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Smart Traffic Document Verification Using QR Code

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Abstract

Traditional traffic document verification is a slow, manual process prone to human error and delays. This paper presents a digitized solution using QR code technology to facilitate instant verification of vehicle registration, insurance, and other mandatory documents. The system employs an ESP32-CAM module to capture and transmit data to a server for real-time decoding and validation. Results indicate that a QR-enabled system significantly reduces document fraud, streamlines law enforcement, and enhances transparency in smart city infrastructure. Traditional roadside traffic document verification is a manual, labor-intensive process that often leads to significant traffic congestion, human error, and opportunities for document fraud. This project proposes an automated, IoT-based solution designed to digitize and streamline the authentication of vehicle records, including registration, insurance, and PUC (Pollution Under Control) certificates.The system architecture integrates an ESP32-CAM module with a centralized cloud-based server and database. The operational workflow begins when the hardware captures an image of a unique QR code generated through a dedicated web portal. This image is transmitted via Wi-Fi to a server where it is decoded; if a valid string is identified, the system cross-references the data against a secure Firestore database to check for real-time compliance.Results of the verification are communicated back to the field officer through immediate visual feedback using LED indicators: a Green LED signifies successful validation, while a Red LED alerts the officer to invalid or expired documentation. By replacing physical inspections with instant digital scanning, the proposed system minimizes paperwork, enhances transparency in law enforcement, and provides a scalable framework suitable for integration into Smart City infrastructures.

Introduction

Roadside document checking currently faces several challenges:

Inefficiency: Manual verification is time-consuming for both officers and motorists.

Accuracy: Physical documents are susceptible to being error-prone or fraudulent.

Delays: Traditional methods often lead to traffic congestion during routine checks.

By digitizing this process, authorities can instantly verify a vehicle's legal status—including PUC certificates and registration—by simply scanning a QR code.The introduction to your project, Smart Traffic Document

Verification Using QR Code, provides the essential background, identifies the existing problems in traffic management, and outlines how your technology serves as a solution.

1. Background of Traffic Management-In the current era of increasing vehicle ownership, traffic law enforcement is a critical component of road safety. Authorities must ensure that every vehicle on the road complies with legal requirements, such as valid registration, updated insurance, and Pollution Under Control (PUC) certification. Traditionally, this has been managed through physical documentation held by the driver.

2. Problem Statement: The Manual System-The traditional method of manual document verification faces several significant challenges:

Inefficiency and Delays: Stopping vehicles for physical inspections is a slow process that often leads to traffic congestion and delays for motorists.

Human Error: Manual checking is prone to oversight or mistakes during the inspection of expiry dates and document authenticity.

Vulnerability to Fraud: Physical papers can be easily forged, altered, or duplicated, making it difficult for officers to verify their legitimacy on the spot.

Corruption Risks: The lack of a digital trail in manual processes can sometimes lead to lack of transparency and vulnerability to corruption.

3. The Proposed Solution: QR-Based Digitization-This project focuses on creating a smart and secure digital ecosystem using QR code technology. By shifting from paper-based records to a centralized digital system, the verification process becomes faster and more accurate.The core idea is to provide each vehicle with a unique, encrypted QR code that acts as a digital gateway to all mandatory legal documents. When scanned by an officer using an IoT-enabled camera (ESP32-CAM), the system instantly retrieves real-time data from a cloud database.

4. Objectives and Scope-

The primary objectives of this system include:

Instant Verification: Enabling police officers to verify a vehicle's legal status in seconds by simply scanning a code.

Enhancing Road Safety: Ensuring that only compliant and environmentally safe (PUC-certified) vehicles are on the road.

Improving Transparency: Creating a tamper-proof digital log of all verifications to reduce fraud and improve law enforcement accountability.

Smart City Integration: Providing a scalable framework that can eventually be adapted for automated fine collection and broader smart city infrastructure.

System Methodology

The proposed system integrates hardware and software to create a seamless verification loop:

1. Hardware Integration

ESP32-CAM: Used as the primary capturing device to take photos of the QR codes.

Visual Feedback: The system uses LEDs to communicate results: a Green LED for successful verification and a Red LED for invalid or failed results.

2. Working Principle

Initialization: The device powers on, initializes the camera, and establishes a Wi-Fi connection to reach the server.

Capture and Transmission: The camera captures the QR code image and sends it to the server.

Server-Side Processing: The server decodes the image. If the QR is missing or invalid, the system loops back to the capture stage.

Verification: Valid decoded data is cross-referenced against the database for final verification.

Proposed System:

System Architecture and Components

The system is built upon four primary pillars:

Registration & Generation Portal: A web interface where users can register their vehicles and generate unique QR codes containing their document IDs.

