Yisheng Lv, Editor

Laboratory of Emerging Transportation Systems at Chalmers University of Technology

EDITOR'S NOTE

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The modern transportation system has been undergoing a disruptive transformation driven by the fast development of a number of interactive areas, such as information and communications technology, vehicular technology, and mobility services. In past decades, not only has the way that people travel changed rapidly but also the data, tools, and methods that we use to study transportation systems. Among these, three changes are quite notable. To begin, data size and quality have been consistently advanced from an aggregated and offline paradigm to a real-time and individualized paradigm. Second, the evolving mobility options and services significantly enriched the transportation system as compared to the conventional car-centric system. Third, transportation systems increasingly interact with other urban systems such as electricity grid and communication networks, entailing a perspective of systems of systems.

Based on our understanding of the opportunities and challenges in years to come, the mission and focus of the Laboratory of Emerging Transportation Systems (LETS) are to apply traffic flow, network optimization, and emerging technologies/solutions to maximize the efficiency, safety, sustainability, and equity of transport infrastructures, considering the interactions with other systems. The team has particular interests in the improvement of operations of electric vehicles (EVs), control of connected and automated vehicles (CAVs), and management of mobility as a service (MaaS).

History

LETS was established in 2018 by Xiaobo Qu at Chalmers University of Technology, Gothenburg, Sweden. Since its foundation, the lab has received valuable support from Chalmers's Civil Engineering Department, Areas of Advance Chalmers, the Swedish Innovation Agency, the Swedish Energy Agency, and the European Union (EU), and has developed close collaborations with major industry partners such as Williams Sale Partnership AB, Volvo Cars, Scania AB, and so on. With the disruptive development of emerging technologies such as EVs, CAVs, and MaaS, unprecedented changes have been witnessed in nearly every aspect of the urban transport system, and more are foreseeable. In the past few years, the group has been actively working on those topics, and the collective effort has resulted in a number of high-quality research papers, major research

QUICK FACTS

Lab name: Laboratory of Emerging Transportation Systems

Affiliation: Chalmers University of Technology

Website: https://www.chalmers.se/en/staff/Pages/Xiaobo-Qu.aspx

Established: 2018

Research focus: CAVs, EVs, and MaaS; large, complex, and interrelated urban mobility systems in the era of emerging vehicular and communication technologies

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grants, and newly developed international collaborations. The current team consists of two faculty members, two research assistant professors, five postdocs, and more than a dozen Ph.D./visiting Ph.D. students.

Research

The research in LETS covers a wide range of topics pertaining to emerging mobility and vehicular technologies. Of particular interest are the understanding, operations, and management of EVs, CAVs, and MaaS.

EV Operation and Charging

Many governments around the world are striving to promote the development of EVs for the obvious advantages in sustainability and efficiency. However, most EVs, either private or public, are still operated similar to their internal combustion engine predecessors, although they have distinct vehicle dynamics and refreshing mechanisms (charging versus refueling). How EVs should be efficiently operated on both microscopic and macroscopic levels remain unclear, and considerable efforts have been devoted in the group to scrutinizing key problems of already existed and futuristic EV systems.

On the system level, one of our recent investigations has surprisingly found that EVs could induce extra congestion in morning peak hours. The major reason is that gasoline vehicle users usually depart very early to avoid the extensive energy consumption in peak hours; on the contrary, EV commuters are less concerned with the congestion cost and more inclined to a tight schedule, resulting in a more condensed departure time window and thus more severe congestion. On the operational level, we have addressed several key problems in the operations of EVs, including optimal E-bus routing, charging strategy development (Figure 1), EV speed control, and EV lifecycle cost analysis.

