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Review on Simulation Model To Reduce The Fuel Consumption Through Efficient Road Traffic Modelling

Md Muneer Alam, Dr. Sunil Sugandhi
Department Of Civil Engineering
Jawaharlal Institute Of Technology,
Borawan Dist. Khargone.

Abstract- Traffic control strategy plays a significant role in obtaining sustainable objectives because it not only improves traffic mobility but also enhances traffic management systems. It has been developed and applied by the research community in recent years and still offers various challenges and issues that may require the attention of researchers and engineers. Recent technological developments toward connected and automated vehicles are beneficial for improving traffic safety and achieving sustainable goals. There is a need to develop a survey on traffic control techniques, which could provide the recent developments in the traffic control strategy and could be useful in obtaining sustainable goals. This survey presents a comprehensive investigation of traffic control techniques by carefully reviewing existing methods from a new perspective and reviews various traffic control strategies that play an important role in achieving sustainable objectives. First, we present traffic control modeling techniques that provide a robust solution to obtain reasonable traffic and sustainable mobilities. These techniques could be helpful for enhancing the traffic flow in a freeway traffic environment. Then, we discuss traffic control strategies that could be helpful for researchers and practitioners to design a robust freeway traffic controller. Second, we present a comprehensive review of recent state-of-the-art methods on the vehicle design control strategy, which is followed by the traffic control design strategy. They aim to reduce traffic emissions and energy consumption by a vehicle. Finally, we present the open research challenges and outline some recommendations which could be beneficial for obtaining sustainable goals in traffic systems and help researchers understand various technical aspects in the deployment of traffic control systems.

Keywords- Instantaneous emission; Integrated traffic and emission modelling; Traffic speed management; Microsimulation.

I. INTRODUCTION

Vehicle fuel consumption is a major concern of our society for many reasons including fuel costs and environmental impacts. Studying traffic patterns can reveal some solutions for this problem. Vehicles deceleration and accelerations when approaching signalized intersections causes a huge amount of fuel consumption. For a traditional human-driven vehicle, it is common that the driver will try to accelerate when approaching an intersection to pass it with the current green light. However, the signal light may turn red before the vehicle reaches the intersection. In this case, the vehicle must decelerate to stop before the stop line and keep idling for the next green light.

These sharp accelerations/decelerations and idling will lead to unnecessary fuel consumption at signalized intersections. Connected autonomous vehicles technology may create a novel response to this issue. By communicating with traffic signals, connected vehicles (CVs) have the potential to avoid this kind of energy waste. Global warming and environmental pollution have led to more severe regulations on CO_2 and other pollutant emissions. In this context, electric vehicles (EVs) have become an alternative to conventional vehicles as they offer a zero-emission alternative. Besides, they are cheaper to be recharged as electricity is cheaper than petrol/diesel and also energy recovery is possible from regenerative braking in EVs. However, the EVs' market penetration rate is not very quick because of their limited range, charging time, battery replacement cost, and other limitations related to infrastructure. This study is particularly related to one of these restrictions, the limited EV range. This limitation causes an issue called “range anxiety” that refers to drivers' fear of running out of energy while driving.[1] This phenomenon can be limited by increasing the battery capacity and/or the number of charging stations.

However, both solutions are expensive, and will not improve the confidence of drivers in the remaining driving range estimation. Nowadays, range estimators are not sufficiently accurate because they are mainly based on vehicle historical data. Thus, they can lead to major estimation errors and cannot be fully trusted by drivers. “Range anxiety” can be reduced by improving the range estimation to increase drivers' confidence. For EV range estimation, an accurate estimation of the EV's energy consumption is vital and is therefore the purpose of this study.

II. RESEARCH MOTIVATION

Quantifying the impacts of ITS technologies is an important and necessary undertaking in order to justify the expenditure of public funds on ITS projects. For example, roadway incidents such as accidents, broken-down vehicles or other events that reduce the capacity of the facility impose a substantial cost to society when delays, congestion, secondary incidents, and environmental emissions are taken into consideration. These impacts can be substantially reduced through implementation of incident management programs. Significant benefits can be gained from early incident detection, quick response, provision of real-time traveler information and timely dispatch of emergence services.

