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AUTOMATED TOLLGATE USING IOT FOR THREAT ASSESSMENT AND PROTECTION SYSTEM

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Abstract: This project proposes an intelligent toll gate security system integrating machine learning and IoT-based sensors for enhanced vehicle monitoring and safety checks at toll gates. When a vehicle approaches the toll, a camera activates to capture and detect the vehicle's number plate, identifying it through image processing algorithms. Additionally, metal sensors analyses the vehicle to detect any unauthorized metallic objects, such as weapons. If any potential threat is detected, the system prevents the vehicle from passing by automatically controlling a gate mechanism powered by a DC motor connected to an ESP-32. The system also alerts higher authorities through a notification sent via a Telegram bot. In cases where police personnel allow vehicles to pass without thorough inspection, notifications are sent to higher authorities, with vehicle tracking for further monitoring. This setup uses a laptop camera as the visual input for machine learning tasks, while ESP-32 manages sensors and gate operations through UART communication. The proposed system enhances toll gate security, ensuring strict vehicle checks and real-time alerts to prevent unauthorized or hazardous vehicle entry.

Keywords: Check post Security, Unauthorized Access, Alerts, Weight detector.

I. INTRODUCTION

This project presents an advanced toll gate security system that uses a camera for number plate recognition, metal sensors for detecting unauthorized objects, and real-time notification systems to alert authorities of any suspicious activity. When a vehicle approaches the toll gate, the camera captures and processes the vehicle's number plate using machine learning algorithms to quickly identify it. Simultaneously, a metal sensor scans the vehicle for any potential threats, such as concealed weapons. If any threats are detected, the system prevents the vehicle from passing, controlling a gate mechanism operated through a DC motor connected to an ESP-32 microcontroller. In addition to preventing unauthorized access, this system ensures accountability through continuous tracking of vehicles that bypass security checks. Notifications are sent directly to higher authorities through a Telegram bot, creating a streamlined alert process that requires minimal manual intervention.

This approach not only increases the reliability of toll gate security but also establishes a structured and quick-response protocol, significantly reducing the chance of unmonitored vehicles accessing sensitive areas. By automating threat detection and vehicle tracking, this project offers a modern solution to security challenges faced at toll gates, enhancing both operational efficiency and safety. Monitoring a vehicle's load using load cell sensors involves installing the sensors at critical points, such as under the suspension or on the chassis. These sensors measure the weight applied to them and convert it into an electrical signal. The data is processed by a microcontroller or dedicated system to calculate the total load. This information can help ensure safety, prevent overloading, and optimize performance. If the vehicle moves too fast, the overspeed detector activates a buzzer as an alert. This helps in warning the driver about excessive speed, allowing them to slow down. However, this process is often inefficient, leading to slowdowns in traffic and creating opportunities for human error. An efficient and automated toll gate system that integrates machine learning and IoT technology can offer a solution, enhancing both security and traffic flow.The system ensures safety by preventing accidents caused by over speeding. MEMS (Micro-Electro-Mechanical Systems) sensors can be used in check posts for various applications, such as vehicle monitoring, weight measurement, and security checks. These sensors detect motion, acceleration, pressure, and vibration, helping authorities analyze vehicle speed, stability, and load. For instance, an accelerometer can identify over speeding vehicles, while a pressure sensor can measure axle load to prevent overloading.

1.1 MOTIVATION

The increasing rate of security threats at checkpoints and the limitations of manual security checks motivate the development of an automated solution. By leveraging machine learning and IoT technology, this project aims to enhance the reliability and responsiveness of toll gate security systems. The integration of real-time monitoring, automated object detection, and instant notifications to authorities aligns with the modern requirements for efficient, error-free security mechanisms at toll gates. The project seeks to not only improve security but also streamline the vehicle flow, reducing congestion at tolls and making the process safer for both security personnel and the public.

