J. Indian Inst. Sci.
A Multidisciplinary Reviews Journal
ISSN: 0970-4140 Coden-JIISAD

EDITORIAL

Recent Advances in Transportation Research

Abdul Rawoof Pinjari[*]

These are truly exciting times to be in transportation research. Various combinations of technology and policy solutions are being explored to address traffic congestion and other externalities of transportation. Notable among these are connected and automated vehicle (CAV) technologies being experimented in a variety of different forms and settings. At the same time, cities around the globe are reviving their public transit systems to enhance the quality of service, reach, connectivity, and travel market share of buses and trains. Further, a variety of shared mobility modes have emerged, thanks to sharing economy and the ubiquity of smart phones. In addition, large and diverse data streams are becoming available for measurement, inference and control of transportation systems. Yet, traffic congestion, traffic related pollution and other public health problems attributable to transportation continue to be on the rise in most cities of the world.

Keeping the above trends in view, this special issue on Transportation Research features a set of eight invited papers by leading researchers on the following topics: traffic modeling and control in the context of CAVs and disorderly traffic, public transit systems and car ownership in emerging economies, planning and operation of bicycle sharing systems (BSS), the use of emerging data sources for transport planning and operations, and an overview of transportation planning and policy approaches typically used to address traffic congestion. The papers not only discuss the topics in detail, but also review the mathematical modeling methods used and outline an agenda for future research in these topics. Each of these papers is briefly discussed next.

The first paper, by Chakroborty et al. (2019) focuses on a central yet largely neglected issue relevant to modeling and control of vehicular traffic—understanding, representing, and modeling two-dimensional spatial movement (i.e., longitudinal and lateral movement) dynamics of vehicles. The paper convincingly highlights the importance of two-dimensional representation and modeling for analysis and control of 'disorderly' traffic streams that are characterized by lack of lane discipline and a substantial extent of lateral movements typical to traffic streams in India and several other countries. Further, the paper provides a synthesis and critical review of existing literature on two-dimensional modeling of vehicular traffic. It is worth noting here that, since most existing theories and models of traffic dynamics consider only the longitudinal movement (and relegate lateral movements to infrequent, lane-changing episodes), much of the CAV related research has also been based on a unidimensional representation of traffic dynamics. However, it becomes paramount to consider two-dimensional representation of vehicular movement for CAV traffic flow analysis and control for disorderly traffic conditions.

The next two papers focus on modeling and control of vehicular dynamics in the context of CAVs. Before discussing these papers, it is useful to note that a primary purpose of CAV technologies is to automate the functions of driving, such as path-planning, vehicle-following, lane-changing, and collision avoidance. While these technologies have the potential for increasing traffic safety and improving vehicular traffic flows, several critical issues are yet to be addressed for safe and robust deployment of CAVs at a large scale. For example, models for accurate prediction of vehicular dynamics in traffic streams and control designs for stable vehicle-following systems are necessary to prevent pileups from CAV platoons. To addresses these specific issues, the paper by Vegamoor et al. (2019) provides a review of the vehicle dynamics models, string stability characterization, and spacing policy design of vehicle-following systems for CAVs with different information/communication flow regimes. Their paper will be a good reference for researchers interested in understanding the technical issues relevant to design of vehicle-following systems for CAVs. The next paper, by Wang et al. (2019), focuses on a complementary topic—lane-changing maneuvers of CAVs. Specifically, the paper synthesizes literature on models and algorithms for CAV lane-changing as well as analysis of traffic impacts due to and field experiments of CAV

[1] *Department of Civil Engineering, Centre for infrastructure, Sustainable Transportation and Urban Planning (CiSTUP), Indian Institute of Science (IISc), Bangalore, India.*
**abdul@iisc.ac.in*

Springer IISc Press

lane-changing. Given the sparsity of CAV research on lane-changing maneuvers when compared to longitudinal vehicle-following, this paper will be helpful for researchers and CAV manufacturers in the context of integrating models and algorithms for lane-changing with those of vehicle-following and other maneuvers.

Public transit systems continue to be an important mode of travel; not only for the not so affluent who cannot afford cars but also for the affluent who would rather not spend time behind the steering wheel nor add to traffic congestion. Importantly, a well-functioning and accessible public transit system is widely believed to be essential for addressing traffic congestion in today's cities in both developed and developing countries. However, many cities do not have access to the type of data they need for appropriate planning and efficient operation of public transit systems. In this context, the paper by Zannat and Choudhury (2019) provides a synthesis of contemporary literature on using emerging sources of passively generated big data (such as smart cards and other ridership data, vehicle location data, social media data, and mobile phone traces) for planning public transit systems. The paper provides an assessment of the strengths and weakness of different data sources, the challenges in using such data, and research directions to enhance the use of such data sources for public transit planning. This paper is of value to researchers and transit agencies in the developing world, where public transit systems have traditionally served a major share of travel but have recently been losing mode share to other modes. Given the scarcity of carefully collected travel behavior survey data, methods to use a wide variety of emerging data sources can help improve public transit planning and operation in developing countries.

