Dynamic Toll Charging System

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Abstract—In India, most toll collection systems still rely on fixed charges through FASTag or manual cash booths. Although faster than traditional methods, these systems cause traffic congestion, unfair charges for short-distance travelers, and limited tracking. The proposed Dynamic Toll Charging System overcomes these challenges by integrating Automatic Number Plate Recognition (ANPR) and Radio Frequency Identification (RFID) technologies. Cameras at entry points capture number plates, while RFID scanners at exits identify vehicles to determine the exact distance traveled. The system automatically calculates tolls based on this distance and stores the data in a centralized database. This approach ensures faster, fairer, and transparent toll collection while minimizing human intervention and congestion.

Index Terms—Dynamic Toll Collection, ANPR, YOLOv8, RFID, Distance-Based Tolling, Intelligent Transportation System, OCR, Smart Highways

I. INTRODUCTION

1. Background: Toll collection plays a crucial role in maintaining and modernizing highway infrastructure. In a developing country like India, efficient toll systems are essential for managing road usage and funding growth. However, current methods are largely traditional, relying on fixed charges through manual booths or semi-automated FASTag systems. These models fail to consider factors like distance traveled, leading to inefficiencies and unfair practices where short-distance travelers pay the same as long-distance ones.

2. Motivation: The motivation for this project arises from the limitations of current fixed-rate structures. The static approach contributes to congestion, fuel wastage, and user dissatisfaction. As India moves toward smart city initiatives, there is an urgent need for a system that is intelligent, transparent, and adaptive. A technology-driven process is necessary to align with national goals and improve transportation efficiency.

3. Problem Statement: Current systems charge fixed fees without considering the actual distance a vehicle travels. Manual methods lead to human error and financial leakage, while FASTag still operates on a static, pre-determined model. There is a need for a dynamic system that employs a hybrid approach—integrating ANPR for detection and RFID for tracking—to ensure accuracy and fairness.

4. Objectives:
- Develop a distance-based tolling model that calculates charges proportionally to the distance travelled.
- Implement vehicle detection using the YOLOv8 deep learning model for real-time accuracy.
- Utilize RFID-based verification at exit points to match vehicles with entry records.
- Ensure automation and transparency to eliminate manual errors and provide a centralized database for auditing.

II. LITERATURE SURVEY

1. Existing Systems Review: Most existing systems use RFID and ANPR to automate payments but still rely on fixed-rate models. The FASTag system, widely adopted in India, uses RFID for contactless payments but operates on a static pricing model that does not account for actual distance covered. Research by Bhanu Teja et al. (2024) proposed a hybrid RFID and CNN-based system for vehicle classification, but it retained a flat-rate structure. Similarly, camera-based solutions using OCR improve transparency but often lack dynamic pricing and struggle with environmental factors like poor lighting.

2. Limitations and Gaps: The most significant limitation of existing systems is the inflexible pricing model, which penalizes short-distance travelers. Furthermore, reliance on single-mode technology (only RFID or only ANPR) creates vulnerability; if one component fails, the system falters. Many prototypes function well in labs but fail to address real-world scalability or lack the integrated hybrid

approach required for distance-based dynamic tolling.

3. Mini Project Contribution: The proposed Dynamic Toll Charging System addresses these gaps by integrating ANPR and RFID into a single intelligent framework.

| Contribution	Detail
Dynamic Pricing	*Unlike static models, this system introduces distance-based pricing, ensuring fairness for every vehicle.*
Hybrid Verification	*Combining camera-based recognition at entries with RFID verification at exits enhances accuracy and provides redundancy.*
Advanced Processing	*The use of YOLOv8 allows for precise recognition under variable conditions, while a centralized database ensures real-time data synchronization for nationwide scalability.*

III. PROPOSED SYSTEM

1. Introduction: The system introduces a hybrid framework integrating ANPR cameras at entry points and RFID scanners at exit points. This setup achieves end-to-end automation, calculating toll fees based on the exact distance travelled.

2. Architecture/Framework: The architecture represents the operational flow where vehicles are detected, identified, and billed dynamically.

