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Automation of Tollgate and Blocking of Unauthorized Vehicles

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ABSTRACT

The rapid increase in the number of vehicles has created significant challenges in manual toll collection systems, leading to traffic congestion and delays. To overcome these issues, an automated toll gate system with unauthorized vehicle detection is proposed. The system uses RFID technology to identify vehicles and enable automatic toll deduction from prepaid accounts. As a vehicle approaches the toll gate, sensors detect its presence and activate the system for processing. A camera captures the vehicle's number plate, and an Automatic Number Plate Recognition (ANPR) system extracts and verifies the registration details. The collected data is compared with a centralized database to ensure vehicle authenticity. The system performs dual verification using both RFID and license plate information to improve accuracy and prevent fraud. If the vehicle is authorized and has sufficient balance, the gate opens automatically, allowing smooth passage. In contrast, unauthorized vehicles are detected based on invalid RFID tags, insufficient balance, or mismatched data. In such cases, the gate remains closed, and an alert is generated for authorities. The system also stores vehicle data for monitoring and security purposes. This approach reduces waiting time, minimizes human intervention, and enhances operational efficiency. It improves traffic flow and ensures secure toll management. The proposed system is reliable, scalable, and suitable for modern intelligent transportation systems. It also supports real-time monitoring and future smart city integration.

KEYWORDS: ***IoT-Based Toll System, ESP32, RFID Reader, RFID Tags, Infrared Sensor, Servo Motor, LCD Display, Buzzer Alert System.***

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INTRODUCTION

Transportation is an essential part of modern society, playing a key role in economic growth and daily mobility. With the rapid increase in vehicle population, traditional toll collection systems have become inefficient, leading to long waiting times, traffic congestion, fuel wastage, and environmental pollution. Manual toll processing also increases human errors and reduces transparency in revenue collection. To overcome these challenges, automated tollgate systems have been developed using technologies such as RFID, sensors, microcontrollers, and communication networks. These systems enable automatic vehicle identification, fast toll deduction, and barrier control without stopping vehicles. Each authorized vehicle is equipped with an RFID tag that is scanned at the toll plaza for instant verification. If the vehicle is valid and has sufficient balance, the gate opens automatically, ensuring smooth traffic flow. This automation improves efficiency, reduces operational cost, enhances security, and supports smart transportation infrastructure, making road travel faster, safer, and more convenient.

RELATED WORK

Several researchers have proposed automated toll collection systems using RFID, ANPR, and IoT technologies to improve traffic efficiency and reduce manual intervention. Studies show that RFID-based toll systems enable fast and accurate vehicle identification, significantly reducing congestion at toll plazas. Other works integrate image processing and Automatic Number Plate Recognition to detect unauthorized vehicles and enhance security. IoT-enabled systems provide real-time monitoring and centralized data management for better transparency and control. These approaches demonstrate improved accuracy, reduced waiting time, and increased revenue efficiency, highlighting the effectiveness of automation in modern intelligent transportation systems.

LITERATURE REVIEW

The literature on smart toll collection systems highlights the use of RFID, ANPR, IoT, and communication technologies to improve traffic efficiency and security. Researchers have proposed automated toll systems that enable real-time vehicle identification, automatic payment deduction, and unauthorized vehicle detection. RFID-based systems ensure fast and accurate toll processing, while ANPR enhances security by verifying number

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plates against centralized databases. IoT and GSM technologies support real-time monitoring and alert generation for violations. Advanced approaches also include cloud and blockchain integration for secure data management.

EXISTING METHOD

The existing automated tollgate system is designed to reduce manual intervention and improve traffic flow using technologies like RFID, sensors, and centralized databases. In this system, each authorized vehicle is assigned an RFID tag that is read automatically when the vehicle approaches the toll plaza. The system verifies vehicle details, checks account balance, and deducts the toll amount electronically. After successful verification, the barrier gate opens automatically, allowing smooth vehicle movement. Infrared and ultrasonic sensors are used to detect vehicle presence and ensure safe gate operation. Some systems also incorporate ANPR technology to identify vehicles without RFID tags and detect unauthorized or stolen vehicles. All transaction data is stored in a centralized server for monitoring and analysis. If an unauthorized vehicle is detected, the system triggers alerts, displays warnings, and prevents gate access. Although efficient, the existing system still faces limitations in accuracy, flexibility, and advanced intelligence features for real-time decision-making.

