Journal of Information Technology and Cyber Security Engineering
Volume 01, Issue 02, September 2025
www.ijitcse.com

Optimising Traffic Light Signal Parameters Through Multielement Genetic Algorithm Modification

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To Cite this Article
Srikanth and Hima Bindu, "Optimising Traffic Light Signal Parameters Through Multielement Genetic Algorithm Modification", Journal of Information Technology and Cyber Security Engineering", Vol. 01, Issue 02, September 2025, pp:01-04

***Abstract**: The timing of traffic signals is essential to the future of reducing traffic and increasing urban mobility. This is executed in such a manner that in this work, a multielement genetic algorithm (MEGA) modification is employed to do an optimal setting of traffic light signals in a new manner. The proposed method adaptively changes green time, cycle length and phase sequence depending upon the real-time available actual traffic flow data by improving the traditional genetic algorithms with adaptive crossover, mutation, and selection operations. The simulation results indicated that the mean vehicle delay, mean queue length, and throughput have substantially mitigated vehicles of various traffic conditions. Adaptive traffic control systems are suitable to the MEGA optimisation owing to the fact that it is more responsive and efficient compared to the conventional ones. This approach to addressing the smart transportation systems issue offers a data-driven, scalable solution in more and more complex urban environments.*

***Keywords**: Artificial intelligence, GA, Optimization, Signal parameters, Transportation system*

I. Introduction

The issue that continuously occurs in the city is that of congestion on the streets and this causes time wastage, fuel consumption, and wastes. Static timing schemes that are common amongst conventional traffic signaling systems cannot adapt to real-time changes in the traffic. Due to its flexibility and robustness, evolutionary algorithms, especially genetic algorithms, or GAs, have gained a lot of popularity in optimisation processes. But, during complicated traffic situation volume GAs may experience the issue of convergence speed and quality of solution. To optimize some key traffic signal parameters more efficiently, such as green time, cycle length, the sequence of phases, this paper proposes a variation to Multielement Genetic Algorithm (MEGA). By means of multi-point evolutionary methods and flexible operators, MEGA enhances convergence accuracy, and solution diversity. The method is backed by simulations in several different traffic conditions that exhibit some significant improvements on the efficiency of traffic flow. This research contributes to development of smart transporting networks through the creation of intelligent, responsive traffic signal systems and at the same time makes urban transportation networks more intelligent [1].

II. Related Work

Optimisation of the traffic signal parameters has long been studied over the years. The normal methods, such as Webster method, do provide fixed-time control which measures the past traffic data and hence are not dynamic enough to respond to real-time changes. The evolution of intelligent transportation systems has made the metaheuristic algorithms like Genetic Algorithms (GAs) popular as these algorithms can solve complex nonlinear optimisation problems. Superior performance upon application of Foy et al. (1992) of GAs to signal timing in place of fixed-time techniques thus appeared. Subsequent experiments conducted by Park et al. (2000) and Ceylan & Bell (2004) surveyed the GA-based optimisation of signal under several traffic conditions. As captured in these research GAs improves performance measures such as stop frequency, queue length and delay [3-6].

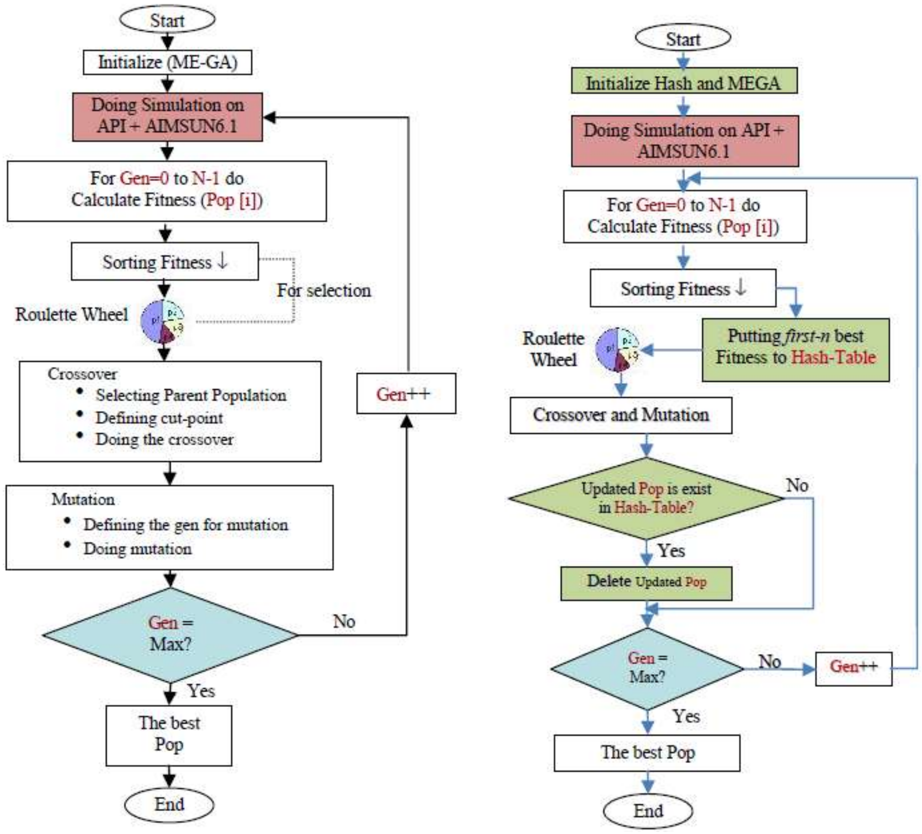

Fig 1: Flow Chart of H-MEGA.

