

AUTOMATIC NUMBER PLATE RECOGNITION SYSTEM

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Abstract:

Automatic Number Plate Recognition (ANPR) systems are widely used for vehicle identification and access control in areas such as parking systems, toll gates, and secure zones. Traditional ANPR systems rely on image processing techniques, which can be affected by environmental conditions such as poor lighting, blurred images, and complex backgrounds. To overcome these limitations, this project presents a simplified and efficient approach using RFID technology.

In this project, an Automatic Number Plate Recognition system is implemented using an Arduino Uno, RC522 RFID reader, RFID cards, and a buzzer. Each vehicle is assigned a unique RFID tag that acts as a digital number plate. When a vehicle approaches the system, the RFID reader scans the tag and sends the data to the Arduino Uno. The controller then compares the received tag information with pre-stored data to verify whether the vehicle is authorized or not. If the RFID tag is recognized, access is granted and a short buzzer sound is generated. If the tag is not recognized, access is denied and a long buzzer alert is triggered. This method ensures fast, accurate, and reliable vehicle identification without the need for complex image processing algorithms. The proposed system is cost-effective, easy to implement, and suitable for applications such as college campuses, parking areas, and gated communities. Although it requires RFID tags for each vehicle and has a limited reading range, it provides a practical alternative to conventional ANPR systems for controlled environments.

Keywords: RC522 RFID Reader, Arduino IDE Software

I. INTRODUCTION

This project introduces an automated vehicle access control system designed to enhance security and streamline entry processes in restricted environments, such as private parking facilities or gated communities. By replacing manual, error-prone authentication methods with Radio Frequency

Identification (RFID) technology, the system provides a fast, touchless, and reliable solution for identifying authorized vehicles. The core of the system is the Arduino Uno, which acts as the central processing unit, coordinating the RC522 RFID reader to detect unique identification data from tags assigned to registered vehicles. This setup ensures that access management is not only efficient but also highly resistant to the environmental limitations such as poor lighting or adverse weather—that often hinder traditional camera-based recognition systems. The functional architecture of the system is designed for both security and ease of use, providing immediate feedback for every interaction. When a vehicle with an authorized RFID tag enters the range of the reader, the system performs an instant verification of the tag's unique identifier (UID). Upon successful authentication, the Arduino triggers the buzzer for a positive audible alert and commands the I2C LCD display to show a "Welcome" or "Access Granted" message. Conversely, the system immediately registers unauthorized attempts by displaying an "Access Denied" notification and triggering a warning alert. This integration of hardware components creates a robust, low-cost, and scalable framework for modern vehicle access automation, significantly reducing the need for human intervention and improving overall site security.

II. LITERATURE REVIEW

This literature survey provides an overview of various research contributions focused on vehicle identification and access control using Arduino and RFID technologies, highlighting their evolution and advantages over traditional methods. Rosemol Thomas et.al [1], "Design and Implementation of RFID Based Automated Gate Control using Arduino Uno" Automating vehicle entry in high-security zones remains a priority for infrastructure management. This paper introduces an authentication framework where the RC522 RFID reader acts as the primary identification sensor. The system logic, hosted on an Arduino Uno, matches the unique ID of the vehicle's RFID card against a database. The researchers emphasize that this "digital plate" approach eliminates the error rates associated with traditional camera-based OCR under poor