1.2 OBJECTIVE

1. **Automate Security Checks**: Integrate vehicle number plate recognition and metal detection for thorough checks at toll gates.
2. **Unauthorized Object Detection**: Detect metallic objects like weapons in vehicles and prevent unauthorized access.
3. **Authority Notification**: Notify higher authorities through Telegram in cases of suspected threats or unauthorized passes.
4. **Vehicle Tracking**: Track the vehicle's movement for enhanced security monitoring.
5. **Reliable Communication**: Establish efficient UART communication between the laptop and ESP-32 for real-time sensor data processing.
6. **Automate gate operation** using a DC motor for efficient and remote-controlled access.
7. **Monitor vehicle load** accurately using load cell sensors for weight management and safety.
8. Here is the description in paragraph form:

The proposed system integrates several technologies to enhance the security and efficiency of vehicle access management. A camera equipped with number plate recognition capability is used to automatically identify and record the license plates of incoming and outgoing vehicles. This ensures accurate tracking and prevents unauthorized entry. To further bolster security, a metal detection sensor is employed to identify any concealed or unauthorized metallic objects that may be carried by vehicles. In case of any security breach or irregularity, an automated authority notification system promptly alerts the concerned personnel through communication channels such as SMS or email. For controlling access, a DC motor is utilized to operate the gate automatically, allowing seamless and secure entry and exit.

II. METHODOLOGY

The proposed system is a smart vehicle monitoring and gate control mechanism that integrates multiple sensors and components coordinated by an ESP-32 microcontroller. The methodology begins with a camera input that captures vehicle images, which are then processed using a laptop running OpenCV for license plate recognition.

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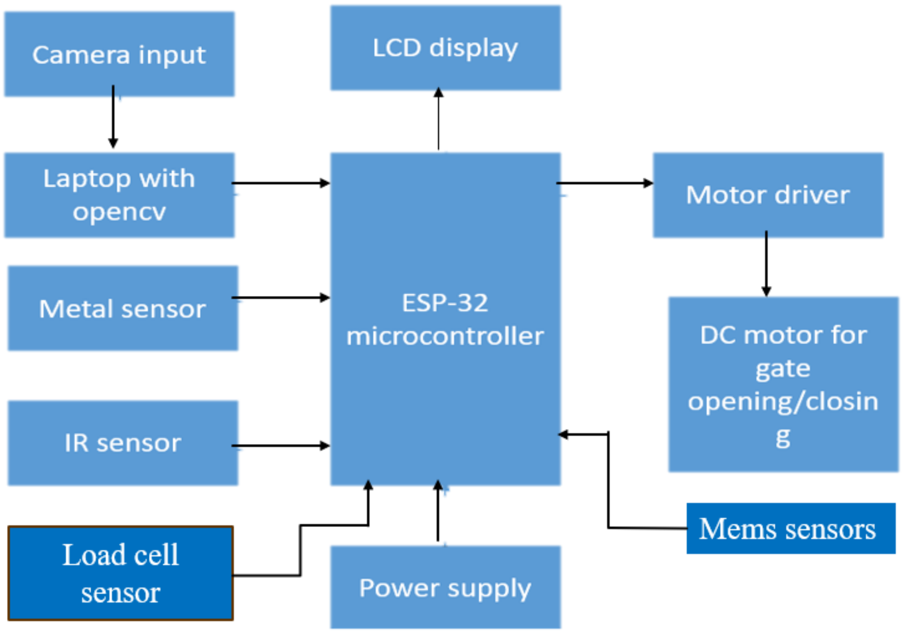

Fig: 1 Block diagram of AUTOMATED TOLLGATE USING IOT FOR THREAT ASSESSMENT AND PROTECTION SYSTEM

Laptop with OpenCV: This acts as the processing unit for image analysis. OpenCV (Open Source Computer Vision Library) is used for implementing computer vision tasks such as vehicle detection and Automatic Number Plate Recognition (ANPR). It extracts the vehicle number plate from the captured image, performs character segmentation, and uses Optical Character Recognition (OCR) to convert image data into text.

