



Online Competitive Algorithms and Reinforcement Learning for Traffic Management

Project Objective

This initiative seeks to modernize infrastructure management by applying advanced computer science, deep learning, and algorithmic simulation to urban traffic control. The primary goal is to provide transportation agencies with low-cost, data-driven tools that continuously identify failing traffic signals, optimize traffic light timing, and significantly reduce motorist delay and vehicle emissions across public road networks.

Problem Statement

Outdated traffic signal infrastructure costs commuters millions of hours in lost productivity and unnecessarily increases fuel consumption. Currently, major metropolitan areas rely on multi-year retiming cycles (often taking up to two years to complete) and outdated 70-year-old mathematical models that favor excessively long red light wait times. Because physical traffic sensors are expensive to install and maintain, municipalities lack cost-effective, automated methods to detect which intersections require immediate retiming, leaving bottlenecks unaddressed for years.

Research Methodology

This study utilizes open-source data, artificial intelligence, and simulation modeling to analyze traffic congestion and signal timing across the Las Vegas Valley. By leveraging over 13 million trip status data points from regional utility and maintenance vehicles, traffic performance was evaluated across four local jurisdictions.

Targeted Mapping: Using a Speed Performance Index, which compares average driving speeds against maximum speed limits, researchers filtered and mapped severe congestion points, isolating a candidate list of 70 high-priority intersections.

AI-Driven Anomaly Detection: A semi-supervised machine learning model (an Autoencoder) was built using TensorFlow Keras. By compressing 13 complex traffic variables into a 4-feature space, the model automatically detects failing traffic signals by flagging statistical anomalies.

Signal Cycle Simulation: Applying computer science "batch scheduling" principles, traffic simulations evaluated vehicle delay queues under various signal timings. Incorporating overhead and penalty delays, tests revealed that cutting traffic signal cycle lengths in half yields only minimal increases in average vehicle wait times compared to optimal timing.

Results

Evaluating 2025 traffic data produced direct findings on regional gridlock, automated monitoring performance, and how signal timing strategies perform under real-world conditions. Key findings include:

Pacific Southwest Region UTC Research Brief

Regional Congestion Hotspots: The study isolated 70 priority intersections suffering from severe delays, with the highest concentration of bottlenecks located in unincorporated Clark County, followed by Las Vegas, Henderson, and North Las Vegas.

AI Detection: The artificial intelligence model successfully flagged failing traffic signals, proving that sudden vehicle speed drops and variations are reliable triggers for automated monitoring.

Batch Scheduling Efficiency: Traffic queue simulations applying computer science "batch scheduling" principles proved that halving signal cycle lengths causes virtually no increase in driver delays, even after factoring in a 5-second per-vehicle overhead and a 3-second batch penalty.

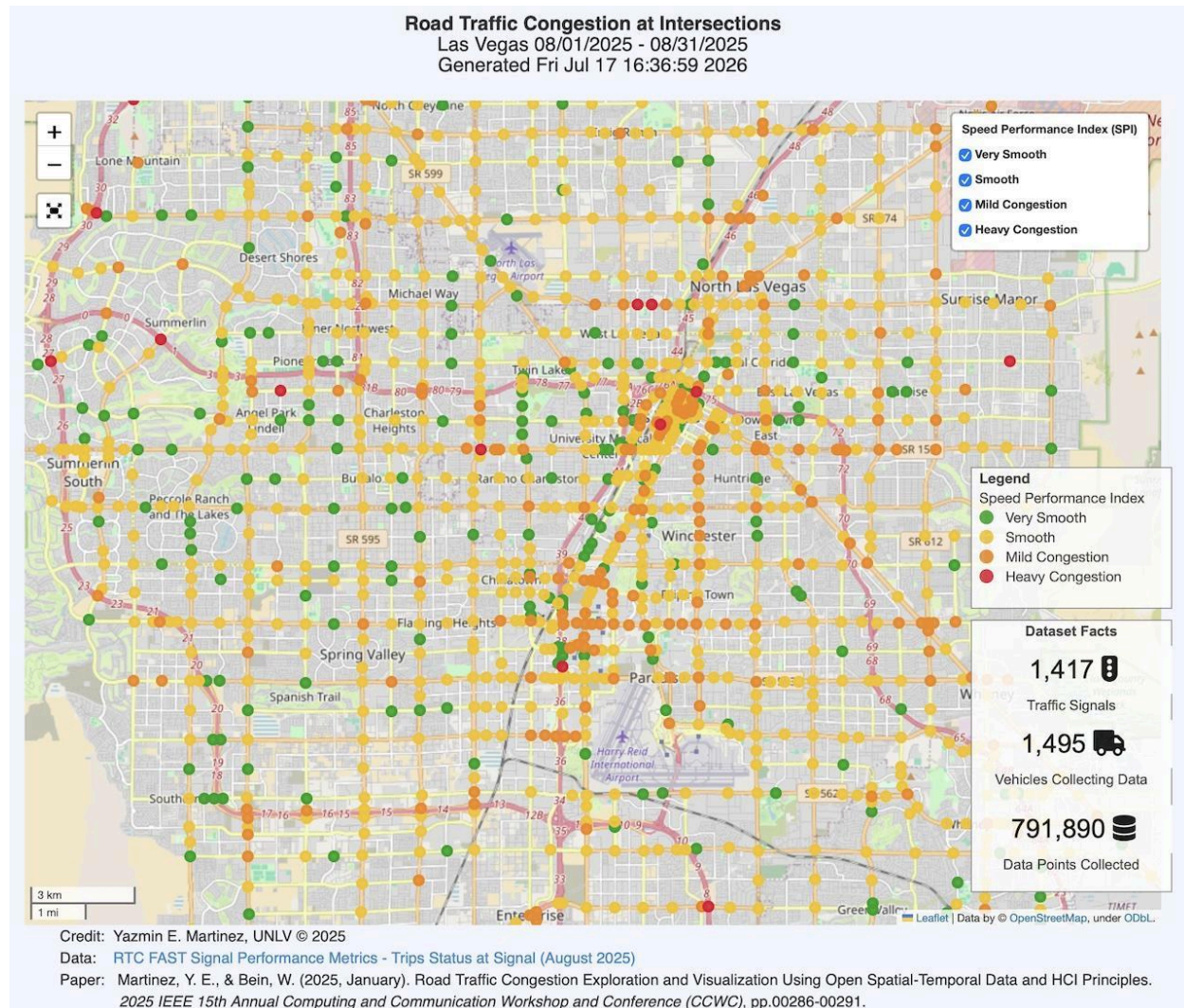


Figure 1: August 2025 Geospatial Map Showing Aggregated Signal Performance Index Congestion Measure.