The team also completed studies regarding electric public transit network design, scheduling, fleet management,

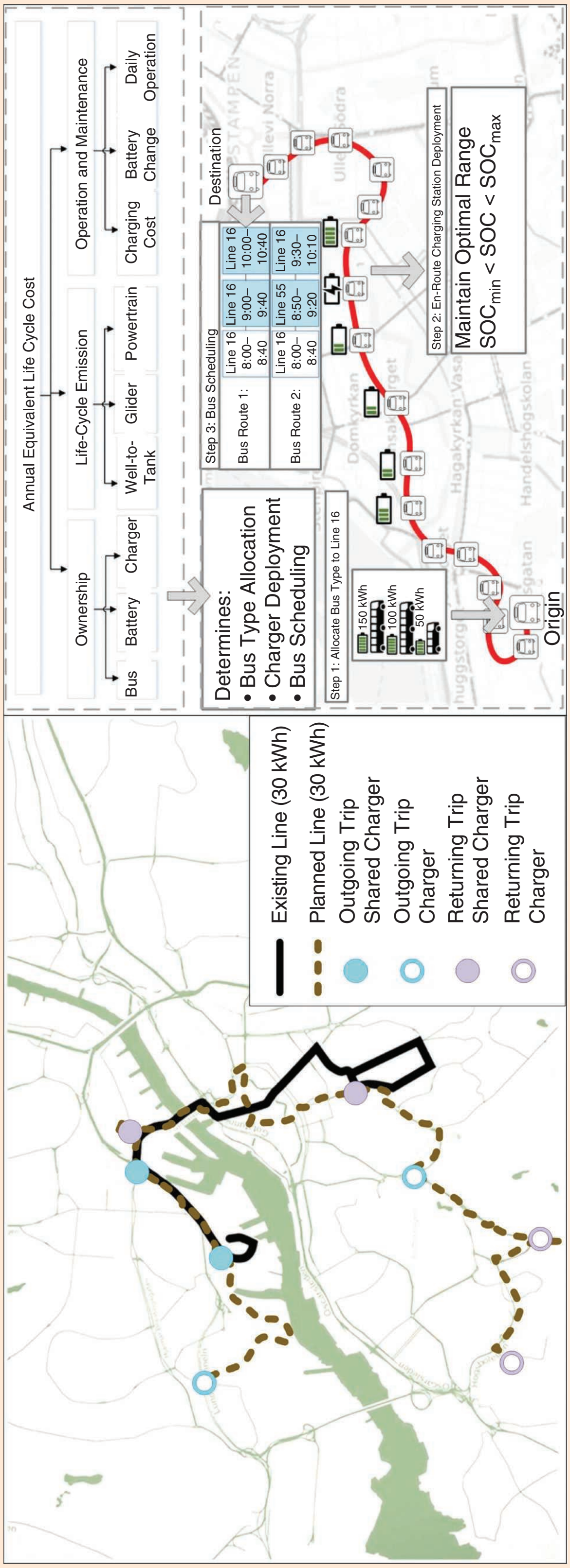

FIG 1 The E-bus charging infrastructure planning in Gothenburg, Sweden. SOC: state of charge. (The figure was generated by LETS lab and is sponsored by a JPI Urban Europe grant.)

lifecycle analysis, individual vehicle speed control considering road geometry, transit modularization, and so on. These works were sponsored by the EU, the Swedish Energy Agency, and Area of Advance Chalmers.

CAV Control

CAV technology is developing quickly and is expected to drastically improve traffic efficiency, stability, and safety. To achieve those ambiguous goals and advance field implementations of CAV technology, we study key problems in this area from fundamental tasks that CAV users encounter every day, such as car-following and trajectory optimizations, to advanced implementations, such as emergency management and congestion alleviation. For instance, the longitudinal (car-following) and lateral (lane-changing) control of vehicles were conventionally studied separately. In the era of CAVs, the gap could be potentially bridged through cooperative driving, which would lead not only to guaranteed safety but also to improved efficiency.

