iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: XII Month of publication: December 2024

DOI: https://doi.org/10.22214/ijraset.2024.65908

AI-Based Adaptive Traffic Management

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Abstract: Traffic congestion is one of the biggest and most important issues facing modern city dwellers, necessitating effective and efficient solutions. AI-powered traffic light optimization has grown in popularity. The available literature indicates that intelligent approaches outperform traditional management techniques. The amount of cars on each intersection road determines the signal timings, which are adjusted to reduce traffic at the intersection. The recommended topology may significantly reduce traffic jams and wait times at the intersection. A lot of benefits can arise from an efficient traffic control system, such as less traffic on the roads, more economic efficiency, and enhancements in pedestrian safety and air quality. This paper discusses the several phases of the process, including data collecting, data analysis, and simulation development. At the conclusion of the process, a Python simulation model is created to test the topology.
Keywords: Artificial Intelligence; Adaptive Traffic Control System; Gridlock;

I. INTRODUCTION

The growing amount of traffic in cities has had a significant impact on road network congestion and the time it takes for cars to get to their destinations. Another significant cause of the congestion is the steadily rising demand for vehicles. Controlling traffic flow in metropolitan regions has grown more and more important given that there are undoubtedly more cars on the road. According to Hamilton et al., this is required to minimize time wasted, provide the maximum levels of safety and capacity, and lessen the negative environmental effects of congestion. The intersection will remain a bottleneck, so merely extending the roads and adding lanes won't solve the issue. Even while traffic congestion are unavoidable, there may be ways to manage crowded crossings more effectively. An adaptive traffic control system can be used to combat this problem. The basic idea behind all of the main urban traffic control systems is to optimize traffic flow through a sequence of intersections by modifying the split, cycle, and offset durations (Papageorgiou et al. 2007). Because the following effects on neighbouring junctions are not taken into account, there is more freedom to modify the traffic signals at isolated vehicle-actuated junctions than in a coordinated system. Isolated vehicle-actuated junctions have this advantage over a coordinated system. The network as a whole might suffer, though, if each traffic signal were to function independently.

II. METHODOLOGY

The adaptive road traffic control system, or ATCS for short, will be utilized. Artificial intelligence (AI) is used to optimize traffic flow in urban areas.

The ACS system's three primary algorithmic components are the transition manager, run-time refiner, and time-of-day (TOD) tuner.

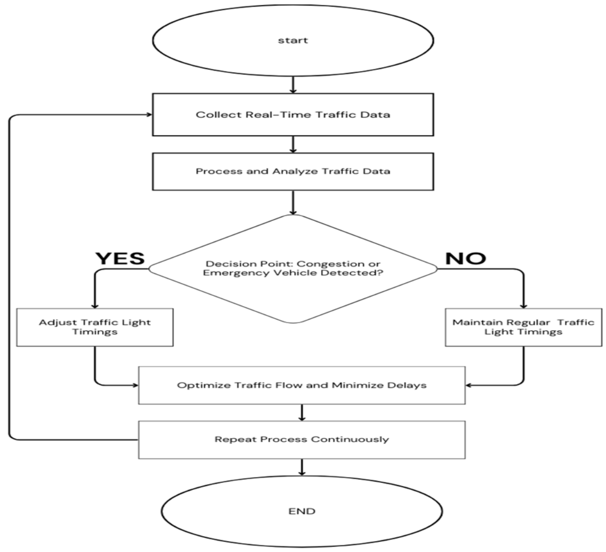
The TOD tuner maintains the plan's parameters (cycle, splits, and offsets) constant despite changes in long-term traffic conditions.

The run-time refiner modifies the cycle, splits, and offsets of the current running plan in response to observations of traffic conditions that fall beyond the usual range of circumstances this plan is intended to manage. Additionally, the run-time refiner determines when it is best to move from the current plan to the one that follows on the schedule. Alternatively, similar to a traffic-responsive system, it may move to a plan that is not scheduled to follow the current plan in the list of plans.

The transition manager selects one of the transition mechanisms included into the local controllers to strike a compromise between the amount of time spent out of step and the possible delay and congestion caused by returning to step as soon as possible.

