Transcend Traffic: Integrating Vision-Based Analysis, SPSA-NN Optimization, Distracted Driver Detection, and V2X Communication

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Urban transportation faces multifaceted challenges including traffic congestion, road safety, and the need for real-time accident prevention. This project presents a comprehensive approach employing a five-part system, integrating Vehicle-to-Everything (V2X) communication with a Vision Pipeline for live traffic camera analysis, an SPSA-NN Traffic Optimization Algorithm for adaptive signal control, Distracted Driver Detection for road safety, and Enhanced Road Stud Capability for improved signaling and traffic flow. The vision pipeline analyzes live traffic footage using background modeling, Gaussian mixture models, and ViBe, enhanced by V2X data for vehicle detection, occlusion resolution, and greater accuracy, generating vital data for optimization. Based on this combined data, the distracted driving detection system (TCD3) uses machine learning to track movement, detect anomalies, achieving improved accuracy through V2X validation and real-time alerts to nearby vehicles and authorities. The multiagent system for signal control integrates the simultaneous perturbation stochastic approximation (SPSA) theorem in fuzzy neural networks (FNN), leveraging V2X telemetry to improve signal timing predictions. The SPSA-NN algorithm demonstrated superior performance in 24-hour extreme scenarios, achieving a substantial 83% reduction in mean delay with continuous online learning capabilities and enhanced responsiveness to real-time conditions. The enhanced road studs, dynamically updated through V2X data, improve visibility and adapt to traffic conditions without requiring reversible lane switching. Together, these components significantly enhance traffic flow, safety, and urban transportation efficiency, marking a major advancement in intelligent mobility systems.

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