PROPOSED METHOD

A person is required to register their vehicle with the RTO office before they may purchase a vehicle. In addition to a licence plate, the personnel of the RTO will provide it with a tag that is equipped with RFID technology. This card's one-of-a-kind identification number is only valid for usage in conjunction with the specified automobile. In addition to that, they will establish a unique account for that smart card and keep a database with a record of all of the transactions made with it. It is necessary for the person who owns the automobile to deposit at least some money into this account. When a vehicle that has been previously registered draws near the toll booth, the RFID circuit is activated so that the RFID-enabled smart card that is affixed to the windshield may be scanned. The infrared sensors are the ones that make the first discovery that there is a vehicle in the area. The procedure will start, and depending on the amount that is available, the vehicle will either be relocated to another lane so that the tax may be paid manually, or the toll will be promptly deducted from the vehicle's account. The

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programme refreshes the information that is saved on the primary database server.

SYSTEM ARCHITECTURE

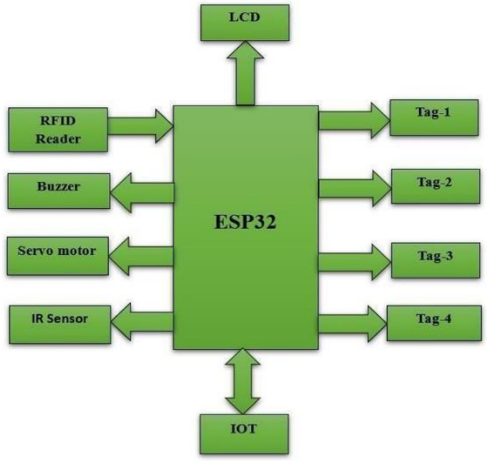

Fig 1: Block Diagram

METHODOLOGY DESCRIPTION

ESP32 Controller: The ESP32 acts as the main processing unit of the system, controlling all input and output operations. It receives data from RFID reader and sensors, processes it, and sends control signals to connected devices.

RFID Authentication System: The RFID reader identifies and verifies tags such as Tag-1, Tag-2, Tag-3, and Tag-4. Each tag contains unique ID data used for authentication and access control decisions.

IR Sensing Unit: The IR sensor detects the presence of objects or individuals near the system. It ensures proper positioning before processing RFID-based access or automation actions.

Output and Alert System: The LCD display shows tag information, system status, and access messages in real time. The buzzer and servo motor provide alerts and physical actions like gate opening or closing.

IoT Communication System: The IoT module enables wireless data transfer and remote monitoring of system activities.

SOFTWARE AND HARDWARE REQUIREMENTS

Microcontroller (ESP32)

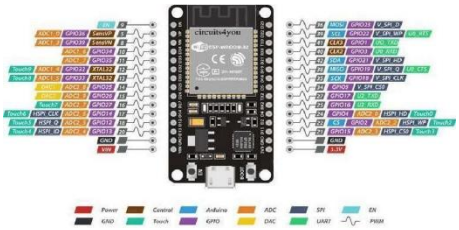

Fig 2: Microcontroller-ESP32

The ESP32 is the main control unit of the system that processes all sensor inputs and controls output devices. It performs real-time decision making for obstacle detection, authentication, and motor control.

RFID Reader

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Fig 3: RFID Reader

The RFID reader is used to scan RFID tags for vehicle or user identification. It sends the tag ID to the ESP32 for verification and access control decisions.

IR Sensor

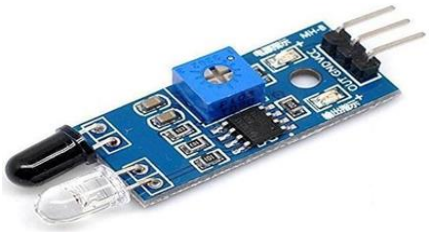

Fig 4: IR Sensor

The IR sensor is used for obstacle detection and proximity sensing. It continuously monitors nearby objects and provides signals to prevent collisions or unauthorized access.

Servo Motor

Fig 5: Servo Motor

The servo motor is used for mechanical movement such as opening and closing a gate. It operates based on control signals from the ESP32 using PWM technique.