Metal Sensor: The metal sensor detects the presence of metallic objects hidden within the vehicle. It is used as a security measure to identify unauthorized or suspicious items. Once detected, the sensor sends a signal to the ESP-32 microcontroller, which can trigger further action (e.g., alerting security personnel or denying gate access).

IR Sensor : The Infrared (IR) sensor detects the presence or motion of a vehicle near the gate. It works by emitting infrared light and detecting the reflection from nearby objects. When a vehicle arrives at the entrance, the IR sensor notifies the microcontroller, which initiates the recognition and inspection process.

ESP-32 Microcontroller: This is the central controller and brain of the system. It receives input from all sensors (IR, metal sensor, camera output via serial/Wi-Fi), processes the logic, and controls the output devices. It decides when to open or close the gate, displays data on the LCD, and can be programmed to send alerts or notifications over Wi-Fi/Bluetooth.

LCD Display: The LCD display provides a user interface to show real-time information such as vehicle status, load data, detected anomalies, or system alerts. It helps operators monitor the process and verify system outputs.

Motor Driver: The motor driver acts as an interface between the ESP-32 microcontroller and the DC motor. Since microcontrollers cannot supply the current required by motors directly, the driver amplifies the control signals from the ESP-32 to power the DC motor as per required direction and speed.

IMPLIMENTATION

3.1 Hardware Setup:

3.1. ESP-32 microcontroller: it serves as the central processing unit of the system, coordinating all input and output operations. It receives data from various sensors, processes the logic based on programmed instructions, and controls the system's actions accordingly.

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3.1.2 power supply: it is used to convert and regulate electrical energy, providing the required voltages to each component, such as 5V for the ESP-32 and 12V for the motor.

3.1. DC motor: since the microcontroller cannot directly power the motor. The motor driver amplifies the control signals to drive the motor, which is responsible for the actual opening and closing of the gate, thus enabling automated vehicle access. This integrated approach ensures a smart, secure, and efficient vehicle entry system.

3.1.4 LCD display: The LCD display provides a user interface to show real-time information such as vehicle status, load data, detected anomalies, or system alerts. That presents real-time information like vehicle status, gate operation, and sensor readings, providing clear feedback to the user.

3.1.5 DC Motor for Gate Opening/Closing: This motor is responsible for physically opening and closing the gate. Based on the signal from the motor driver, it rotates in the appropriate direction to control gate movement automatically.

3.1.6 Power Supply: The power supply provides the necessary voltage and current to operate all components of the system. It ensures stable and uninterrupted performance, converting AC to DC and regulating voltages where necessary (e.g., 5V for ESP-32 and sensors, 12V for motors).

4.1 Software Development:

4.1.1 OpenCV (Open Source Computer Vision Library): it is used for real-time image and video processing tasks, particularly for vehicle detection and automatic number plate recognition (ANPR) in this system. It works in conjunction with a camera and helps extract useful data such as license plate characters.

4.1.2 Python: it is the programming language used to implement image processing algorithms with OpenCV, offering simplicity, powerful libraries, and wide community support. On the hardware side.

4.1.3 Embedded C : it is the language used to write low-level, efficient code for the ESP-32. It is suitable for time-critical operations such as reading sensor inputs and controlling actuators like the motor driver and LCD. Together, these tools form the complete software ecosystem for developing and integrating both the hardware and software components of the system.

