

Adaptive Traffic Management System

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ABSTRACT

Urban transportation networks are increasingly strained by rapid population growth and rising vehicle density, necessitating intelligent traffic management solutions capable of responding to dynamic roadway conditions. Adaptive Traffic Control Management (ATCM) systems address these challenges by utilizing real-time data from sensors, cameras, and connected devices to continuously optimize traffic signal timings. Unlike conventional fixed-time control mechanisms, ATCM integrates advanced algorithms—such as machine learning models, predictive analytics, and rule-based decision systems—to evaluate traffic flow, congestion patterns, and intersection demand. This adaptability enables the system to minimize delays, reduce queue lengths, and improve throughput across signalized intersections. Moreover, ATCM contributes to significant reductions in fuel consumption and vehicular emissions

by decreasing idle time and stop-and-go behavior.

This paper examines the architectural design, operational framework, and underlying computational techniques of adaptive traffic control systems. Experimental findings and literature analyses demonstrate that ATCM enhances travel time reliability, supports scalable urban mobility, and offers a sustainable alternative to traditional traffic management strategies. The results highlight the potential of adaptive traffic control as a critical component in the development of intelligent transportation systems and smart city infrastructures.

INTRODUCTION

Congestion in the road network and the amount of time

it takes drivers to reach their destinations have been greatly influenced by the ever-increasing volume of traffic in urban areas. The consistently increasing vehicle demand is another major reason for the congestion. Considering the fact that there are certainly more vehicles on the road, the necessity to regulate traffic flow in metropolitan areas has become increasingly crucial. This is necessary to provide the highest possible levels of safety and capacity, as well as to reduce the amount of time wasted and to mitigate the adverse impacts of congestion on the environment (**Hamilton et al**). Simply widening roads and adding lanes won't alleviate the problem because the intersection will continue to pose a

bottleneck. Although traffic jams are inevitable, the management of congested crossings might be optimized. To counter this issue, the use of adaptive traffic control systems can be done. All of the major urban traffic control systems operate on a similar basis of adjusting the split, cycle and offset times to optimize the traffic flow through a series of junctions (**Papageorgiou et al. 2007**). There is greater flexibility to adjust the traffic signals at isolated vehicle actuated junctions as compared to a coordinated system because there is no consideration of the subsequent impacts on nearby junctions. This is a benefit of isolated vehicle actuated junctions over a coordinated system. However, if every traffic signal was to operate independently then the network as a whole could potentially suffer.

METHODOLOGY

The ATCM, which stands for adaptive road traffic control system, will be used for operation. The vehicle flow in an urban setting is optimized using artificial intelligence (AI).

The three main algorithmic parts of the ACS system are the time-of-day (TOD) tuner, the run-time refiner, and the transition manager.

As the long-term traffic circumstances vary, the TOD tuner keeps the plan's parameters (cycle, splits, and offsets) constant.

Based on observations of traffic situations outside the typical range of conditions this plan is meant to handle, the run-time refiner alters the cycle, splits, and offsets of the present running plan. The run-time refiner also chooses when it is optimal to switch from the current plan to the next one on the schedule, or, like a traffic-responsive system, it might switch to a plan that is not planned to come after the current one in the list of plans.

To balance the time spent out of step with the potential delay and congestion created by getting back into step as quickly as possible, the transition manager chooses among the transition mechanisms included into the local controllers.

We will use an isolated crossroads on a road with four road legs to better comprehend it. There are various numbers of automobiles on each road stretch. The red time and green time of the signal settings are adjusted in accordance with the information gathered from real-time data collecting. In juxtaposition with the other road legs, the road leg with the most vehicles is given more green time and less red time. To make up for the extra green time given to the road leg with the most vehicles, the road leg with the fewest vehicles relative to the other road legs receives less green time and more red time.

The road that comes subsequent to national highways, state highways, district highways, and village/rural roads is given preference if all of the road legs have fairly the same number of vehicles. If there are four intersecting roads at an intersection and two of them are state highway segments while the other two are district highway segments, the state highway segments are given primacy and are given the green timing first.

SIMULATION MODEL

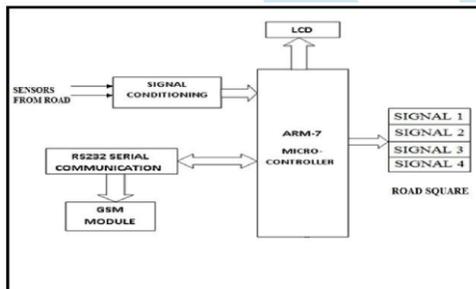


Figure 2. Block Schematic of Adaptive Traffic Light Control System

Fig 1.1 : Working of the model

The above figure 1.1 shows the building of the simulation model. In order to construct the simulation model, the detection of the car is to be performed. The timing of the signal is predicted based on the amount of vehicles that are currently on the road segment. In the central control station, the timing of the feedback signal that would be expected as well as the timing of the signal that was forecasted are examined simultaneously. When the appropriate signal timing has been chosen after taking into account a variety of parameters, the traffic signal controller will place the signal timing in the appropriate position. When the appropriate moment occurs, the signal timings are modified so that they are suitable.

The first step is to collect data on the flow of traffic and then to analyze that data. The second step is to design control algorithms and then to test and validate those algorithms. Python is utilized for vehicle recognition, and the collected data is then used to determine the appropriate signal time based on the density of the cars.

For the purpose of data collection, traffic data can be gathered using a variety of methods, including manually, as well as through the use of loop detectors, cameras, and GPS systems. These data include the number of vehicles, the speeds at which they travel, and the journey times they average, all of which can be utilized to assess traffic patterns and design control algorithms.

In order to get a better understanding of the nature of the area as a whole, it is necessary to conduct a reconnaissance survey. This is something that needs to be done in order to determine the course of action that is the most feasible, as well as for following in-depth research. After that, one can move on to the process of data collection.

The task of counting the flow of traffic has been delegated to specific locations known as counting stations. It is essential to select the count stations in such a way that the data obtained is indicative of the traffic flow over equivalent stretches of the roadway. Following that, an average daily traffic count (ADT) can be determined by using data from the previous week's worth of days. This data can be converted into the Annual Average Daily Traffic (AADT) by taking into consideration the effects of the seasons and making use of the conversion factors that are generated from any continuous traffic count that has been carried out within the region. As input, the code for the adaptive traffic control is created with these values after they have been transformed by the PCU. The majority of our work is done in the Python programming language. We will determine the total number of automobiles by utilizing the Python library in our research. The complete number of vehicles that can be seen in each of the videos that are included in the list is presented, and the one that contains the greatest number of vehicles is highlighted.

We are able to determine the amount of time needed for moving vehicles in order to ease traffic by performing mathematical calculations on the data that we have obtained.

CONCLUSION

Adaptive Traffic Control Management (ATCM) presents a transformative approach to addressing the growing challenges of urban traffic congestion and mobility. By integrating real-time data acquisition, intelligent algorithms, and automated signal optimization, ATCM systems significantly outperform traditional fixed-time traffic control methods. The findings discussed in this study highlight that adaptive systems not only enhance traffic flow efficiency but also contribute to measurable reductions in travel time, queue lengths, fuel consumption, and vehicular emissions. Furthermore, ATCM supports scalability and interoperability, making it well-suited for integration within modern Intelligent Transportation Systems (ITS) and emerging smart city infrastructures.

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