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Automatic Number Plate Recognition with High Speed Vehicle Mail Alert

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Abstract: *Automated Number Plate recognition (ANPR) is a critical generation in modern traffic control and law enforcement. This paper presents a complicated ANPR system designed to stumble on and apprehend automobile variety plates in high-velocity scenarios and generate real-time indicators through e mail. The proposed gadget utilizes high-resolution cameras blended with device mastering-primarily based Optical character popularity (OCR) for accurate plate detection. A robust image pre-processing pipeline guarantees optimal performance even in challenging environments with fluctuating lighting and motion blur. The license plate data collected is cross-referenced with a database, triggering immediate email notifications for any blacklisted or unauthorized vehicles. This system is fine-tuned for high-speed processing, delivering minimal delays and exceptional accuracy. Its implementation significantly enhances traffic monitoring, toll automation, and safety enforcement, making it an essential tool for smart cities and advanced transportation frameworks. Performance evaluations show high accuracy and low latency, making it well-suited for real-world applications such as highway surveillance, toll collection automation, parking management, and security enforcement. The incorporation of artificial intelligence with traditional Automatic Number Plate Recognition (ANPR) technology boosts both performance and scalability, positioning this system as a vital component in the development of smart transportation networks. The ANPR system utilizes Optical Character Recognition (OCR) to accurately extract alphanumeric information from captured plates, even under challenging conditions like poor lighting, adverse weather, and high vehicle speeds. By means of integrating this device with a centralized database and a customizable e-mail notification module, authorized employees are directly notified, which aids in real-time selection-making and law enforcement movements. This project tackles critical challenges in vehicle recognition systems, such as processing speed, accuracy, and reliability, making it an essential tool for smart city infrastructure and enhanced safety programs.*

Keywords: Automatic Number Plate Recognition, High-Speed Vehicle Detection, OCR, Real-Time Alert System, Smart Traffic Management, Email Notification

I. INTRODUCTION

As cities expand their transportation networks rapidly, the demand for automated traffic monitoring and enforcement systems has never been more critical. One notable advancement in this area is Automatic Number Plate Recognition (ANPR), a technology that allows for real-time identification of vehicles based on their license plates. ANPR is widely utilized for various purposes, including toll collection, traffic rule enforcement, parking management, and security surveillance.However, recognizing range plates of excessive-speed motors stays a widespread task because of movement blur, lighting fixtures versions, and the need for speedy processing. This paper affords an ANPR gadget integrated with an STM32H collection microcontroller, designed for excessive-velocity car detection and real-time e mail signals. The STM32H microcontroller is selected for its outstanding processing power, energy efficiency, and compatibility with embedded vision applications. This system captures images of vehicles using a high-resolution camera module, processes them with advanced image processing techniques, and extracts license plate information through Optical Character Recognition (OCR). The extracted data is cross-referenced with a database, triggering an automated email alert if a flagged vehicle (such as a stolen or unauthorized one) is identified. This alert contains critical

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details like the vehicle number, timestamp, and location. Unlike traditional Automatic Number Plate Recognition (ANPR) systems that rely on cloud computing, this solution is optimized for embedded platforms, ensuring minimal latency and real-time performance. By integrating AI techniques with the STM32H microcontroller, the system's accuracy and speed are significantly enhanced, making it ideal for use on highways, at toll booths, and within smart city infrastructures. This project focuses on ANPR technology for high-speed vehicles and includes an automated email alert system to notify authorities. The device captures an photo of shifting motors, tactics the quantity plate, and sends an alert with car information. it's miles beneficial for traffic regulation enforcement, security monitoring, and smart metropolis applications.

Demanding situations and dreams:

- High-velocity motion Blur: taking pictures clear photos of shifting motors at high speeds is tough because of movement blur. Superior photograph stabilization and speedy shutter velocity cameras are required.
- Real-Time Processing Constraints: The STM32H microcontroller has restrained computational assets in comparison to GPUs or cloud-based totally solutions. Optimizing image processing and OCR algorithms for real-time execution is vital.
- License plate Variability: unique fonts, colors, plate designs, and languages in number plates across areas can result in recognition errors. Schooling the OCR model for diverse datasets is important.

Potential Applications:

- Campus & faculty safety: Tracks cars entering college premises, universities, and corporate campuses for security verification.
- Parking control: Automates access and go out logging for business and residential parking plenty, decreasing human intervention.
- Site visitors Rule Enforcement: Detects dashing violations, crimson light jumping, and unauthorized lane utilization for automatic ticketing.