VI. RESULT

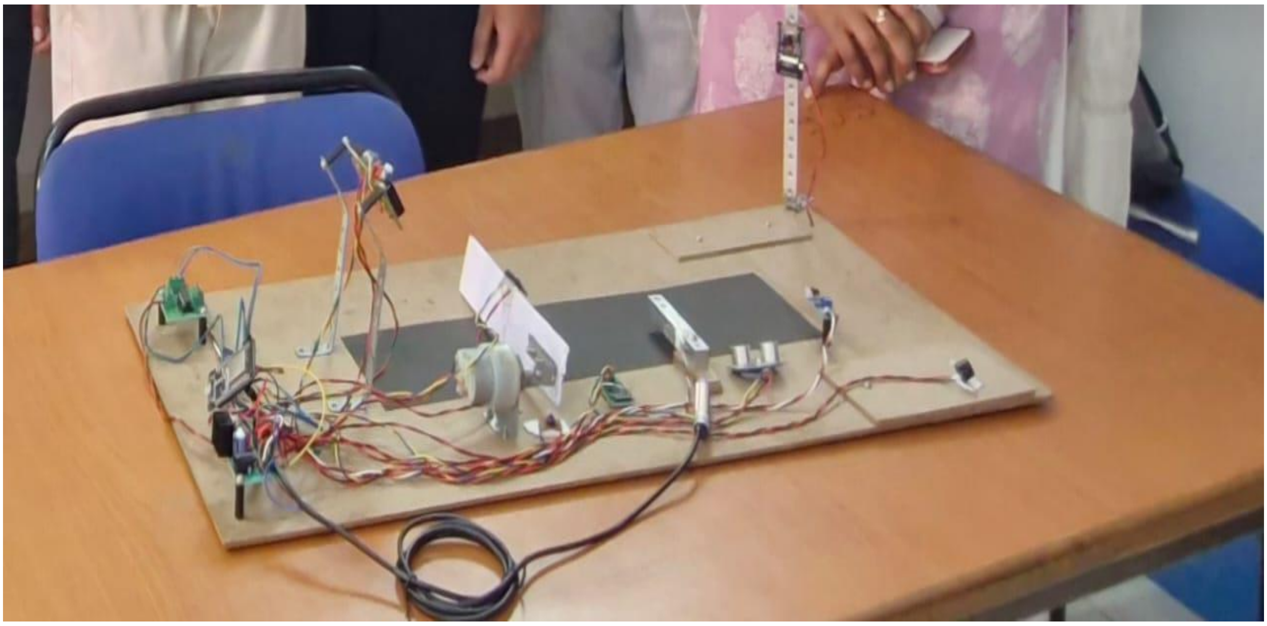

Fig 2: Prototype of model

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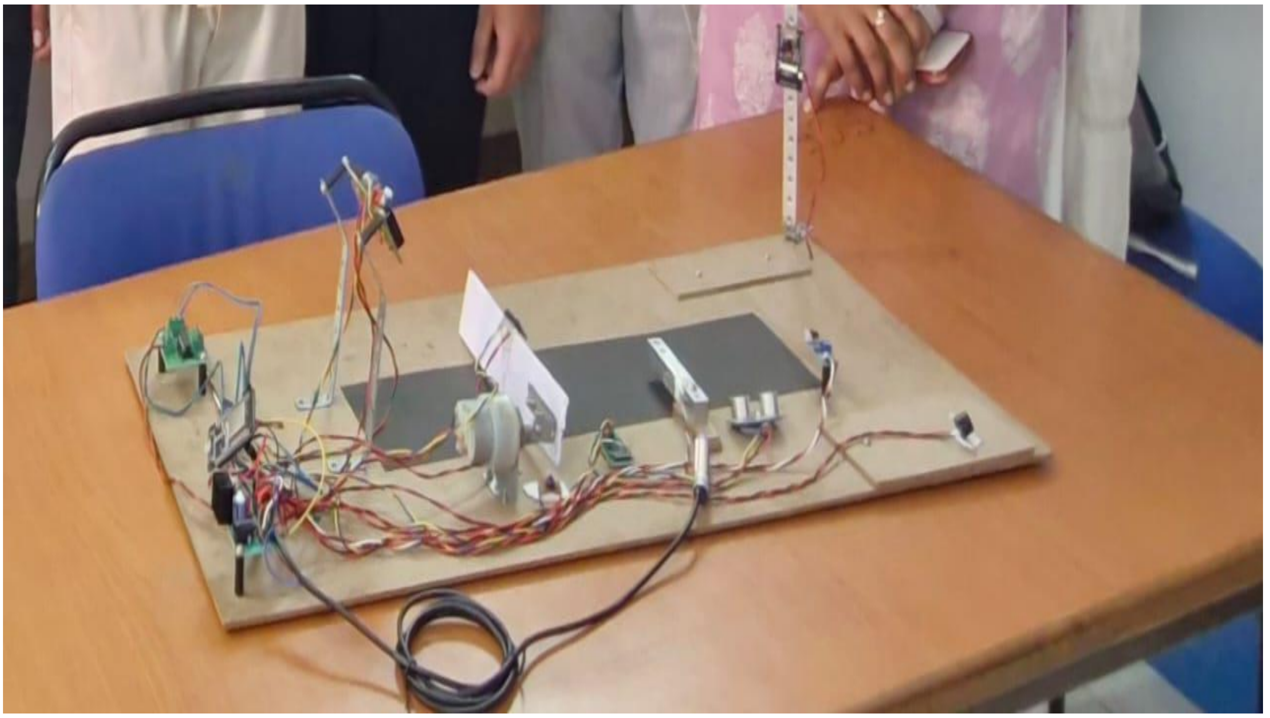