In this regard, we developed a general yet flexible vehicle sorting strategy that could accommodate various kinds of transportation infrastructures and fulfill different objectives. For instance, at signalized intersections, left-turning vehicles and through-going vehicles could be optimally and entirely separated through cooperative driving so that each turning movement can make use of all discharging lanes and thus increase the capacity of the intersection (Figure 2). The developed algorithm has also demonstrated its merits in other applications such as emergency vehicle preemption and highway ramp control. To facilitate field implementations, our industry partner developed

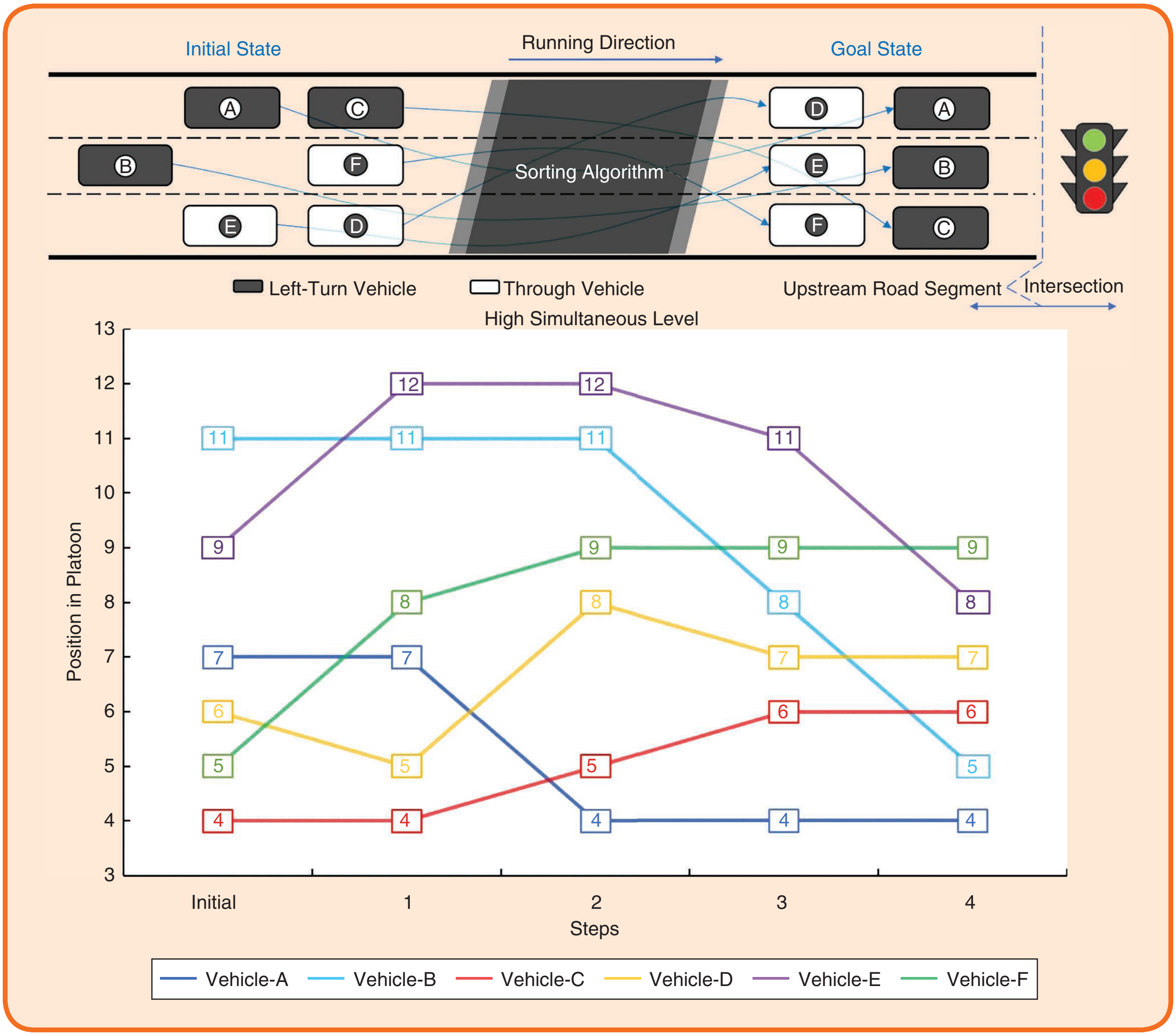

FIG 2 An example of cooperative driving at signalized intersections. (The figure was generated by LETS lab and published in [1].)