IoT Capture Node (ESP32-CAM): A hardware module used by traffic authorities to capture images of these QR codes in the field.

Processing Server: A remote server that receives images from the hardware, decodes the QR data, and cross-references it with a database for validation.

Verification Feedback (LED System): Immediate visual indicators (Green for valid, Red for invalid) that signal the status of the documents to the officer.

Operational Workflow

The system operates through a sequential logic designed for speed and accuracy:

1. Initialization and Connectivity -Upon power-on, the ESP32-CAM initializes its camera sensor and establishes a Wi-Fi connection to ensure it can communicate with the central server.

2. Image Capture and Transmission-When an officer scans a vehicle, the camera captures an image of the QR code. This image is immediately uploaded to the server for analysis.

3. Server-Side Decoding-The server processes the uploaded image to detect and decode the QR code.

If no QR is detected: The system triggers a "LOOP to CAPTURE" instruction, signaling for another photo to be taken.

If a QR is detected: The system extracts the document ID and moves to the verification stage.

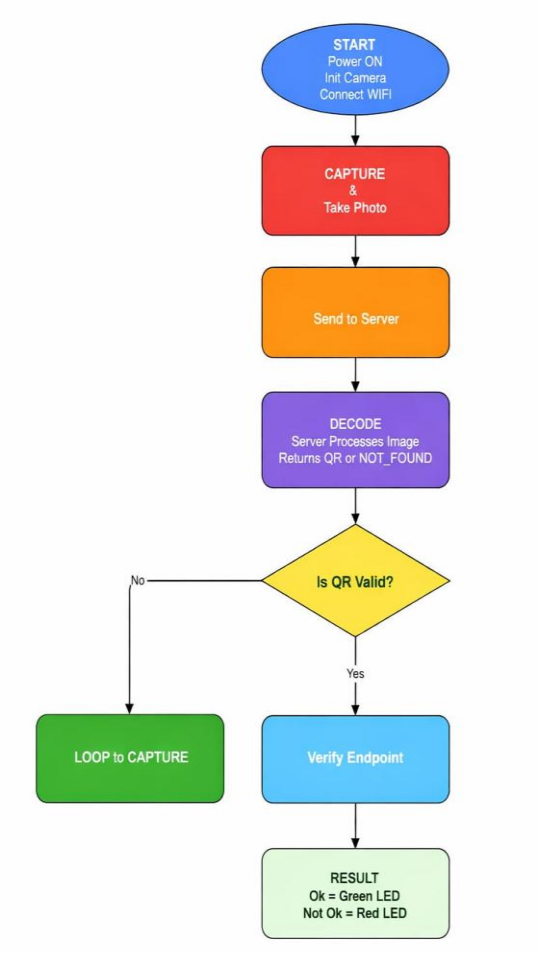

Fig 1: Flowchart of QR Code-Based Traffic Document Verification and Validation Process

4. Database Validation-The decoded data is sent to a Verify Endpoint. Here, the system checks the encrypted cloud database for real-time status on:
Vehicle Registration
Insurance Validity
PUC (Pollution Under Control) Certificates
5. Real-Time Result Notification-The final result is transmitted back to the -field hardware:
Green LED: Indicates successful verification of all documents.
Red LED: Indicates an invalid QR code, expired documents, or failed verification.

System Design
System Architecture

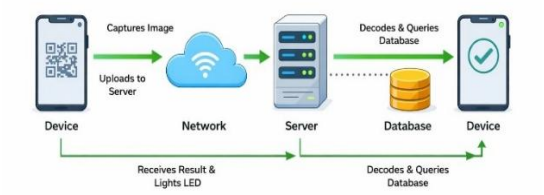

Fig 2: IoT-Based QR Code Vehicle Document Verification and Validation System Architecture

1. Perception Layer (Field Hardware)
ESP32-CAM: The primary controller that initializes the camera and establishes a Wi-Fi connection.
Capture Unit: Takes a high-resolution photo of cthe user's QR code.
Indicator Unit: Uses a Green LED for "Ok" results and a Red LED for "Not Ok" results to provide instant feedback to the officer.
2. Communication Layer (Connectivity):
Wi-Fi Gateway: Acts as the bridge to send captured images and data packets to the remote server.
HTTP Request/Response: The protocol used to transmit data to the verification endpoints.
3. Processing & Application Layer (Cloud/Server):
Web Server: Receives the image, decodes the QR string, and handles logic for "QR Not Found" loops.
Database (Firestore): Stores vehicle registration details, insurance status, and PUC expiry dates for cross-referencing.
Admin/User Portal: A web interface for users to generate QR codes and for police to manage verification logs.