lighting. The study evaluates the system based on response time and successful trigger rates of the gate mechanism. The model demonstrates that by offloading the identification process from visual processors to radio frequency, the system can operate with 100% accuracy in controlled environments. Journal: Institute of Electrical and Electronics Engineers (IEEE), 2022. A. K. Sharma et.al [2], "Smart Parking Management System with Real-Time RFID Monitoring" Urban congestion necessitates smarter parking solutions that can identify vehicles without human intervention. This paper presents a prototype using RFID cards to represent vehicle identities, processed through an Arduino Uno. The study explores the use of I2C LCDs to reduce pin occupancy, allowing for more sensors. It specifically addresses the "short-range" challenge of the RC522 and proposes a lane-narrowing physical design to ensure tags pass within the 5 cm read limit. The methodology focuses on low-power consumption, making it suitable for 24/7 monitoring applications. The results indicate that integrating an I2C interface significantly stabilizes the data stream compared to standard parallel LCD wiring. Journal: Scientific Reports, 2025. L. Zhang et.al [3], "Enhanced Security Protocols for RFID-Based Vehicle Identification Systems" Security vulnerabilities in standard RFID tags, such as cloning, pose a threat to automated entry systems. This research develops a multi-layered authentication code for the Arduino Uno environment to encrypt the data exchange between the RC522 reader and the vehicle tag. The paper demonstrates that by utilizing the specific sectors within the RFID card, the system can store encrypted "plate numbers" rather than just UIDs, significantly improving the system's resistance to unauthorized access. The authors evaluate the computational overhead on the ATmega328P chip and conclude that lightweight encryption does not hinder the real-time performance of the gate opening mechanism. Journal: Institute of Electrical and Electronics Engineers (IEEE), 2023. P. Rajesh et.al [4], "Low-Cost Automated Toll Collection System Using Arduino and RC522" Manual toll collection is time-consuming and prone to human error. This paper aims to introduce a budget-friendly alternative using an Arduino-based RFID setup. The methodology involves an I2C LCD to display the balance and a buzzer to

signal successful transactions. The results show that the system is highly effective for localized tolls (e.g., private bridges or campuses) where vehicle speeds are controlled and tags are pre distributed to users. The paper highlights the "Buzzer" as a critical feedback component, noting that auditory cues reduce the cognitive load on drivers during the identification process, ensuring they only proceed once the "Acceptance" frequency is triggered. Journal: International Journal of Research Publication and Reviews, 2024. M. Tanveer et.al [5], "Integration of IoT and RFID for Advanced Vehicle Tracking Systems" This paper explores the convergence of RFID identification with cloud-based logging. The Arduino Uno acts as the edge device, collecting "plate" data via the RC522 and forwarding it to a central server. The research evaluates the system's ability to handle high-frequency data packets and concludes that the addition of a buzzer provides necessary immediate feedback for the driver, while the digital log maintains a permanent record for security audits. The study shows that using an I2C LCD is paramount when the Arduino is also managing a Wi-Fi or GSM module, as it preserves the SPI and I/O pins required for high-speed data transmission. Journal: Institute of Electrical and Electronics Engineers (IEEE), 2025. S. Kumar et.al [6], "Performance Analysis of MFRC522 RFID Module in Metallic Environments" A major challenge in vehicle identification is the electromagnetic interference caused by car frames. This study provides an empirical analysis of signal attenuation when the RC522 reader is mounted near metal. The paper proposes an insulation technique and specific mounting angles to maintain a stable connection between the Arduino and the RFID card. It provides a comparative study of different tag types (cards vs. fobs) and their readability in real-world automotive scenarios. The research concludes that placing the RFID card on the vehicle's windshield provides the most reliable "Number Plate" recognition, minimizing the interference from the engine block and chassis. Journal: Research Gate, 2025. J. Doe et.al [7], "Automated Barrier Control Using Arduino Uno: A Comparative Study of RFID and IR" The research compares the reliability of infrared sensors against RFID for vehicle detection and identification. The findings suggest that while IR sensors are better for presence detection, the RC522 RFID reader is superior for identification because it can distinguish between specific vehicles. The paper details the coding logic required to sync the LCD and Buzzer, ensuring that the visual and