This can result in reducing traffic delays, secondary accidents, air pollution, and generally improve road safety and real-time traffic control. Recently, there has been a growing interest in developing traffic incident management plans for integrated freeway and arterial road networks and evaluating the effectiveness of such plans in minimizing the effects of congestion. This is particularly important when evaluating incident management plans involving traffic being diverted to adjacent arterial networks. The impacts of incident management programs on network performance can be evaluated either in field studies or using traffic simulation. Field studies are generally expensive to conduct and they don't offer flexibility in investigating alternative scenarios.

The use of computer modelling, and microscopic traffic simulation in particular, offers a more feasible and cost-effective approach, in which input conditions can be varied (e.g. to reflect incidents during peak and non-peak conditions) and their impacts on network performance evaluated. It is clear that the benefits of these programs will depend on the extent of existing congestion in the road network, and will also vary according to the severity of the incident, its duration, and the time of day during which it occurs. These impacts can be determined by simulating incidents and varying their location, duration, and severity, and comparing the resulting network performance against a non-incident base case scenario. The traffic simulation model can also predict changes in the behaviour of individual drivers in response to a set of scenarios and provide output for analysis. Environmental emissions models can also be linked to the traffic simulation model and used to estimate fuel consumption and emissions.

III. PROBLEM IDENTIFICATION

Traffic congestion in urban areas has become serious threat because of the constant growth in the number of vehicles on the roads. This problem is much severe in densely populated countries despite a significant development of road

infrastructure in terms of building new roads, broadening of roads, and frequent maintenance of the existing roads. Traditional approaches have been used to control the traffic at a signalized junction which result in unnecessary delays and jams at the intersection. These traditional approaches use allocation of fixed time for each artery, which do not change with the real-time traffic density. These traditional approaches need to incorporate the latest development in technologies like Internet of Things and Wireless Sensors to cover the real-time traffic density, thereby decreasing the average waiting time and hence saving of fuel and emission of harmful gases at a signalized traffic intersection.

Usually, flow of traffic at any intersection is controlled by the means of pre-timed, traffic actuated and adaptive traffic controllers. The conventional methods such as pre-timed systems assign a fixed time slot for each artery and are good enough to handle the regular and stable traffic. The pre-timed system lacks in dealing with varying traffic flow conditions. Whereas, traffic actuated controllers provide lesser average delay, but respond in limited way to real time traffic flow. The performance of traffic actuated control mechanism results in increased quantity of stopped vehicles in dense traffic conditions. To address these issues, various controllers of adaptive nature have been proposed and implemented to meet the dynamics of real time traffic. The adaptive controllers provide the variation in green light time in regard to both predicted and observed real time traffic density at the signalized traffic intersection.

For a better management of traffic congestion at the signalized intersections, some significant measures in the existing traffic management systems are needed. Conventional mathematical based system modeling is inappropriate for traffic signal control problems, as these problems are comprised of high degree of vagueness and ambiguity. Vehicle arrival is a non-stationary characteristic and has huge variation at every time instance of the day for every road intersection.

Objective

The objective of simulation model is to presents a real traffic situation in to dynamic model. There are three simulation model available to be used in traffic engineering namely macroscopic, microscopic and mesoscopic. The application on each model is depending on the aim of study to be conducted. Selecting the right model according to study aims is an important step towards traffic problem resolution.

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IV. LITERATURE REVIEW

MaramBani **Younes et al. [1]**Traveling vehicles participate in emphasizing the global warming problem due to the gases produced by them. The exponential increase in the number of daily traveling vehicles has exaggerated the world pollution problem threatening the life on the planet. This encourages several environmental organizations to look for designing green vehicles. Moreover, several countries have forced green driving rules and technologies. Road intersections are considered high fuel consumption areas over the road network. This is due to the required power to stop moving vehicles and restart stopped vehicles at these intersections. This work introduces an efficient traffic light scheduling algorithm (SmartLight) that controls the competing traffic flows at the road intersections. It is designed to reduce the total consumed fuel of vehicles and thus it reduces their produced gases. The topology of the road intersection, the context of the competing traffic flows, and the real-time traffic characteristics of each flow are mainly considered to schedule the phases of each located traffic light. The phases of the traffic light cycle are primly set to allow emergency vehicles to pass through the intersection without stopping. Then, the traffic flow that contains heavy vehicles or has the highest weight among the competing traffic flows is assigned the highest priority to pass through the signalized intersection.