a vehicle-to-vehicle transmitter that has been tested in many parts of the world. In this line of research, we also contribute to traffic flow local coordination considering emergency vehicles [Figure 3(a)], vehicle speed planning [Figure 3(b)], machine learning–based car-following models, synchronization of speed limit and ramp metering control, and so on.

MaaS?

MaaS, including bike/e-bike-sharing and e-scooter/e-mopeds-sharing, are potentially sustainable alternatives to fossil-powered transportation and are being embraced worldwide by hundreds of cities to promote sustainable mobility. The research team leverages operational data from MaaS (including bike, e-bike, e-scooter, and e-mopeds) over 100 cities around the world such as Sweden, Germany, France, the United States, China,

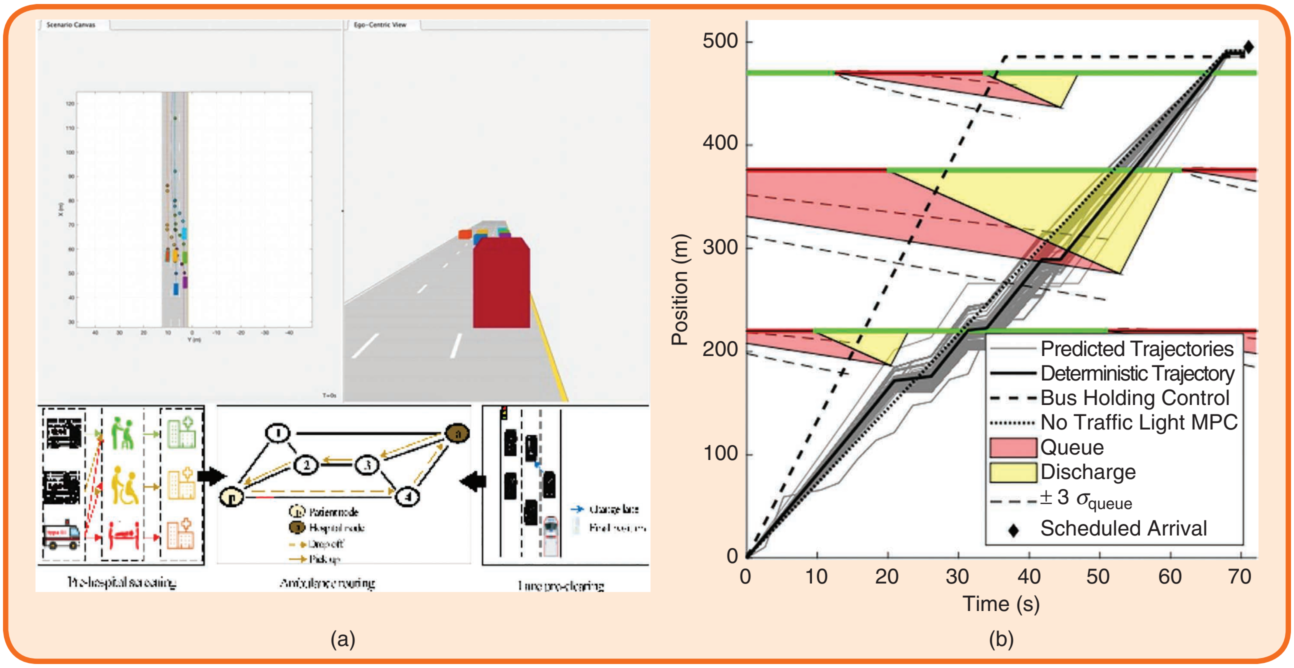

FIG 3 The exemplar research of CAVs: (a) emergency vehicles and (b) automated bus speed planning. MPC: model predictive control. (The figures were generated by LETS lab and published in [2] and [3].)