To better understand it, we'll utilize a remote intersection on a four-leg road. Every length of road has a different quantity of cars. According to the data acquired from real-time data collection, the signal settings' red and green times are modified. The road leg with the greatest number of vehicles receives more green time and less red time in comparison to the other road legs. The road leg with the fewest automobiles in comparison to the other road legs receives more red time and less green time to make up for the additional green time allotted to the road leg with the most vehicles.

If the number of vehicles on each road segment is roughly equal, the road that comes after national highways, state highways, district highways, and village/rural roads is given preference. State highway segments are given priority and the green timing first if there are four roads that intersect at an intersection and two of them are state highway segments and the other two are district highway segments.



III. LITRATURE REVIEW

Intelligent traffic management systems were developed as a result of the long-standing problem of traffic congestion in urban areas. Conventional traffic signal systems rely on static plans and predetermined timetables, which are frequently insufficient to manage traffic flow variations in real time. In order to improve urban traffic management, adaptive traffic control systems, or ATCS, have become a game-changer. In order to reduce delays and improve overall traffic flow efficiency, these systems use cutting-edge technologies, such as artificial intelligence (AI), to dynamically modify traffic signal parameters based on real-time data.

The Time-of-Day (TOD) tuner, which maintains uniformity in signal timings for typical traffic patterns seen during particular times of the day, is one of the fundamental ATCS components that has been the subject of numerous studies. According to research, this characteristic is essential for preserving traffic stability over the long run and making sure that signal plans stay in line with expected traffic patterns, like morning and evening rush hours. To handle abrupt changes in traffic conditions, the TOD tuner frequently needs to be integrated with more dynamic components, even if it works well in predictable scenarios.

Another crucial component that has been covered in-depth in the literature is the Run-Time Refiner. This part keeps an eye on traffic data in real time so that it may instantly modify signal characteristics like offsets, splits, and cycle lengths. According to studies, the Run-Time Refiner is essential for managing unforeseen traffic changes brought on by events, accidents, or construction. Additionally, by using alternate techniques and deviating from scheduled plans, it enhances the system's responsiveness and aligns it with the principles of traffic-responsive control systems.

Finally, to avoid any delays or interruptions, the shift Manager makes sure that signal plans shift smoothly. The literature highlights how crucial this element is to striking a balance between preserving traffic coordination and making fast shifts. The Transition Manager lessens the possibility of congestion during plan modifications by limiting the amount of time spent out of synchronization. According to recent studies, the Transition Manager's capacity to forecast the best times for transitions is much improved by integrating AI-driven decision-making, which also helps to improve traffic flow during peak and off-peak hours.

IV. IMPLEMENTATION

The initial step in installing ATCS is to deploy hardware at intersections, where sensors such as radar, inductive loops, and cameras gather data on traffic volumes, speeds, and road occupancy in real time. A centralised traffic control system receives this data over wireless links or fiber-optic networks. Dynamic changes are made possible by upgraded traffic signal controllers.

The centralised system uses AI and machine learning to monitor traffic, forecast congestion, and optimise signal timings by integrating historical and real-time data. Based on past trends, the Time-of-Day (TOD) tuner generates steady signal plans, and the

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue XII Dec 2024- Available at www.ijraset.com

Run-Time Refiner dynamically modifies plans to account for anomalies in real time. The Transition Manager maintains coordination across junctions and makes sure that changes between signal plans go well.

Following a pilot implementation and simulation-based testing, the system is made available throughout the city. The system is kept responsive through constant monitoring and updates, which enhance traffic flow and lessen congestion.

V. CONCLUSION

In this project, the previously mentioned techniques are used to develop the simulation model of the adaptive traffic control system. Videos are arranged in a list, and the one with the most cars gets the most green time relative to the intersection's other roads. We can conclude from the adaptive traffic control simulation that adaptive traffic control systems have the potential to offer a number of advantages, including reduced travel times, cheaper fuel and emissions, improved safety as a result of fewer accidents brought on by traffic congestion, and more equitable access to transportation for all users. Furthermore, travel times are shortened, resulting in less driver fatigue and more pleasurable trips.