- Entry: An ANPR camera captures the vehicle image. The YOLOv8 model detects the number plate, and OCR extracts the registration number. This data is stored in the Entry Database.
- Exit: An RFID reader scans the vehicle's FASTag to identify it. The system matches this with the entry record.
- Processing: The central processor calculates the distance and computes the

toll. The fee is automatically deducted from the linked account.
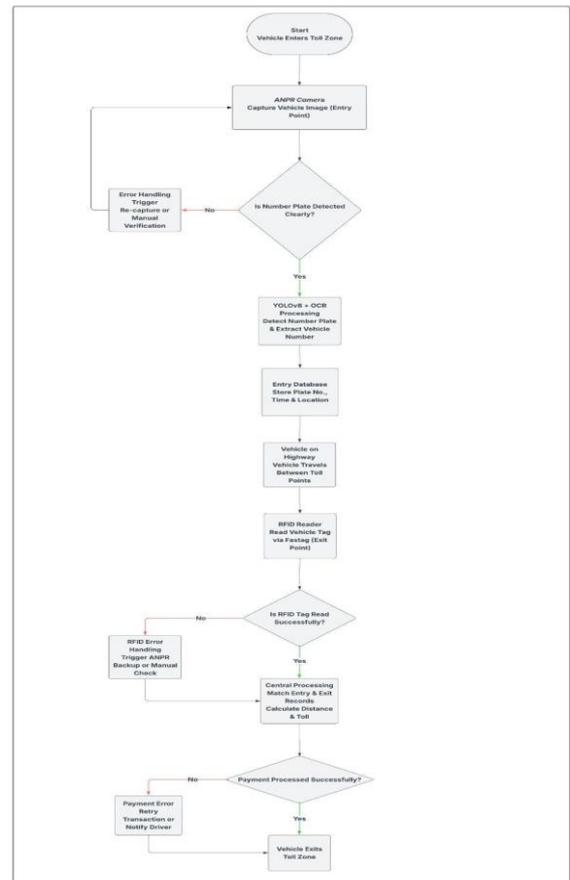

3. Algorithm and Process Design:
1. Start: Vehicle enters the toll zone.
2. Capture: ANPR camera captures the image. If detection fails, error handling triggers a re-capture.
3. Processing: YOLOv8 and OCR extract the vehicle number, which is stored with a timestamp and location.
4. Transit: Vehicle travels to the exit point.
5. Verification: RFID reader scans the tag. If successful, the system matches entry/exit records.
6. Billing: The system calculates the toll and processes payment. Upon success, the vehicle exits.

4. Hardware & Software:
- Hardware: High-resolution cameras for ANPR and FASTag (RFID) readers.
- Software: YOLOv8 for object detection, PaddleOCR for text extraction, Python for system logic, and a SQL backend for database management.

IV. EXPERIMENTS & RESULTS
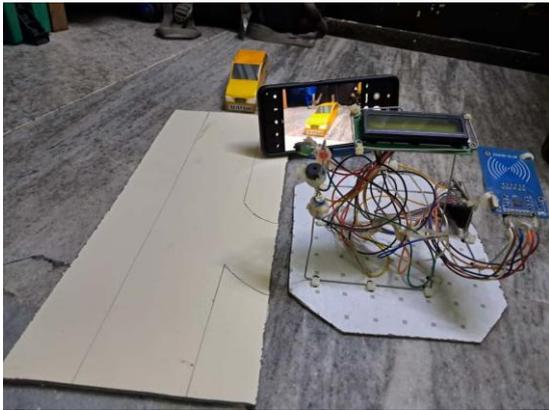
A. Prototype Setup A scaled-down prototype was developed using a model car and a project lane equipped with an ANPR camera and RFID scanner. The setup simulated a highway environment where the vehicle enters a specific lane for processing.
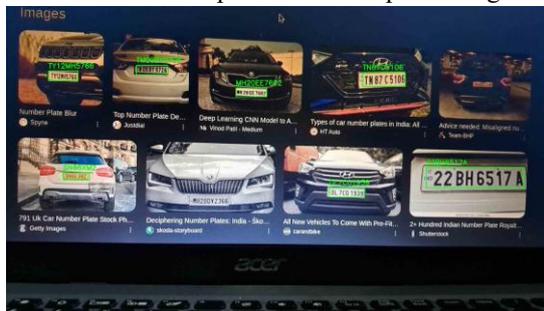
B. Results Testing demonstrated that the ANPR module successfully detected and read multiple number plates under varying conditions. The system accurately matched the optical data with RFID scans at the exit, successfully calculating the distance and corresponding toll without manual input. This confirms the system's ability to handle multi-vehicle processing and automated billing efficiently.

V. CONCLUSION

The Dynamic Toll Charging System successfully addresses the inefficiencies of fixed-rate tolling by implementing a fair, distance-based pricing model. By integrating ANPR and RFID, the system ensures robust vehicle id`entification and reduces human intervention. The experimental results validate that such a hybrid approach can significantly reduce congestion and improve transparency in toll operations.

VI. FUTURE WORKS

1. Cashless Integration: Full integration with banking APIs for automatic wallet deduction.
2. Smart Traffic Analytics: Utilizing data for real-time traffic monitoring and anomaly detection.
3. Scalability: Expanding the system to support multi-lane highways and diverse vehicle types.

VII. ACKNOWLEDGMENT

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