Transformative Impact of Edge-based Automatic License Plate Recognition Technology cum FASTag system (AFS) on Traffic Management: A Case Study of Delhi-Meerut Expressway

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Abstract

The Delhi-Meerut Expressway is not only a significant infrastructure project in India but also a pioneering endeavour in terms of implementing an advanced Intelligent Transport System (ITS). This project paper explores the integral role of the **Automatic License Plate Recognition (ALPR)** technology within the ITS framework, emphasising its Edge based implementation and transformative impact on traffic management. By leveraging ALPR technology, the Delhi-Meerut Expressway has achieved **improved surveillance**, **enhanced safety measures**, and **efficient traffic flow**. This report delves into the implementation, accuracy, benefits, and future prospects of ALPR within the intelligent transportation ecosystem of the expressway.

Introduction

The Delhi-Meerut Expressway stands as a testament to India's commitment to enhancing transportation infrastructure. As part of this initiative, the implementation of an **Intelligent Transport System (ITS)** has revolutionised traffic management. At the heart of this system lies a sophisticated Vehicle Identification system consisting of **AI Powered Automatic License Plate Recognition (ALPR)** Technology, Automatic Vehicle Classification, Vehicle Make-Model and Colour Identification which plays a crucial role in ensuring accuracy, efficiency, and safety on the expressway.

The Expressway is being built in four phases or packages, three of which are along the existing NH-24, while the longest stretch will be an entirely new road, from Dasna to Meerut

Automatic License Plate Recognition (ALPR) Technology: We developed an in-house ALPR engine by making proprietary modifications of already existing OCR models to make them adapt to a few local specific number plates in combination with our Vehicle Classification, Vehicle Make-Model and Colour Identification models.
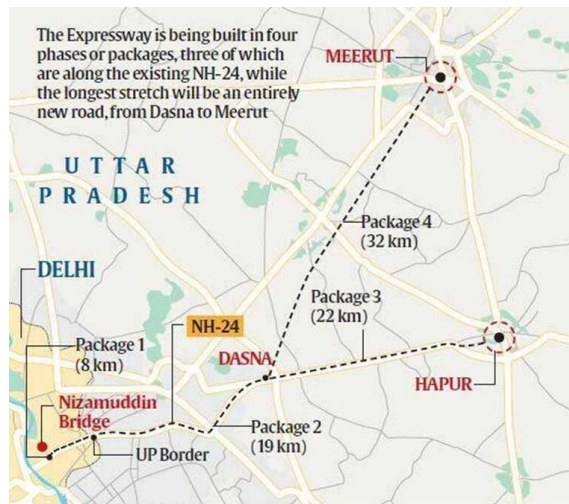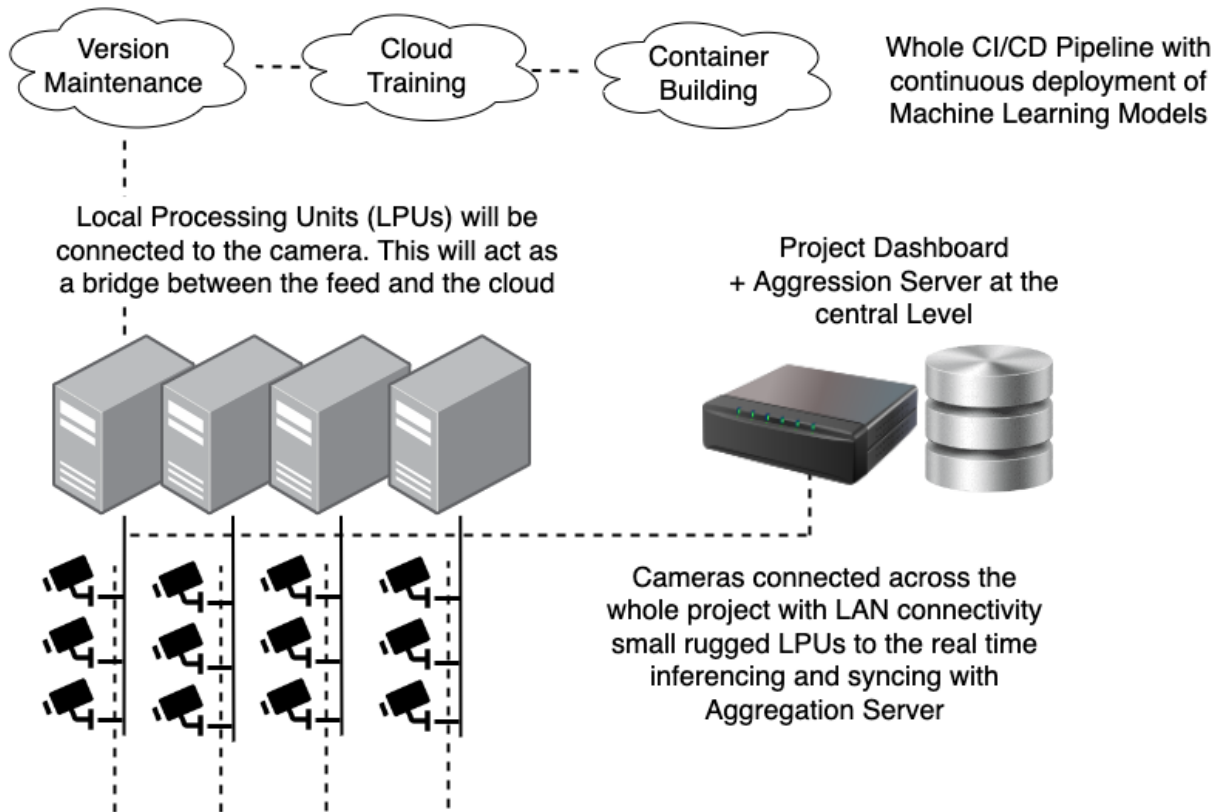
Network Architecture

