areas may lead to delays in reservation updates and system responsiveness. Additionally, cybersecurity risks pose a threat to user data and system security, requiring strong encryption and authentication measures. Despite these challenges, smart charging slot reservation systems enhance EV charging efficiency, reduce congestion, and support the transition to a more sustainable transportation ecosystem.

3. PROPOSED METHODOLOGY

In this paper, we present a working model of an IOT-based EV Charging Slot Booking System. The increasing adoption of electric vehicles (EVs) is straining existing charging infrastructure, leading to challenges in finding available slots. This paper presents a novel EV charging slot booking block utilizing the capabilities of the Internet of Things (IoT) and aESP-32 microcontroller. The system features real-time slot availability monitoring, secure booking and reservation management, user authentication, and integrated charging control

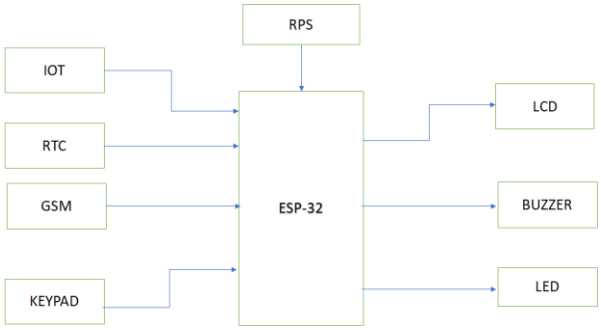

Figure 1: Block Diagram of EV charging system.

Implemented using IOT, ESP32 microcontroller, GSM, keypad, RPS, RTC, LCD, buzzer, Arduino IDE tool, and embedded c language, the system successfully demonstrates the booking of slot using IOT application, RTC gets activated and sends an activation code to the registered user using GSM module, after entering the code and required amount of charging the microcontroller activates the charging station, with this paper the user will benefits with the reduced waiting time for charging slots. This approach has the potential to significantly improve charging efficiency, reduce waiting times, and enhance user convenience, contributing to the advancement of smart grid management and sustainable transportation.

we have RPS, GSM module, ESP32 microcontroller, keypad, RTC module, LCD, buzzer and IOT module. Here the user selects the slot and time for charging his EV, when the selected time comes RTC gets activated and sends an activation code to the user's mobile using GSM, when the user arrives at the slot he needs to enter the code to authenticate EV starts charging when it charges up to the time it automatically turns off. Throughout the process, all details will be displayed in the LCD display.

The proposed system aims to develop a smart EV charging slot reservation platform using ESP32 and IoT technology. It allows users to pre-book charging slots through a mobile app or web interface. The ESP32 microcontroller acts as the central unit, handling real-time data exchange between the server and charging stations. Users can book slots, and track charging status remotely. The system is connected to a cloud database, which stores reservation details and charging history.

Upon arrival, users authenticate OTP to access their reserved slot. The system automatically starts charging once authentication is successful. Real-time sensors monitor power consumption, battery status, and charging duration. The ESP32 communicates with the cloud to update charging status and notify users when charging is complete. If a user fails to arrive within a specified time, the slot is released for other users. Data analytics help optimize charging station utilization and energy distribution. Charging station administrators can monitor usage statistics, energy consumption, and revenue reports. Users receive real-time notifications about their charging session, including estimated completion time. The system reduces waiting times and congestion at charging stations. IoT-based remote monitoring and control enhance security and prevent unauthorized access. This solution is scalable, making it suitable for residential, commercial, and public charging infrastructure. Overall, the system improves EV charging efficiency, accessibility, and sustainability, supporting the global transition to electric mobility.

Applications:

Electric Vehicle charging stations can be used in a wide range of applications, including:

- **Smart EV Charging Stations**
  Used in public charging hubs, malls, parking lots, and highways to enable users to reserve slots in advance.
- **Residential EV Charging Management**
  Homeowners can manage personal EV chargers remotely, monitor energy consumption, and schedule charging sessions.
- **Corporate and Fleet Charging Systems**
  Companies managing EV fleets can schedule and optimize charging for efficiency and cost-effectiveness.
- **Smart Cities and Sustainable Urban Development**
  Integrated into smart city infrastructures to promote green energy usage and reduce congestion at charging stations.
- **E-commerce and Delivery Vehicles**
  Ensures timely charging for electric delivery vehicles, reducing downtime and improving logistics.
- **Tourism and Hospitality Sector**
  Hotels and resorts can offer EV charging reservations as a premium service for guests.