Wen-Long **Shang et al. [2]**Traffic energy consumption estimation is significant for the sustainable transportation. However, it is difficult to directly employ macro traffic flow data to accurately estimate the traffic energy consumption due to many traffic energy consumption models need second-by-second vehicle trajectory. To solve this problem, this paper proposes a traffic energy consumption model based on the macro-micro data, which the macro data derived from the fixed-location sensors and sparse micro data derived from the Connected and Automated Vehicles (CAVs).

Alessandra **Boggio-Marzet et al. [3]**The increasingly widespread use of vehicles has intensified fuel consumption and hence the emission of air pollutants, causing a negative environmental impact on both human health and climate change. It is well known that vehicle fuel consumption depends on several factors such as engine and vehicle technology, road characteristics, traffic conditions, and driver ability. Although the relationship between these variables has been subject of several researches, the combined influence of traffic flow with road type on vehicle fuel consumption has not yet been studied in depth. This paper aims to fill this gap by processing a large dataset of real-world driving data from an experiment carried out in Madrid, Spain; and to develop and validate a new approach using cluster analysis to define real traffic conditions.

Amjad **Issa et al. [4]**Energy consumption contributes to the transportation section with inherent impact in terms of delay, pollutions, and gas emissions. This work aims to assess the effect of road grades on gas emissions and vehicle fuel consumption in Nablus city. Traffic data in peak hours for thirteen representative segments was collected. Vissim was utilized to find the delay, emission, and fuel consumption, for the current situation compared with no grade scenarios. The average fuel consumption was about 14.4 and 12.4 L for the current conditions and assuming no grades, respectively. The average emissions (CO, NOx, and VOC) during the peak hours for the segments were about 264.1 g, 51.4 g, and 61.2 g with grades, and 227.9 g, 46.3 g, and 52.8 g assuming no grades. The maximum potential fuel savings was estimated in 2035 with about 9% by introducing hybrid and electric. The high potential fuel savings can encourage policymakers to adopt this policy in the future.

Chrysostomos **Mylonas et al. [5]**Criticality serves as a foundational concept in the evaluation of the impact of disruptive events on the operation of road networks supporting the identification of road links whose unavailability affects to the greatest extent the mobility of people and goods. Several methods and techniques have been suggested so far for the quantification of criticality in road networks drawing from complex network theory, strategic transportation modeling, and traffic simulation. The current article provides a concise yet comprehensive overview of the relevant literature. Subsequently, it formulates a series of hybrid graph-theoretic measures that aim to evaluate, in a computationally efficient manner, the criticality of a road network's links by respecting their topological attributes and incorporating the inputs/outputs of user equilibrium-based traffic assignment models, assuming that all links are available and operational.

Moreover, it formulates a flow reduction-based criticality metric, quantified through microscopic traffic simulation based on the well-established theory on the Macroscopic Fundamental Diagram. The validity and application potential of both approaches are experimentally scrutinized in two tailor-made case studies. The results of the first case study reveal that traffic volume centrality and two variations of a hybrid measure estimating the demand weighted decrease in network efficiency or the increase in total travel time complement each other and sufficiently explain road link criticality, as assessed through two different metrics of increased computational intensity and accuracy. Building upon this finding, an algorithmic procedure for combining the previously mentioned measures is proposed, enabling the targeted sampling of critical road link candidates.

Jie **Li et al. [6]** This study proposes a novel eco-driving control strategy for connected and automated hybrid electric vehicles, which utilizes deep reinforcement learning (DRL) to optimize various aspects of driving performance, including fuel economy, ride comfort, and travel efficiency, in complex urban traffic scenarios. The proposed strategy incorporates a driving safety model that predicts potential risk associated with the DRL agent's planned speed, thus ensuring the safety of the DRL based eco-driving strategy. Additionally, we propose a multi-objective composite reward function design scheme that considers various constraints caused by traffic elements, such as traffic lights, preceding vehicles, road curvature, and speed limit.