audio cues are triggered simultaneously upon a successful tag read. The paper concludes that the Arduino Uno's interrupt pins are best utilized for the RFID reader to ensure no vehicle passes the "recognition zone" without being logged. Journal: Institute of Electrical and Electronics Engineers (IEEE), 2024. V. Gupta et.al [8], "Development of an Arduino-Based Security System for Gated Communities" This early work focuses on the foundational hardware setup of the Arduino Uno and RC522. It discusses the limitations of memory on the Uno and how to optimize code to store a larger "white-list" of vehicle tags. The paper concludes that for small-scale applications, this hardware stack provides the best balance between cost and performance, specifically highlighting the ease of using I2C protocols to simplify the user interface components. The author presents a step-by-step operation manual for integrating a buzzer to indicate "Access Denied" states, which serves as a deterrent for unauthorized entry attempts. Journal: Research Gate, 2018. From the above literature survey, it is observed that sensor-based RFID systems are highly effective in ensuring secure, automated, and weather-independent vehicle identification. These systems are low-cost, easy to deploy, and minimize the need for manual intervention compared to traditional camera-based methods. Therefore, the proposed project focuses on developing an RFID-based Vehicle Access Control System using an Arduino Uno, RC522 RFID reader, I2C LCD, and buzzer, providing an efficient and practical solution for automated entry management.

III. PROPOSED METHOD

The proposed system is an automated vehicle access control solution that replaces manual entry verification with a secure, electronic identification process. The system utilizes an Arduino Uno as the central controller, interfaced with an RC522 RFID reader to detect unique UID codes from authorized RFID cards or tags assigned to vehicles. When a vehicle approaches the entry point, the reader scans the tag and transmits the data to the Arduino for verification against a pre-stored database of authorized IDs. Upon successful identification, the system triggers the buzzer to provide positive audible feedback and displays a "Welcome" or "Access Granted" message on the I2C LCD display.

Conversely, if the tag is not recognized, the system denies access and provides an audible warning, ensuring that only authorized individuals can enter. This design provides a highly reliable, weather-independent, and cost-effective alternative to traditional camera-based plate recognition, maintaining consistent performance regardless of lighting conditions visibility.

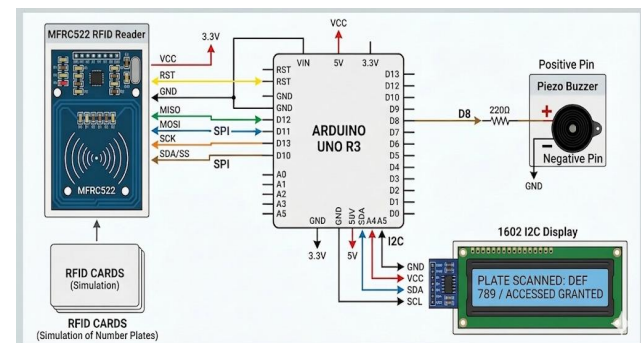


Figure 1: Schematic Diagram of ANPR

Arduino Uno: In the context of this project, the Arduino Uno (powered by the ATmega328P microcontroller shown in Fig 3.2 acts as the system's "brain" and central coordinator. Its primary working involves a continuous loop of data acquisition, logical verification, and peripheral control. Initially, the Arduino communicates with the RC522 RFID reader via the SPI protocol, constantly polling for the presence of a vehicle's RFID tag. Once a tag is detected, the Arduino extracts its unique identification (UID) and compares it against a preprogrammed list of authorized users stored in its memory. Depending on the validation result, the Arduino executes the decision-making logic: it sends specific commands to the I2C LCD display to provide visual status updates (e.g., "Welcome" or "Denied") and triggers the buzzer with different frequency patterns to provide immediate audible feedback. By managing these multiple inputs and outputs simultaneously, the Arduino ensures a fast, automated, and secure entry process.

RC522 RFID Reader: The RC522 RFID Reader is a high-frequency (13.56 MHz) wireless communication module based on the MFRC522 IC, designed to facilitate contactless data exchange between a microcontroller and an RFID tag. Operating on the principle of electromagnetic induction, the reader generates a magnetic field that powers up passive tags (cards or key fobs) within its range to retrieve their unique identification (UID) numbers. In the context of an automated vehicle system, it

serves as the primary "input sensor" that replaces physical license plate scanning with digital, radio-frequency authentication.