Fig 3: model

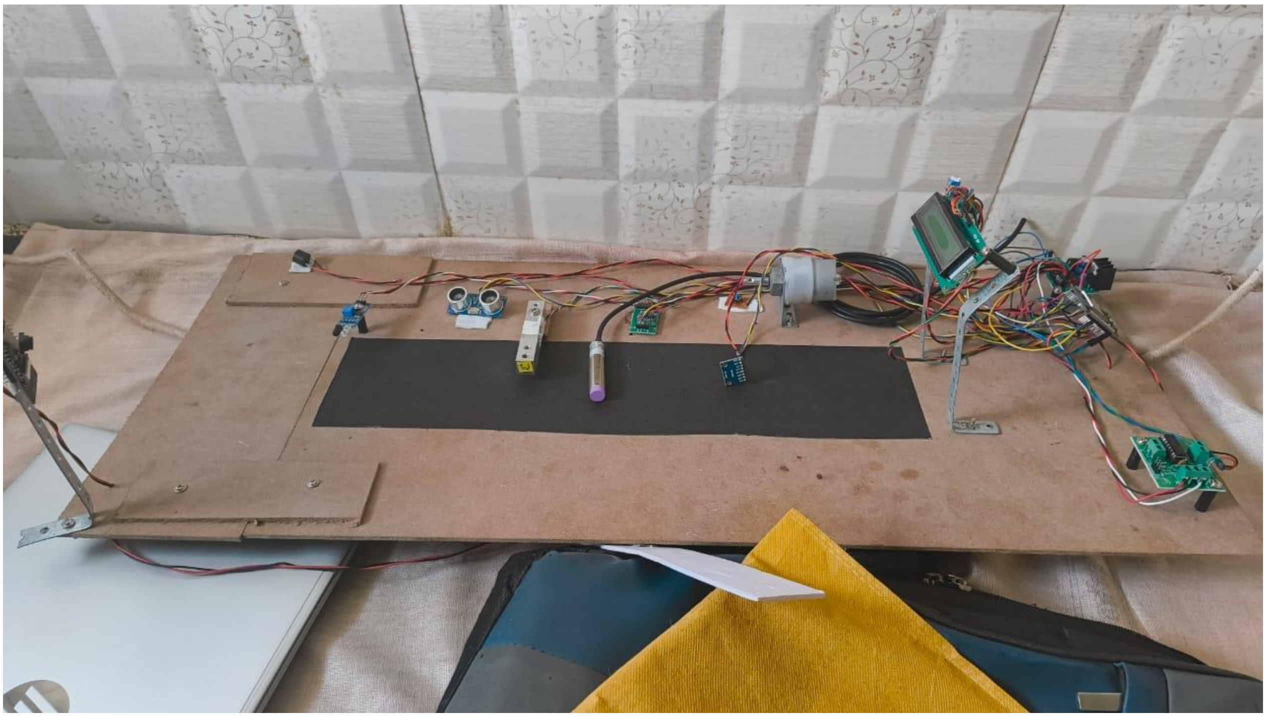

Fig 4: view od model

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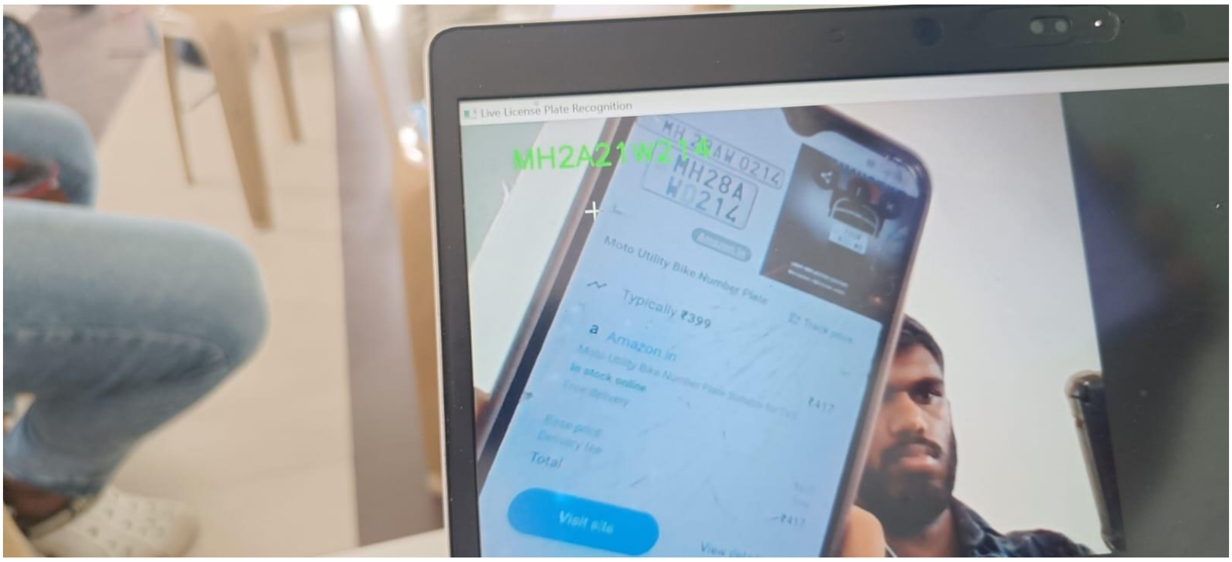

Fig 5:Number Plate Recognation

CONCLUSION

The proposed intelligent toll gate security system successfully integrates machine learning, image processing, and IoT-based sensors to create a robust and automated security solution. By combining vehicle number plate recognition, metal detection, and real-time communication with authorities, the system ensures a high level of safety and control at toll gates. The use of an ESP-32 microcontroller enables efficient management of sensor data and gate operations, while Telegram bot integration facilitates instant alert notifications. This system not only minimizes human error and intervention but also enhances surveillance and responsiveness to potential threats. Overall, it provides a scalable and effective framework for modernizing toll gate security and improving public safety.

FUTURE SCOPE

- **RFID-based vehicle identification** for faster and contactless toll operations.
- **Cloud -based data storage and analytics** for traffic monitoring, historical data analysis, and security pattern detection.
- **Facial recognition integration** to identify drivers and passengers for added authentication and safety.
- **Deployment in smart city infrastructure** for improved traffic management and intelligent transportation systems.
- **Use in high-security zones** such as military bases, government facilities, and border areas for advanced surveillance and automated threat response.
- **Mobile app integration** for authorized personnel to monitor and control system functions remotely.
- solar panel.

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