Advantages:

- **User Convenience & Time Efficiency**
  Users can pre-book charging slots, reducing waiting time and ensuring availability.
  Remote monitoring allows users to check charging progress via mobile apps.
- **Optimized Energy Usage**
  Smart scheduling prevents power overload by distributing charging loads efficiently.
  Reduces energy wastage with automated power cut-off when charging is complete.
- **Enhanced Security & Authentication**
  Secure access using OTP ensures only authorized users can access the charger.
- **Real-Time Monitoring & Control**
  Cloud-based IoT integration provides real-time data on system status.
- **Supports Sustainable & Green Energy Integration**
  Can be integrated with solar panels and renewable energy sources to support eco-friendly charging.
- **Data Analytics for Better Management**
  Collects and analyses charging behaviour, energy usage, and demand trends, helping improve infrastructure planning.
- **Cost-Effective & Scalable**
  Uses ESP32, a low-cost microcontroller, making the system affordable and scalable for different applications.

4. EXPERIMENTAL ANALYSIS

Figure 1 represents an IoT-based electric vehicle (EV) charging slot registration system when the kit is powered ON. The system is activated, it connects to the internet, allowing users to check and book available charging slots. The LCD displays real-time slot status, and the system ensures secure authentication and payment processing for seamless EV charging reservations.

Figure 1: Ev Charge Slot Reservation System

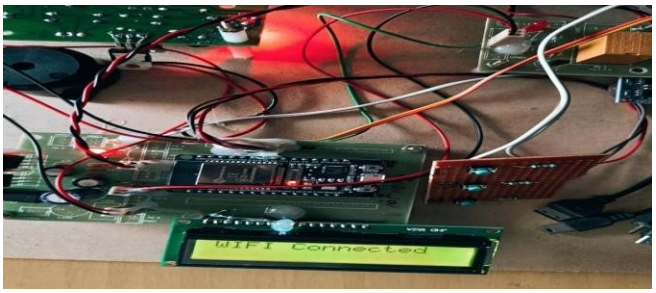

Figure 2: Wi-Fi Connected

The system establishes a stable internet connection via a Wi-Fi module, enabling real-time communication with the cloud server or mobile application. Once connected, users can access the charging slot booking system remotely, check availability, and register for a slot. The LCD display or app interface confirms the successful connection, ensuring seamless interaction between the user and the system. The Wi-Fi is connected to the network as shown in the figure 2 (network name: iotserver and password: iotserver123).

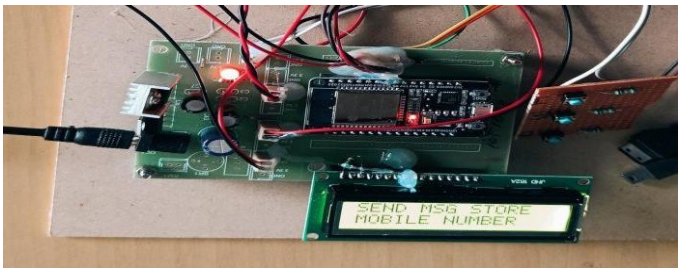

Figure3: Mobile Number Registration

The LCD screen displays a message prompting the user to send an SMS with a mobile number, suggesting a GSM module for communication. The central microcontroller, likely an ESP32 or similar, manages the system's operations, processing user inputs and controlling the charging slot. A buzzer and LED indicators provide real-time feedback, ensuring users are notified about system status We have to send the SMS to the sim which we have inserted in the GSM to register u are mobile number as shown in the figure 3.