Implementation and Results
The project includes a web-based portal for both users and traffic police:
User Dashboard: Allows citizens to register vehicles and generate unique QR codes containing their document IDs.
Police Interface: Enables officers to log in and access the verification camera.
System Performance: Real-time logs show the system successfully uploading images, detecting QR data strings (e.g., "Ced7tr461..."), and returning status codes.

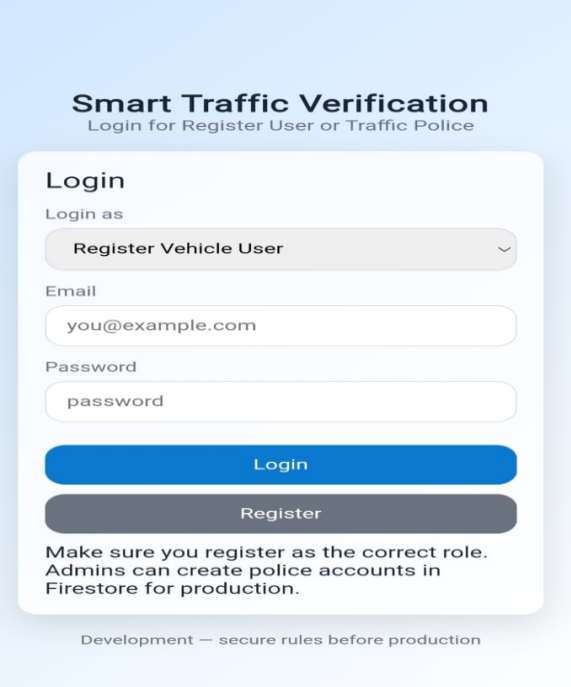

Fig 3: Login Page

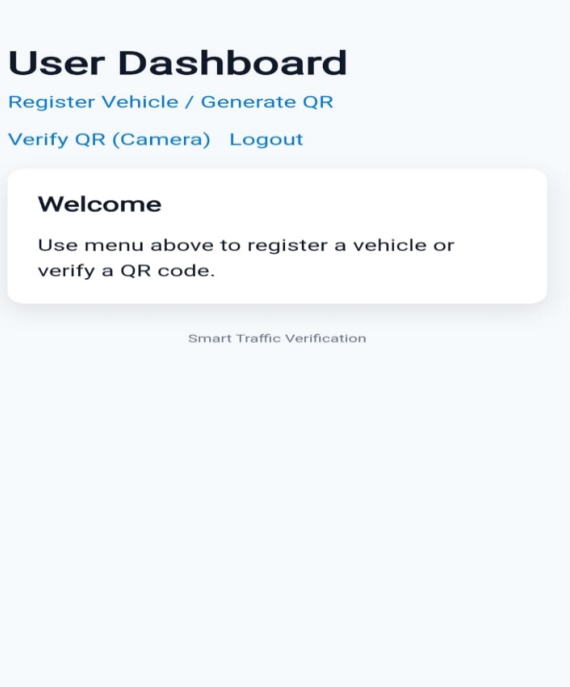

Fig 4: User Dashboard

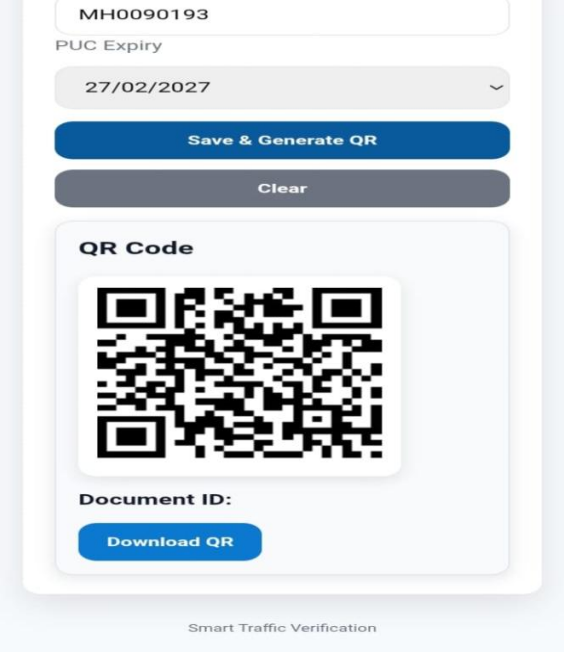

Fig 5: Generated QR Code

Conclusion

The QR-based document verification system offers a scalable alternative to traditional manual methods. By utilizing encrypted cloud databases and mobile-ready scanning technology, the system:

Minimizes paperwork and reduces manual errors.

Enhances transparency and reduces the likelihood of corruption.

Improves safety by ensuring real-time compliance with insurance and registration laws. This solution is highly adaptable for future Smart City integration, potentially enabling automated fine collection and better road safety management.

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