

Time Optimization for Traffic Signal Control Using Genetic Algorithm

Abstract

With rapid urbanization and increasing vehicular congestion, optimizing traffic signal control is crucial for efficient urban mobility. Traditional fixed-time traffic signal systems fail to adapt dynamically to fluctuating traffic conditions, leading to unnecessary delays and inefficiencies. This study presents an adaptive, real-time traffic signal control strategy utilizing Genetic Algorithms (GA) to optimize signal timings and enhance intersection performance.

The research formulates traffic control as an optimization problem, leveraging a fitness function that considers road-specific traffic densities and dynamic green light extension. The GA approach is implemented using Python, with parameters such as population size, mutation rate, and crossover rate optimized for performance. The system operates with a fixed cycle length of 70 seconds and dynamically adjusts green light extensions within a predefined range.

Simulation results indicate that the GA-based system significantly outperforms traditional fixed-time control. Comparative analysis between the two systems demonstrates improved traffic flow efficiency, as measured by vehicle throughput at intersections. The optimal configuration includes a population size of 50, a crossover rate of 0.9, and a mutation rate of 0.1, ensuring steady-state fitness improvements. The real-time adaptability of the proposed system allows for more responsive traffic management, reducing congestion and enhancing overall road network efficiency.

This research contributes to the field of intelligent transportation systems by demonstrating the potential of GA-based optimization for traffic signal control. The findings suggest that integrating computational intelligence in urban traffic management can lead to more adaptive, efficient, and scalable solutions. Future research could explore real-world implementation, refining the algorithm to accommodate varying road conditions and computational constraints.