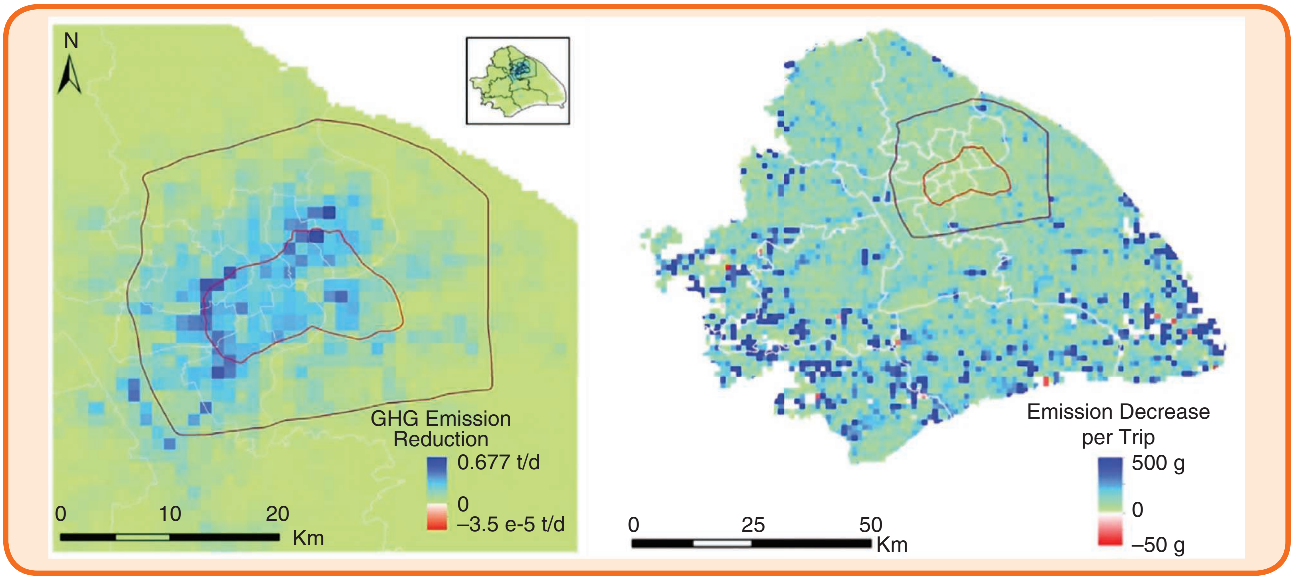

FIG 4 The emission reduction induced by bike-sharing in Shanghai. GHG: greenhouse gas. (The figure was generated by LETS lab and published in [4].)

Singapore, and Australia for promoting MaaS in urban contexts. In LETS, we focus on: 1) societal influences of MaaS, including operational and environmental impacts (Figure 4); 2) user characteristics, incentives, motivations, and barriers of MaaS adaption; 3) travel patterns and influencing factors; and 4) fleet management methods, such as bike-sharing relocation problems and e-scooter dynamic charging problems.

Future Directions

As new technologies emerge and urban subsystems become increasingly interactive and integrated, we will see urban transportation systems in light of development. We will keep contributing to areas that influence urban mobility and transformation the most, such as the autonomation and electrification in the transportation sector and the impacts and management of emerging MaaS.

About the Author

Xiaobo Qu (xiaobo@chalmers.se) is a chair professor of Urban Mobility Systems and the director of LETS lab at Chalmers University of Technology, Sweden.

References

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