Yisheng Lv, Editor

ITS RESEARCH LAB

The UCLA Mobility Labs

EDITOR'S NOTE

Please send your proposal on profiling research activities of your or other ITS research groups and labs for the "ITS Research Labs" column to Yisheng Lv at yisheng.lv@ia.ac.cn.

Mission

The University of California, Los Angeles (UCLA) Mobility Lab is dedicated to harnessing system theories and tools, such as artificial intelligence, control theory, robotics, machine learning, and optimization, to innovate and develop advanced mobility technologies and solutions for smart cities, particularly intelligent vehicular and transportation systems. We leverage the university environment and work with external partners to perform research and development and prepare the future workforce for competitive advantage in the areas of automated vehicles and new mobility. The lab comprises three distinct but collaborative research groups: 1) the Automation Group, 2) the Transportation Systems Group, and 3) the Safety and Risk Sciences Group. Each group uniquely contributes to the advancement of new mobility technologies and systems.

Automation Group

At the heart of the UCLA Mobility Lab is the Automation Group, a pioneering ensemble that has consistently been at the vanguard of innovation in automated driving. This group is acclaimed for devising state-of-the-art algorithms and applications that center on the perception, tracking, planning, prediction, decision making, and control of intelligent vehicles and traffic. Our collective endeavors, backed by rigorous research and development, are geared toward ameliorating both vehicle and traffic safety and sustainability.

Open Cooperative Driving Automation

In the rapidly evolving landscape of single-vehicle intelligence for automated driving, numerous unanticipated challenges emerge, predominantly stemming from the limited ability to perceive and engage with intricate traffic scenarios. Recognizing cooperative driving automation (CDA) as the linchpin for the future of automated driving and intelligent transportation, the UCLA Mobility Lab has spearheaded the OpenCDA initiative. While CDA has garnered tremendous interest across academia and industry, its full prowess remains predominantly untapped. The prevalent industry approach is a guarded development of proprietary tools and data infrastructures. On the flip side, academic pursuits are often bound to rudimentary simulations, devoid of real-world complexities.

Addressing this divide and serving the multifaceted needs of

QUICK FACTS

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Affiliation: The University of California, Los Angeles

Website: https://mobility-lab.seas.ucla.edu

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Research focus: Automated driving and intelligent transportation systems