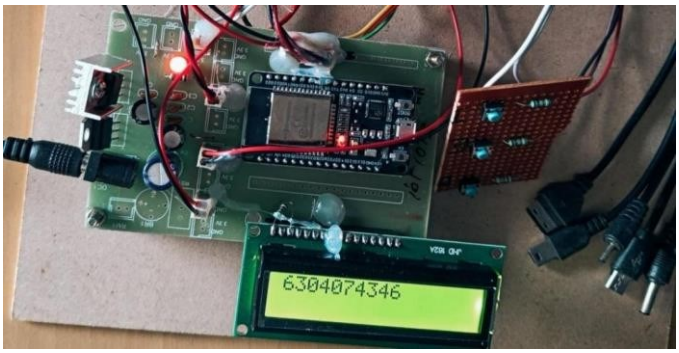

Figure 4: Registered Mobile Number

The figure 4 shows the user enters their mobile number via a mobile app for authentication and registration. The system verifies the number and stores it in the database for future access. Once successfully registered, the user can proceed with slot booking. The LCD display or app interface confirms the registration status, ensuring a secure and user-friendly experience.

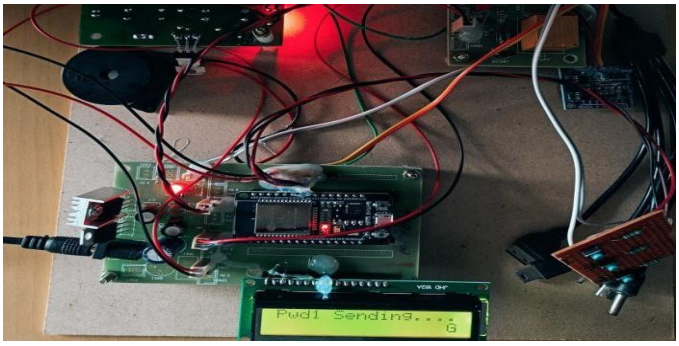

Figure 5: Password Sending

Sends a unique password to the user for authentication. This password allows the user to access the reserved charging slot, ensuring authorized usage. The system utilizes IoT modules for real-time slot monitoring and secure communication, enhancing user convenience and charging station management. The password is sent to the registered mobile number as shown in figure 5.

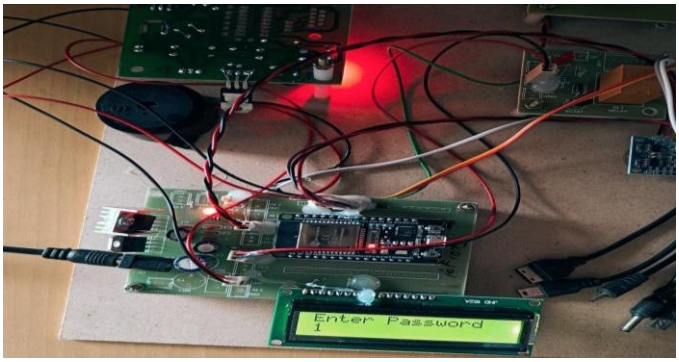

Figure 6: Enter Password

The user enters the password. The system prompts the user to input a secure password via a keypad or mobile app for authentication. The microcontroller processes the input and verifies it against stored credentials. If the password is correct, access to the charging slot booking system is granted; otherwise, an error message is displayed. The LCD screen or app interface updates accordingly, ensuring a secure and user-friendly registration process as shown in figure 6.

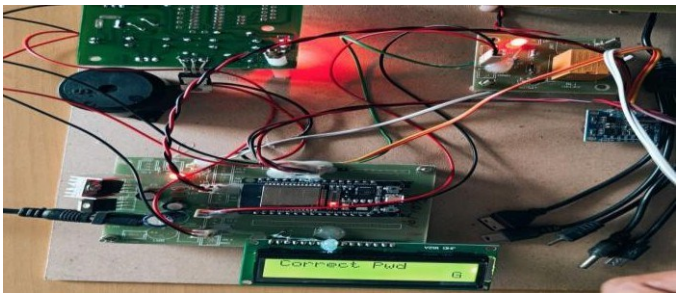

Figure 7: Correct Password

The screen shows the message “Correct Pwd,” indicating a password authentication process, confirming that the system validates user credentials before allowing access to a charging slot. As shown in the figure 7.