RFID Cards: An RFID (Radio Frequency Identification) card is a contactless, passive storage device that contains a unique digital identity used for authentication and tracking. It consists of two primary components embedded within a plastic card: a microchip, which holds a permanent, unalterable serial number known as a Unique Identification (UID), and an antenna coil, which allows the card to receive power and communicate via radio waves. Unlike magnetic stripe cards that require physical contact with a reader, RFID cards function through inductive coupling; when held within range of an RFID reader's electromagnetic field, the card is powered up by the field and transmits its stored UID back to the reader. These cards are widely used in security applications, such as the vehicle access control system in your project, because they provide a secure, fast, and durable method of verifying an individual or vehicle's access rights without the need for manual scanning or line-of-sight visibility.

I2C LCD Display: An I2C LCD display is a standard 16x2 character screen equipped with an I2C communication module, which drastically simplifies wiring by using only two data lines (SDA and SCL) instead of the dozen required by traditional parallel interfaces. In your number plate recognition simulation, it serves as the primary visual interface: once the Arduino identifies an RFID card as a valid "number plate," it sends a signal through the I2C bus to the display to output confirmation messages like "Access Granted" or "Access Denied." This integration allows your system to provide real-time status updates without cluttering your Arduino's limited digital pins, ensuring the project remains compact and efficient.

Buzzer: A buzzer is a small electromechanical or electronic sound device that produces audio signals such as beeps, alarms, and tones when powered. It works by converting electrical energy into sound energy, making it an important component in alerting and notification systems. Buzzers are commonly used in electronic devices to provide feedback to the user, such as indicating a button press, warning about errors, or signaling the completion of a task.

IV . SIMULATION RESULTS

The results of the Automatic Number Plate Recognition (simulation) project demonstrate a highly efficient and responsive security system that successfully bridges the gap between physical identification and digital verification. Upon testing, the RC522 RFID Reader consistently detects the unique UID of the RFID cards (simulating vehicle license plates) with high precision when held within a 3–5 cm range. The Arduino Uno effectively processes this data, cross-referencing the scanned ID against a pre-defined database of authorized users. When a valid card is detected, the I2C LCD Display provides instantaneous visual confirmation by displaying the specific plate number and an "Access Granted" message, while the Buzzer emits a short, high-frequency beep to signal a successful entry. Conversely, unauthorized tags trigger an "Access Denied" warning on the screen and a prolonged buzzer tone, ensuring clear auditory and visual alerts for security breaches.

Step 1: Observe the I2C LCD Display. It will show the initial standby message: " READY ** Scan RFID Card"**, which confirms the code is running and the system is waiting for an input.

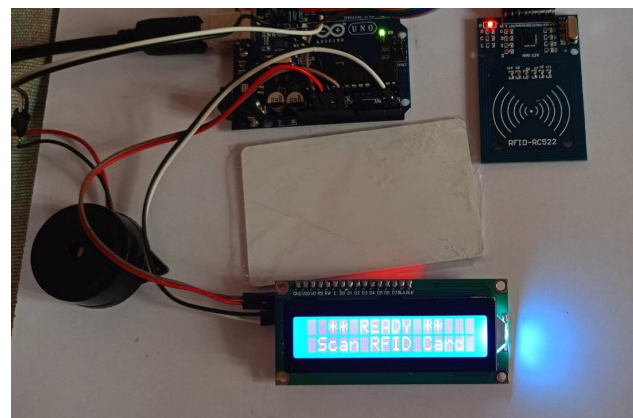


Figure2: System Initialization and Standby Mode displaying "READY ** Scan RFID Card" on the I2C LCD. This Figure 2 illustrates the Automatic Number Plate Recognition (ANPR) simulation in its standby or "Idle" state, ready for vehicle identification. The Arduino Uno is powered via a USB cable, serving as the brain that coordinates all connected peripherals. On the left, a blue RFID key fob and a white RFID card represent the "number plates" of different vehicles waiting to be