Researchers have created hybrid models as a way of overcoming the disadvantages of GAs like premature convergence, limited adaptability by integrating GAs with fuzzy logic, neural networks and particle swarm optimisation [1-3]. There have also been proposals of adaptive genetic algorithms (AGAs) which dynamically adjust the crossover and mutation rates to provide better performance. Notwithstanding these developments, few have been able to successfully optimize a number of signal characteristics across various traffic conditions. This gave birth to the Multielement Genetic Algorithm (MEGA) which modifies the traditional elements of the Genetic Algorithm in order to achieve better convergence, maintenance of population diversity and delivery of dependable real time traffic signal optimisation.

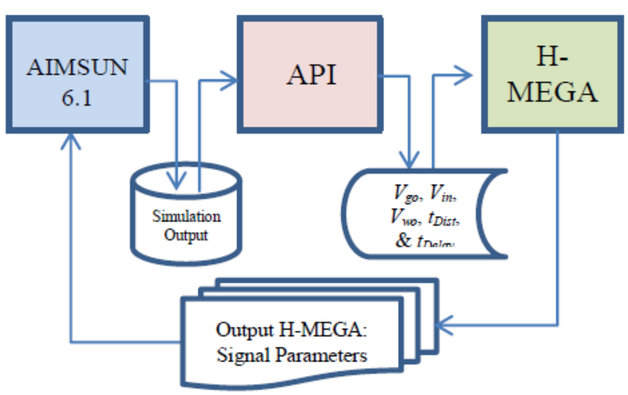

Fig 2: Block diagram of coordination and communication

III. Evaluation and Discussion

By using real metropolitan situations with varying volumes of traffic as well as traffic patterns, the proposed Multielement Genetic Algorithm (MEGA) was evaluated in terms of the simulation using traffic. Some of the main performance indicators related to average vehicle delay, queue length, stop frequency, and intersection throughput. The results were compared with fixed-time control, adaptive genetic algorithms (AGAs), or conventional genetic algorithms (GAs) because it demonstrates the effectiveness of MEGA. As per the results, MEGA outdid the baseline approaches more frequently in a normal course. The mean stoppage of vehicles decreased by 10-18 percent in comparison to normal GAs and 20-35 percent in comparison with fixed-time control. There was also a shortening of queues especially in peak times implying an enhancement of congestion bottlenecks. Since MEGA was responsive, one could adjust signal timing during real time and this enhanced movement of traffic and reduced stop start behavior.

Fig 3: Network with two different roads

In the discussion, the adaptive crossover, mutation, and selection techniques that MEGA uses to optimize the speed of convergence and the quality of solutions are highlighted. This flexibility allowed better exploration and exploitation of the solution space and reduced premature convergence which is observed in the normal GAs. Besides, MEGA was found to be normal and expandable across different intersection types and levels of traffic. Nevertheless, the quality of the simulation and the quality of the input traffic data identify the quality of the work of the algorithm. To further test its usefulness, it is possible to implement it under large smart traffic systems and to unite it with current networks of real-time sensors [1-4].

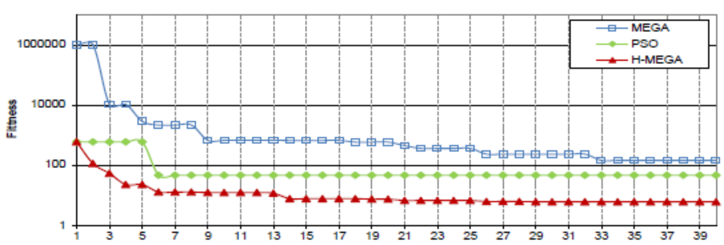

Fig 4: H-MEGA existing methods

IV. Conclusion and Future scope

The investigation was effective in demonstrating the optimality in the use of Multielement Genetic Algorithm (MEGA) on the attributes of traffic light signals. When compared to fixed-time control systems and traditional GAs, MEGA generated a tremendous decrease in average vehicle delay, queue lengths, and frequency of stops in a variety of traffic conditions. It should be used in real-time traffic management of urban traffic due to its adaptive nature which entails dynamic crossover and mutation, which enable faster convergence and accuracy of solution.

The scalability and flexibility of MEGA show how perfectly it can be incorporated in intelligent vehicle technologies. Practical application remains challenging, however, with respect primarily to processing requirements, as well as accessibility of real-time traffic information.

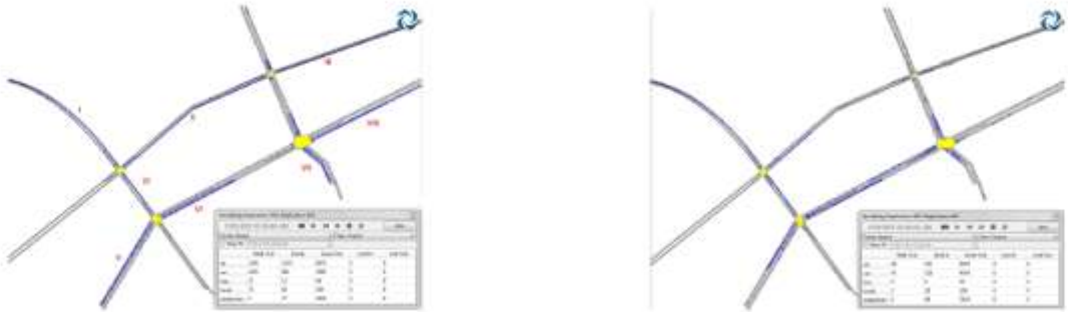

Fig 5: Traffic congestion with signal parameters

It is expected that future studies can enhance MEGA with multi-objective optimisation to balance mobility and environmental goals, a IoT sensor networks to collect current data in real-time and machine learning as a traffic presage. The effect on the efficiency of city traffic, as well as its practical implementation, could be further confirmed by the wide-scale testing under the conditions of smart city.

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