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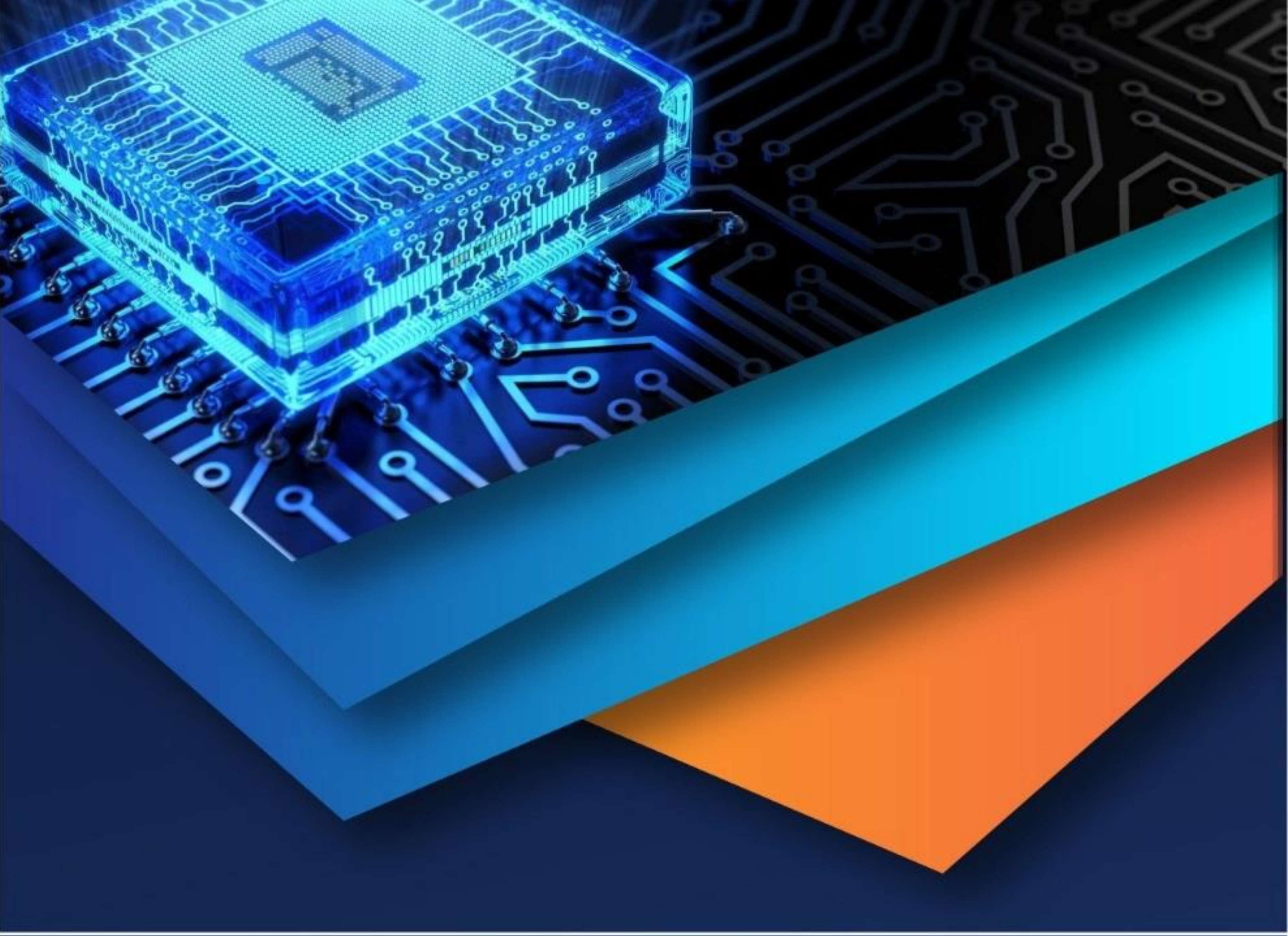

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