Camera Network:

- A comprehensive network of **ALPR cameras** is strategically installed along the Delhi-Meerut Expressway to capture licence plate images from various angles and distances, ensuring comprehensive coverage of the traffic flow. There are **14 entry** and **14 Exit points** on the whole 60 Km stretch apart from the main toll at the Meerut end,
- This 60km stretch is a big local network connected with **Optical Fiber and Lan cables.**
- Each lane hosts one **front facing**, one **rear facing** and one **wide-angle vehicle classification camera** on such entry and exit locations having multiple lanes.
- There are redundant locations near foot-over bridges (Carriageway) with additional cameras installed at multiple strategic locations to **ensure 100% accuracy in capturing the vehicles.**
- The expressway also hosts **FASTag readers** on each lane at all locations.
- These locations have a dedicated industrial grade **Edge AI (Local) processing Unit (LPU)**. Each unit **processes multiple cameras** and **deduplicates entries** of vehicles travelling in the middle of lanes which are captured by multiple cameras at that location.

Benefits of Edge Based system:

1. Limited Bandwidth consumption.
2. No loss due to Network Disconnection.

Edge AI Processing Unit (LPU) :

Processes all the Cameras of one Entry/Exit or Carriageway Location. The role of LPU is to process each camera at its full frame rate supported by the camera. A few of the functions of LPU are.

1. **Detect**, **identify** and **track** specific objects and events of interest.
2. **Deduplicate objects** across cameras so that each object/event **is identified as one**.
3. Deduplicate vehicles across cameras and **FASTag readers**.
4. Check business logic and **send corresponding alerts** to the central aggregation server.
5. Store the **data locally** to reduce redundancy.
6. **Automatically flag incorrectly read number plates** that don't match the number plate pattern.

Incidents Identification such as:

1. Vehicles travelling in the **wrong direction**.
2. **Stalled/stopped/slow moving** vehicles on the road.
3. **Bad weather/Low visibility** on road, **Fire Incidents** on the highway.
4. **Tampering** of Camera.

Central Aggregation Server:

Central Aggregation Server collects data from LPUs of all locations and then **maps the journey** of vehicles. **AI powered suggestions** help **audit the journeys of vehicles** where entry or exit of vehicle is neither captured by Edge AI nor on Fastag readers.

Performance Evaluation and Testing Results

The accuracy of the Vehicle Identification system is daily monitored by auditing sample data for both daytime and nighttime footage.

The following data represents the aggregation of vehicle audits over the past 180 days, which is exceptional in its breadth and scope:

Analytics		
Type	**Use cases**	**Accuracy**
ANPR	Vehicle Count	**99.8%**
	Standard Number plate recognition (day)	**98%**
	Standard Number plate recognition (night)	**98%**
	Non Standard Number plate recognition (day)	**90%**
	Non Standard Number plate recognition (night)	**85%**
AVC	Vehicle Counting Accuracy	**99%**
	Vehicle classification Accuracy	**97%**

Conclusion

In conclusion, the integration of ALPR technology within the ITS framework of the Delhi-Meerut Expressway has resulted in significant improvements in traffic management. The performance metrics collected over the past 180 days highlight the system's effectiveness:

Vehicle Count Accuracy: Achieving an impressive 99.8% accuracy, the ALPR technology ensures comprehensive coverage of traffic flow on the expressway.

Number Plate Recognition: With recognition rates of 98% during both day and night conditions for standard number plates, and 90% during the day and 85% at night for non-standard plates, the ALPR system showcases reliable performance.

Vehicle Counting Accuracy: The system achieves a remarkable accuracy rate of 99%, providing reliable data for congestion management and infrastructure planning.

Vehicle Classification Accuracy: With a classification accuracy rate of 97%, the system enables precise identification of vehicle types, contributing to optimised traffic flow.

These metrics demonstrate the **effectiveness** and **reliability** of the ALPR technology on the Delhi-Meerut Expressway. By leveraging **edge-based processing units** and **strategically placed ALPR cameras**, the system has **improved surveillance**, **enhanced safety measures**, and **facilitated efficient traffic management**. This successful implementation sets a benchmark for intelligent transportation systems, paving the way for further advancements in traffic management nationwide.