5. CONCLUSION

In conclusion, this paper introduces a practical model of an Internet of Things (IoT)-based EV Charging Slot Booking System to address the challenges posed by the growing adoption of electric vehicles (EVs). The escalating demand for EV charging spots has strained existing infrastructure, necessitating innovative solutions. By leveraging IoT and a Raspberry Pi Pico microcontroller, the system effectively addresses these challenges.

Key features of the system include real-time monitoring of slot availability, secure booking and reservation management, user authentication, and integrated charging control. The implementation involves the use of IoT, ESP-32 microcontroller, GSM, keypad, RPS, RTC, LCD, buzzer, Arduino IDE tool, and embedded C language. The system demonstrates the seamless booking of slots through an IoT application, where the Real-Time Clock (RTC) activates and sends an activation code to the registered user via the GSM module. After entering the code and specifying the required charging duration, the microcontroller activates the charging station.

An IoT-based EV charging slot reservation system using ESP32 improves efficiency, accessibility, and security while reducing waiting times and energy wastage. Its affordability and scalability make it an ideal solution for modern electric vehicle infrastructure, contributing to a sustainable and smarter future.

REFERENCES

[1] Review on IoT based Electric Vehicle Charging and Parking System, International Journal of Engineering Research & Technology (IJERT) Vol. 9 Issue 08 (S. Phadtare , S.S. Wadkar , S.S. Thorat , A.S. Ghorpade, Mr.A.B. Jadav).

[2] Journal of Engineering and Technology (IRJET) Volume:07 Issue:08 (Ms. Lekshmi M, Mr. Mayur P, Mr. Manjunatha B, Ms. Kavya U, Mr. Anil Kumar J H).

[3] IoT Based Electric Vehicle Application Using Boosting Algorithm for Smart Cities (Shabana Urooj, Fadwa Alrowais, Yuvaraja Teekaraman, Hariprasath Manoharan, Ramya Kuppusamy).

[4] IoT Enabled Smart Charging Stations for Electric Vehicles, Journal of Telecommunication Study Volume:4 Issue:2 (Esha Sharma, Bharath S, Adarsh Devaramani, Deepti Sr, Saravana Kumar).

[5] An article on “PARKPLUS Electric Vehicle Charging for Automated Parking”.

[6] Julian Timpner, Lars Wolf, A Back-end System for an Autonomous Parking and Charging System for Electrical Vehicles, International Electrical Vehicle Conference Greenville, SC, USA IEEE 2012.

[7] Mehmet Sukru Kuran, Aline Carnerio Viana, Luigi Iannone, Daniel Kofman, Gregory Mermound, Jean P. Vasseur, A Smart Parking Lot Management System for Scheduling the Recharging of Electric Vehicles, IEEE Transaction on Smart Grid November 2015.

[8] Abhirup Khanna, Rishi Anand, IoT based Smart Parking System, International Conference on Internet of Things and Applications (IOTA), Maharashtra Institute of Technology, Pune, India, pp. 266-270, 22 Jan-24 Jan, 2016. IEEE.

[9] Aniket Gupta, Sujata Kulkarni, et al, Smart Car Parking Management System Using IoT, American Journal of Science, Engineering and Technology. Vol. 2, pp. 112-119, November 30, 2017.

[10] Nazish Fatima, Akshaya Natlkar, Pratiksha Jagtap, SnehlChooudhari, IoT Based Smart Car Parking System for Smart Cities, International Journal of Advance Research, Ideas and Innovations In Technology, Vol. 4, Issue 1, 2018, ISSN.

[11] Zhe Wei, Yue Li, Yongmin Zhang, Lin Cal, Intelligent Parking Garage EV Charging Scheduling Considering Battery Charging Characteristic, IEEE Transaction on Industrial Electronics, Vol 65, 3 March 2018.

[12] Anusha, Arshita M S, Anushri, Geetanjali Bishtannavar, Ms. Megha D Hegde, Review Paper on Smart Parking System, International Journal of Engineering Research and Technology, Vol. 7, 2019 IJERT.

[13] H. J. Deva Koresh, S. K, S. M R, S. S and V. K, "Smart Charging Slot Reservation and Utilization System for Electric Vehicles," 2024 Second International Conference on Inventive Computing and Informatics (ICICI), Bangalore, India, 2024, pp. 464-469, doi: 10.1109/ICICI62254.2024.00081.