Buzzer

Fig 6: Buzzer

The buzzer provides audio alerts during events like unauthorized access or obstacle detection. It helps in giving immediate warning signals to the user.

LCD Display

Fig 7: LCD Display

The LCD is used to display real-time system information such as RFID status, sensor values, and system messages. It provides a clear visual interface for monitoring system operations.

SOFTWARE REQUIREMENTS

Arduino IDE

The Arduino IDE is the main development platform used to write and upload code to the ESP32 microcontroller. It provides a simple interface for programming embedded systems using C/C++ based

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syntax. It supports multiple libraries that simplify the integration of RFID, sensors, LCD, and motor modules. The IDE compiles the code and uploads it directly to the ESP32 board for execution. It is cross-platform software that works on Windows, Linux, and macOS systems. This makes it flexible for development in different environments. Overall, Arduino IDE helps in faster development, debugging, and implementation of IoT and embedded system projects with ease.

RESULTS AND DISCUSSION

The automated tollgate system operates in such a way that when an authorized RFID tag is detected, the gate opens automatically without human intervention. A servo motor or relay is activated to lift and close the barrier smoothly based on vehicle access. The system provides clear visual feedback using an LCD or display, showing messages such as “Access Granted” for authorized vehicles and “Access Denied” for unauthorized ones. In case of unauthorized vehicle detection, a buzzer is activated to generate an alert. Additionally, a red LED indicates unauthorized access, while a green LED signals authorized entry. The system also maintains a record of vehicle entry and exit data for monitoring and security purposes. Real-time status updates are transmitted through Wi-Fi or a mobile application for remote monitoring.

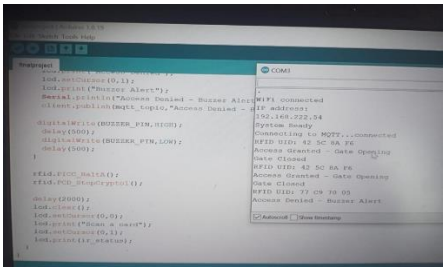

Fig 8: software execution process

Analysis: The automated tollgate system using the ESP32 microcontroller developed by Espressif Systems successfully detects and processes vehicle entry and exit without manual intervention. Authorized vehicles are identified using RFID tags or registered credentials, and the system automatically opens the barrier gate when a valid vehicle is detected. Unauthorized vehicles are detected by the system and are prevented from entering the toll area.

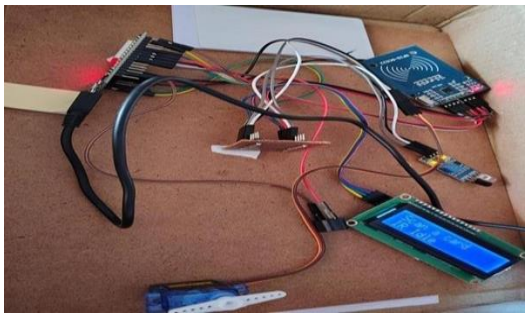

Fig 9: Kit Connections

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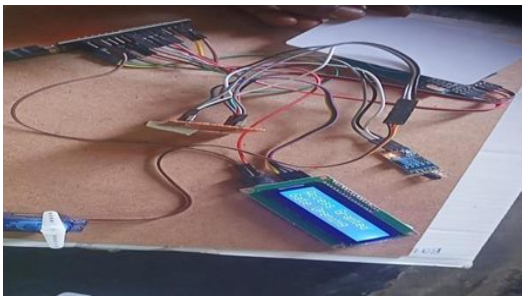

Fig 10: Authorized

Fig 11: Unauthorized

CONCLUSION

The automatic toll gate system with unauthorized vehicle blocking improves traffic efficiency by enabling fast and contactless toll collection using RFID and sensor-based technologies. It reduces congestion, waiting time, and fuel wastage at toll plazas while ensuring smooth vehicle movement. Overall, it provides a secure, reliable, and smart solution for modern transportation systems.

FUTURE SCOPE

The future scope of the automatic toll gate system includes integration of artificial intelligence and machine learning to improve vehicle detection accuracy and decision-making efficiency. It can also be enhanced with IoT and edge computing for real-time monitoring, faster processing, and remote control of toll operations. Further advancements such as satellite tracking, FASTag integration, and smart city connectivity will enable fully automated, barrier-less, and highly efficient toll management systems.

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