SMART TRAFFIC MANAGEMENT SYSTEM USING REAL-TIME AI AND REINFORCEMENT LEARNING

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Abstract

This paper presents the design and development of an AI-powered Smart Traffic Management System that addresses urban traffic congestion using real-time video analytics and adaptive signal control. Traditional traffic systems operate on pre-set signal timers, which fail to respond to varying traffic conditions, leading to increased congestion, fuel wastage, and pollution. To overcome these limitations, the proposed system integrates a custom-trained YOLOv8x object detection model for real-time vehicle recognition and tracking via CCTV feeds. It accurately identifies cars, bikes, buses, and trucks, and detects common traffic violations such as over-speeding, red-light jumping, and helmet-less riding. Additionally, the system employs Reinforcement Learning (Q-Learning) to dynamically adjust signal timings based on live traffic density, optimizing flow and minimizing wait times. A unique feature of the system is its capability to recognize emergency vehicles such as ambulances and fire trucks, and prioritize their movement through a green wave mechanism, ensuring rapid response and enhanced public safety. Through extensive testing, the system demonstrated a 30% improvement in traffic flow efficiency and a notable reduction in violations, confirming its real-time effectiveness. This AI-driven, adaptive approach contributes to safer, smoother, and more eco-friendly road traffic management in urban areas.

KEYWORDS: YOLOv8x, Reinforcement Learning, Q-Learning, Traffic Violation Detection, Emergency Vehicle Priority, Smart Traffic Signal Control.