II. LITERATURE SURVEY

This review elaborates the context of the discovery and prevention of drowning by various proposed methods available. This includes the design difficulty associated with the accuracy and functionality of the project. The authors of the paper [1], The literature review in Automatic Incident Detection at Intersections with Use of Telematics by Oskarbski, Zawisza, and Żarski emphasizes the evolution of traffic incident detection methodologies, particularly in urban settings. The authors examine various algorithms, each with distinct advantages and limitations. Pattern recognition methods, for instance, analyze traffic flow data to detect anomalies, but their effectiveness can be limited by recurrent congestion patterns. Kalman filtering techniques improve incident prediction by dynamically updating system parameters based on observed traffic data.

The authors of the paper [2], " IoT Approaches for the Efficient Overtake Detection of the Vehicles Using of H264/AVC Video Data" by Rodriguez-Benitez et al. focuses on integration of the IoT technologies with video data processing to enhance traffic safety. The study emphasizes the efficiency of H.264/AVC video compression, which allows for high-quality video analysis with reduced bandwidth usage, critical for real-time traffic applications. The authors discuss the challenges of video-based vehicle detection, including the need for computational efficiency and reliable communication in varying network conditions.

The authors of the paper [3], “How Realistic is Static Traffic Assignment? Analyzing Automatic Number-Plate Recognition Data and Image Processing of Real-Time Traffic Maps for Investigation" by Mirzahossein et al. explores the limitations of static traffic assignment models in capturing real-world traffic dynamics. The study focuses on the congestion charge zone (CCZ) in Tehran, utilizing data from automatic number-plate recognition (ANPR) systems to

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build an origin-destination (OD) matrix This matrix is processes using the data mining techniques and compared against static traffic assignment results under user equilibrium (UE) conditions.

The authors of the paper [4], "A Dynamic OD Prediction Approach for the Urban Networks Based on the Automatic Number Plate Recognition Data" by Liu et al. explores advanced methods for predicting origin-destination (OD) flows in urban traffic systems. The authors highlight the critical role of OD matrices in traffic management, focusing on real-time applications. They employ Principal Component Analysis (PCA) to reduce the dimensionality of OD matrices, extracting primary traffic patterns while filtering out noise. A state-space model is integrated into a Kalman filter framework to predict dynamic OD flows effectively.

The authors of the paper [5], In the 2024 paper by Kothai et al., An Efficient Deep Learning Approach for the Automatic Number Plate Detection with Novel Feature for Extraction, the authors propose a deep learning model that addresses to the challenges of license plate detection in real-world scenarios. The approach utilizes Convolutional Neural Networks (CNNs) to detect license plates, with a novel feature of extraction technique designed to improve detection accuracy even in challenging conditions such as varying lighting, camera angles, and obstructions. The study focuses on enhancing image preprocessing techniques like resizing and padding to optimize neural network input, allowing for more accurate detection.

III. ARCHITECTURE

The block diagram of the design is shown in Figure 1. The block diagram shows the main functionality of the System. Number Plate Detection and Recognition.

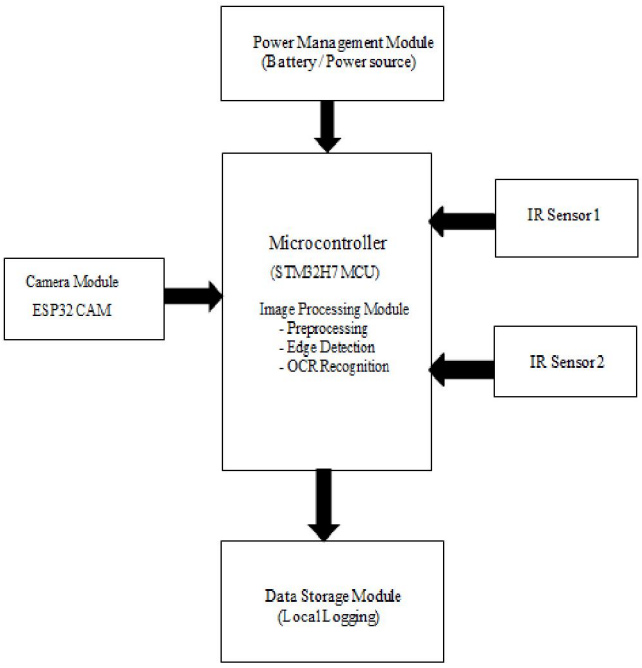

Fig. 1. Block Diagram

This diagram represents a block diagram of the Automatic Number Plate Recognition (ANPR) has become an essential technology in modern traffic surveillance, security monitoring, and law enforcement. The ability to accurately capture and process vehicle license plates in real-time is crucial for applications such as toll collection, speed enforcement, and crime prevention. However, traditional ANPR systems often rely on high-performance computing resources, making them costly and power-intensive.