Many cities in the world are promoting or experimenting with BSS not only to reduce traffic congestion and pollution but also as an alternative mode of travel for short distance travel and to enhance connectivity to public transit systems. Planning of such systems requires determining the number, location and capacity of BSS stations (if they are docked systems) and designing the bicycle route network. Operation of these systems requires consideration of fine-grained spatial and temporal variations in demand and maintenance requirements and uncertainty therein to make off-line and near real-time decisions for supply rebalancing. The paper by Nath and Rambha (2019) synthesizes the state-of-the-art on these aspects as well as discusses potential avenues for future research. They highlight that the development of methods for accurate forecasting of the usage of such services in fine temporal and spatial scale is an immediate need. Indeed, this is an important research need for any shared mobility service.

Another topic germane to the planning of transportation systems is household car ownership. This topic is particularly relevant in developing economies where increasing affluence has accelerated the growth in personal car travel and related traffic congestion, pollution and other externalities. In this context, understanding and modeling car ownership is an important prerequisite due to its influence on individual-level travel behavior and aggregate-level travel demand. The paper by Ma and Ye (2019) provides a detailed synthesis of the modeling methods and data sources used to model car ownership, along with a review of relevant studies in developing countries. This paper would be a good starting point for researchers embarking on analyzing car ownership in developing countries.

Most approaches used to model car ownership, transit ridership, bicycle sharing usage and other aspects of travel behavior (e.g., whether, why, when, and how people travel; what mobility tools they own; how they respond to information, pricing, etc.) are based on a widely used econometric method called discrete choice modeling. These models, with foundations in microeconomics and mathematical psychology, specify travelers' choices as a function of their sociodemographic, transportation, built environment, technological and cultural contexts. In developing and applying such models, the analyst must consider stochasticity since it is not possible to completely observe or perfectly measure and represent all factors influencing a traveler's choice. In this context, the paper by Paleti (2019) provides a review of alternative stochastic distributions used in the literature to model traveler choices, such as mode choice, route choice and destination choice. The paper discusses the pros and cons of each class of distributions and outlines the scope for further research with alternative classes of parametric and non-parametric distributions. This paper will be of interest to discrete choice modelers from a variety of fields, including transportation, economics, and marketing.

An ultimate goal of most research, development and practice in transportation is sustainable mobility, which in-turn is key for sustainable

cities. In this context, the discussion paper by Ortúzar (2019) focuses on an important aspect of sustainable mobility–traffic congestion. The paper first provides a traffic engineer's view of the traffic congestion problem and then describes two well-known paradoxes from the network science literature to discuss why the apparently commonsense solutions such as adding more roads might not be adequate for addressing the problem. Two most commonly used approaches—*carrots* and *sticks*—are discussed as the most consensual solutions to tackle traffic congestion, where *carrots* comprise measures to pull travelers to alternative modes of travel (particularly public transit) and *sticks* comprise measures such as pricing to push travelers away from personal cars. The paper emphasizes that political will and long-term strategies are necessary for the success of these approaches in addressing the problem of traffic congestion.

It is worth noting here that the eight papers presented in this special issue are only a subset of what would be a fully representative set of contemporary research in transportation. Yet, these papers comprise a valuable resource for graduate students and other researchers who wish to embark on related research topics. As importantly, the papers are a go-to place for a synthesis of literature and ideas for future research in the respective areas. In this context, I am grateful to all the authors for their contribution to the special issue. My thanks are also due to reviewers who provided careful yet constructive reviews to improve the value of these papers. Finally, I wish to thank Prof. Ananthasuresh, the Editor-in-Chief of the journal for giving me this opportunity and acknowledge the support of IISc Office of Communications and Springer staff in publishing this special issue.

Publisher's Note

Published online: 8 November 2019

Abdul Rawoof Pinjari is an Associate Professor in the Department of Civil Engineering and Chairman of the Centre for infrastructure, Sustainable Transportation and Urban Planning (CiSTUP) at the Indian Institute of Science (IISc). His research is in modelling human choice and consumer behavior in infrastructure service systems, particularly in transportation systems. He uses choice modelling and statistical/econometric data analytic methods for travel behavior and travel demand analysis; public transportation systems planning; and integrated land-use and transport modelling. He currently serves as an Associate Editor of *Transportation Research Part B* and on the editorial boards of *Transportation*, *Journal of Choice Modelling*, and *Transportation in Developing Economies*.