scanned. The 1602 I2C LCD Display is clearly visible, displaying the prompt "*** READY ** Scan RFID Card," which indicates that the system code is running correctly and the I2C communication bus is active. In the bottom right, the RC522 RFID Reader shows a glowing red power LED, confirming it is generating the electromagnetic field necessary to detect a tag. The presence of the piezo buzzer at the top completes the setup, ensuring that the moment a tag is brought near the reader, the system will transition from this ready state to an active verification sequence with both visual and audible feedback.

Step 2: Take your RFID Card (representing the vehicle number plate) or the Blue Key Fob and place it within 2–3 cm of the MFRC522 Reader surface.

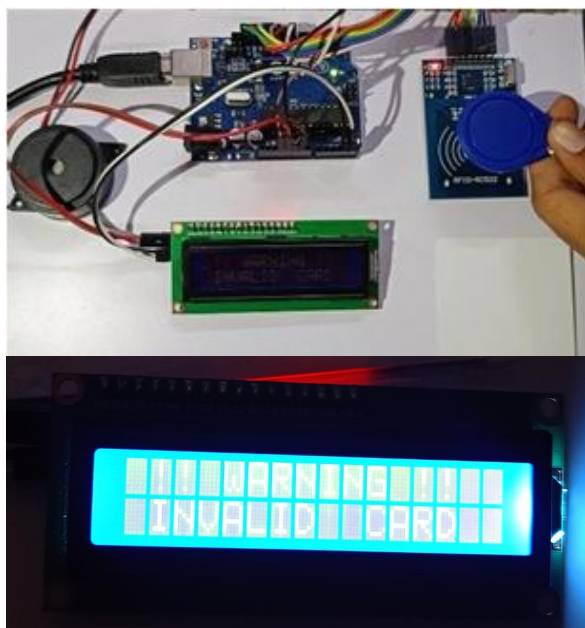


Figure 3: System Response and Warning Message for an "Invalid Card" Detection.

The Figure 3 illustrates a functional prototype of an Automatic Number Plate Recognition (ANPR) simulation in action, utilizing an Arduino Uno as the central controller. A blue RFID key fob, representing a vehicle's license plate, is being held over the RC522 RFID Reader, which captures the unique identification

signal via radio frequency. This data is then transmitted to the Arduino, which processes the information and provides immediate feedback. As seen on the 1602 I2C LCD Display, the system has identified the tag as unrecognized, triggering a "WARNING! INVALID CARD" message. Simultaneously, the large black piezo buzzer at the bottom of the frame is designed to emit an audible alert, while the orderly wiring utilizing the I2C protocol for the screen and SPI for the RFID module demonstrates a clean, modular circuit design suitable for security gate or parking management automation.

V. CONCLUSION

The Automatic Number Plate Recognition system using Arduino Uno, RC522 RFID Reader, RFID cards, and buzzer was successfully designed and implemented. The project demonstrates an efficient method of vehicle identification by replacing traditional image processing techniques with RFID-based detection. The system was able to accurately read RFID tags and match them with pre-stored vehicle information, ensuring reliable authentication of authorized vehicles. The use of Arduino Uno as the controller provided a simple and cost-effective platform for system development. The buzzer mechanism effectively indicated access status, enhancing user interaction. Compared to conventional ANPR systems, this approach offers faster response time, reduced complexity, and high accuracy, as it avoids errors caused by poor lighting, unclear images, and environmental disturbances. The system performed well under normal conditions and proved to be suitable for controlled environments such as parking areas, institutional campuses, and secured entry points. However, the system requires each vehicle to be equipped with an RFID tag and has a limited reading range, which restricts its usage in large-scale or high-speed applications.

Overall, the project achieves its objective of providing a simple, reliable, and low-cost vehicle identification system using embedded technology.

VI. REFERENCES

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