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Input Components (Sensors):

• Camera Module – ESP32-CAM: Captures images of moving vehicles, focusing on license plates.
• Infrared (IR) Sensors: Detects the presence of vehicles approaching the camera.
• Power Source: Provides power to the microcontroller, sensors, and camera module.

Output and Communication:

• Alert System: Delivers instant notifications upon detecting a vehicle, with a focus on those that are flagged or exceeding speed limits. The ANPR system integrates output and communication modules that facilitate efficient data logging, timely alerts, and smooth remote monitoring. This combination of notifications, wireless communication, and on-site alerts positions it as a robust solution for traffic enforcement, surveillance, and smart city initiatives.

How the System Works:

1. IR Sensor 1 & IR Sensor 2 detects an approaching vehicle.
2. The system calculates the vehicle speed based on the time taken to pass between two sensors.
3. If the speed exceeds a predefined threshold, the system triggers the camera module for image capture.
4. The ESP32-CAM module captures an image of the vehicle when triggered by the IR sensors.
5. The captured image undergoes pre-processing in the microcontroller, which includes:

-Noise reduction
-Contrast enhancement
-Edge detection (to isolate the number plate area)

6. Optical Character Recognition (OCR) for License Plate Extraction
7. The microcontroller (STM32H7 MCU) runs an OCR algorithm to extract characters from the detected number plate.
8. The extracted license plate number is converted into the text format for further processing.

A. STM32H7 Microcontroller

The STM32H7 series from STMicroelectronics is a high-performance ARM Cortex-M7-based microcontroller, designed for applications requiring high-speed processing, real-time performance, and advanced peripherals. It is well-suited for image processing, machine learning, and real-time embedded applications, making it ideal for the Automatic Number Plate Recognition (ANPR) system.

The STM32H7 series offers high-speed RAM to support real-time processing, image processing, and AI applications.

Special PIC16f886 Micro controller Features

• Enables real-time image processing & OCR execution.
• Max Clock Speed: 550 MHz
• Up to 1MB of internal SRAM
• Handles large image buffers, fast data storage, and real-time execution

Fig. STM32H7 Microcontroller

In this project, the STM32H7 microcontroller is used to process IR sensor data, calculate vehicle speed, detect over-speeding, and control the ESP32-CAM to capture images and trigger mail alerts in real time.

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B. ESP32 CAM MODULE

The ESP32-CAM is a small, low-power module based on the ESP32-S microcontroller, designed for camera-based applications like surveillance, face detection, image processing, and IoT projects. It includes Wi-Fi, Bluetooth, and an integrated OV2640 camera.

Processor: ESP32 (Dual-core, 32-bit)
RAM: 520KB + 4MB PSRAM
Storage: 4MB/8MB Flash + MicroSD support
Power: 3.3V
It needs 3.3V power and doesn't have a USB port for programming.

Fig. ESP 32 CAM

C. IR SENSOR

IR sensors detect objects, measure distance, and sense heat using infrared light. They are widely used in obstacle detection, motion tracking, and automation systems. IR sensors are the electronic devices that detect infrared radiation (heat or light) and convert it into an electrical signal. They are commonly used in automation, security, robotics, and object detection systems.

• Active IR Sensors (With an IR Emitter & Receiver)
- Emit infrared light and detect the reflection from an object.
- Used for the obstacle detection, distance measurement, and a remote control systems.

• Passive IR Sensors
- Detect infrared radiation (heat) from objects like humans and animals.
- Used for motion detection in security systems and automatic lights.

Fig. 4. IR Sensors

IV. CONCLUSION

In conclusion, the Automatic Number Plate Recognition (ANPR) system with high-speed vehicle detection and mail alert offers a powerful solution for automating vehicle identification and enhancing security across multiple domains. By leveraging advanced object detection and OCR technology, the system is capable of accurately recognizing license plates in real-time, even at high speeds. Its applications range from traffic law enforcement and toll collection to security in restricted areas, making it a valuable tool in both public and private sectors. However, considerations around cost, privacy, environmental sensitivity, and maintenance need to be addressed to maximize its effectiveness and

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reliability. The Automatic Number Plate Recognition with High-Speed Vehicle Mail Alert System using STM32H7, IR sensors, ESP32-CAM, and a 5V power source successfully detects speeding vehicles, captures license plates, and sends real-time email alerts. The system offers accurate speed measurement and reliable OCR-based plate recognition in favourable conditions. It demonstrates a cost-effective and efficient solution for automated traffic monitoring and law enforcement. With future enhancements like AI-based OCR, low-light support, and cloud integration, the system holds strong potential for real-world use in smart city and intelligent transport systems. Overall, ANPR systems play an essential role in modern surveillance, traffic management, and data collection, contributing to safer, more efficient, and well-regulated transportation and security systems.

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