Yonggang **Liu et al. [7]**Transportation accounts for a large proportion of energy consumption and environmental pollution, and eco-routing is recognized as a potential solution to green mobility. In this context, this study investigates the co-optimization problem of eco-routing on a road network for heterogeneous continuous vehicle flow. Firstly, the energy consumption estimation models for 33 types of vehicles are constructed by artificial neural networks with a large amount of historical driving data. In this case, the Bureau of Public Roads function and traffic light models are imported to establish the road network model, accurately reflecting the impact of congestion and traffic lights change on vehicle speeds.

Hongjie **Liu et al. [8]**Mixed traffic flow is a prevalent phenomenon in the trend of connected automated vehicles (CAVs), where a diverse set of road users, including cars, motorcycles, bicycles, pedestrians, and even animals, share the road infrastructure. This coexistence poses a range of challenges, not limited to traffic safety, efficiency, and environmental sustainability. Compared with the traditional traffic streams, the controllability of connected and automated vehicles within mixed traffic offers new possibilities for eco-driving. As CAV technologies continue to flourish, this study explores the imperative of constructing eco-roads within a mixed traffic framework and optimizing eco- driving strategies to enhance vehicle energy efficiency and reduce emissions. We extended the concept of mixed traffic flow to incorporate scenarios involving animal crossings, introducing an eco-road-based green mixed traffic model. Analyzing the driving behaviors of both autonomous and manually-driven vehicles within a vehicular network ecosystem, we proposed an eco- road driving model that includes vehicle-following and lane-changing behaviors. From the perspective of dynamic programming, we conducted a discrete analysis to create an energy- saving driving model apt for mixed traffic conditions, with Q-Learning serving as the optimal solver.

Yi **Wang et al. [9]**With the advent and advancement of connected and automated vehicle technologies, it is now possible to control connected and automated vehicles (CAVs) in mixed traffic flows to reduce traffic oscillations and enhance traffic flow performance. Recently, a control strategy for autonomous vehicles (AVs) named "The Follower Stopper controller" (FS) has been proposed. However, the existing studies for the FS strategy only considered the situation that all CAVs execute the FS strategy individually. And the impact on the mixed traffic flow when CAVs in the mixed traffic flow execute FS strategies as platoons is not investigated.

Yen-Lien T. **Nguyen et al. [10]**This study aims to identify the impact of real-world driving characteristics on the actual fuel consumption (FC) of motorcycles (MC) so that drivers can have better driving behavior to save fuel and reduce air emissions. A data logger installed directly on MC was utilized to gather real-world operation data of MC which includes instantaneous speed and fuel consumption rate (FR_{inst}), second by second. The collected data were preprocessed, then fed to extract typical driving characteristic parameters that strongly impact the fuel consumption of MC. Among the extracted parameters, vehicle-specific power (VSP) and its distribution best reflect the impact of real-world driving characteristics on the FC rate of MC ($R^2 = 0.88$). The VSP bin in the range [0, 1] has the highest FC, 3.6 L/100 km, while the actual FC corresponding to the full VSP distribution of MC in Hanoi is 3.01 L/100 km only.

V. CONCLUSION

The subject of emissions modelling, as well as traffic modelling has developed rapidly in recent years. Initially, emission models were created on the basis of chassis dynamometer tests and the collection of emission data during their execution. Subsequent years and the technological development of emission measurement equipment made it possible to collect emission data while driving in real traffic conditions. This was made possible by equipment. Many research institutes around the world now carry out vehicle emission tests in this way, generating large amounts of data that can then be used to develop new and more accurate emisson models through processing.

In terms of vehicle traffic modelling, calibration of the traffic model is also an important topic in the work described earlier. The calibration of the traffic models for further analysis is of great importance because this process has a major impact on the results obtained from the exhaust emissions from simulated vehicles. Traffic simulation calibration is the process of adjusting the simulation parameters in relation to the actual observed traffic conditions. This is crucial to ensure that accurate and reliable results are obtained. This process is usually concerned with adjusting parameters such as vehicle speed and acceleration, but also includes parameters related to, for example, vehicle spacing or determined issues of priority. Failure to carry out this process accurately, or omitting it altogether, can result in differences in exhaust emissions, differences of up to several dozen percent. In the context of emission calculations, acceleration and vehicle speed are the most important simulation parameters, particularly at the micro scale.

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