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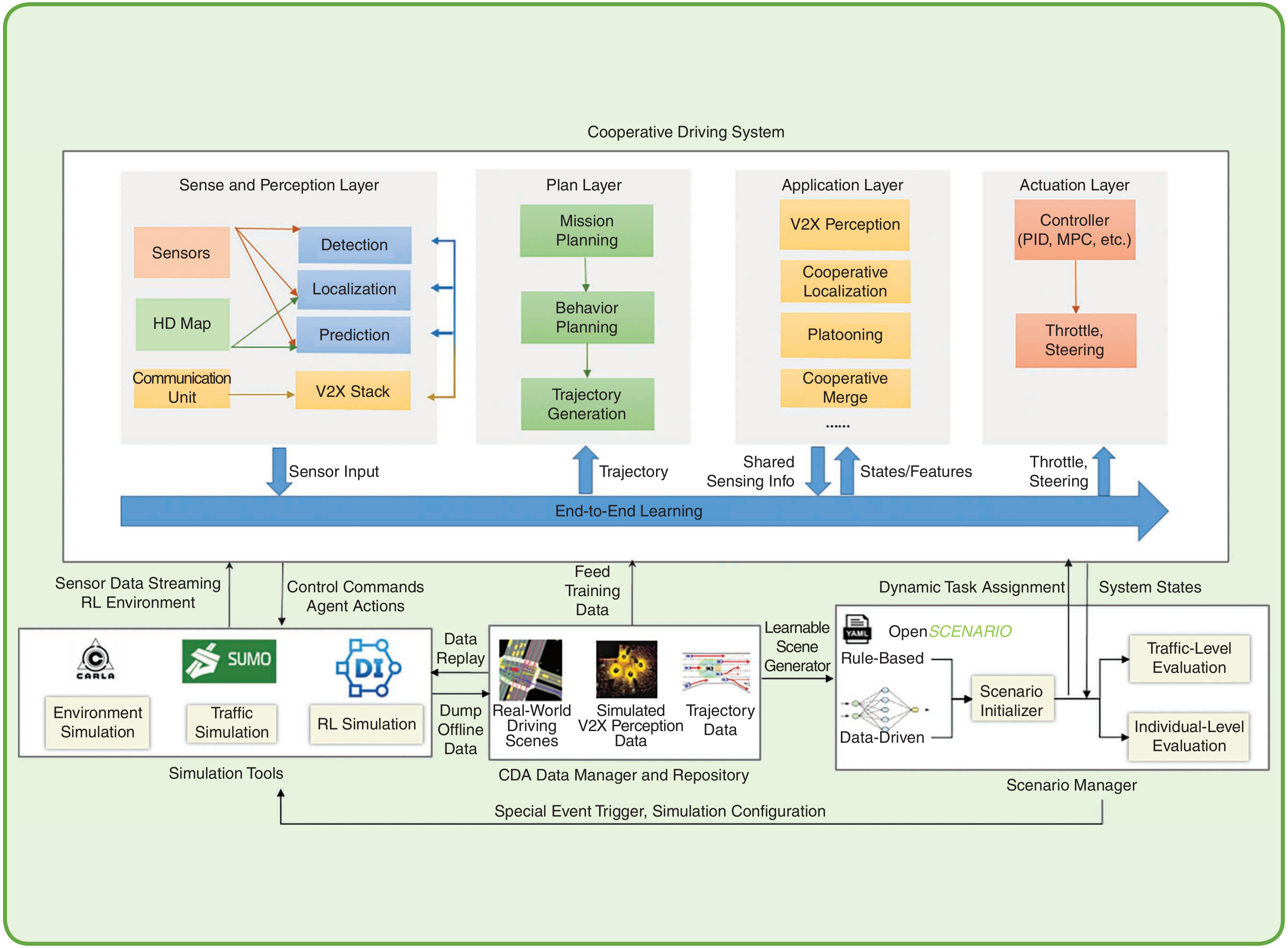

FIG 1 OpenCDA framework. RL: reinforcement learning.

the CDA research community, our lab has championed the OpenCDA research ecosystem (illustrated in Figure 1). This trailblazing framework offers a comprehensive open source ecosystem (OSE) amalgamated with a model zoo, high-fidelity driving simulators, expansive datasets, robust development toolkits, and a versatile scenario database/generator. The OpenCDA-robot operating system (OpenCDA-ROS) has also been introduced to enable seamless integration of OpenCDA resources with physical systems in real-world testing and validation. The OpenCDA OSE's inception has fueled a slew of avant garde CDA applications, including but not limited to cooperative 3D lidar object detection and cooperative camera-based map prediction. Esteemed entities like the U.S. Department of Transportation (USDOT), California Department of Transportation (Caltrans), and the Transportation Research Center have showcased these innovations, underscoring their significance and impact.

Smart Infrastructure

Safety, especially for vulnerable road users, like pedestrians and cyclists, stands as a nonnegotiable priority in intelligent transportation. Demonstrating unwavering commitment, the UCLA Mobility Lab has emerged as a bastion of roadway and intersection safety, harnessing the potency of automation technologies. Through this pursuit, we have fostered breakthroughs that adeptly discern and neutralize potential hazards, tapping into the synergy of smart sensors and the nexus between infrastructure and automated vehicles, exemplified in our smart intersection testbed (Figure 2).

Delving into the specifics of intersection safety, the Lab leverages a fusion of advanced sensing, artificial intelligence (AI), machine learning, and communication technologies. By mastering facets like cooperative perception, multimodal sensor fusion, trajectory prediction, vehicle-to-everything communications, and real-time decision making, we are scripting a new era of holistic safety strategies, marking an evolutionary leap in intersection protection protocols.

Transportation Systems Group

The Transportation Systems Group of the UCLA Mobility Lab focuses on addressing urban transportation

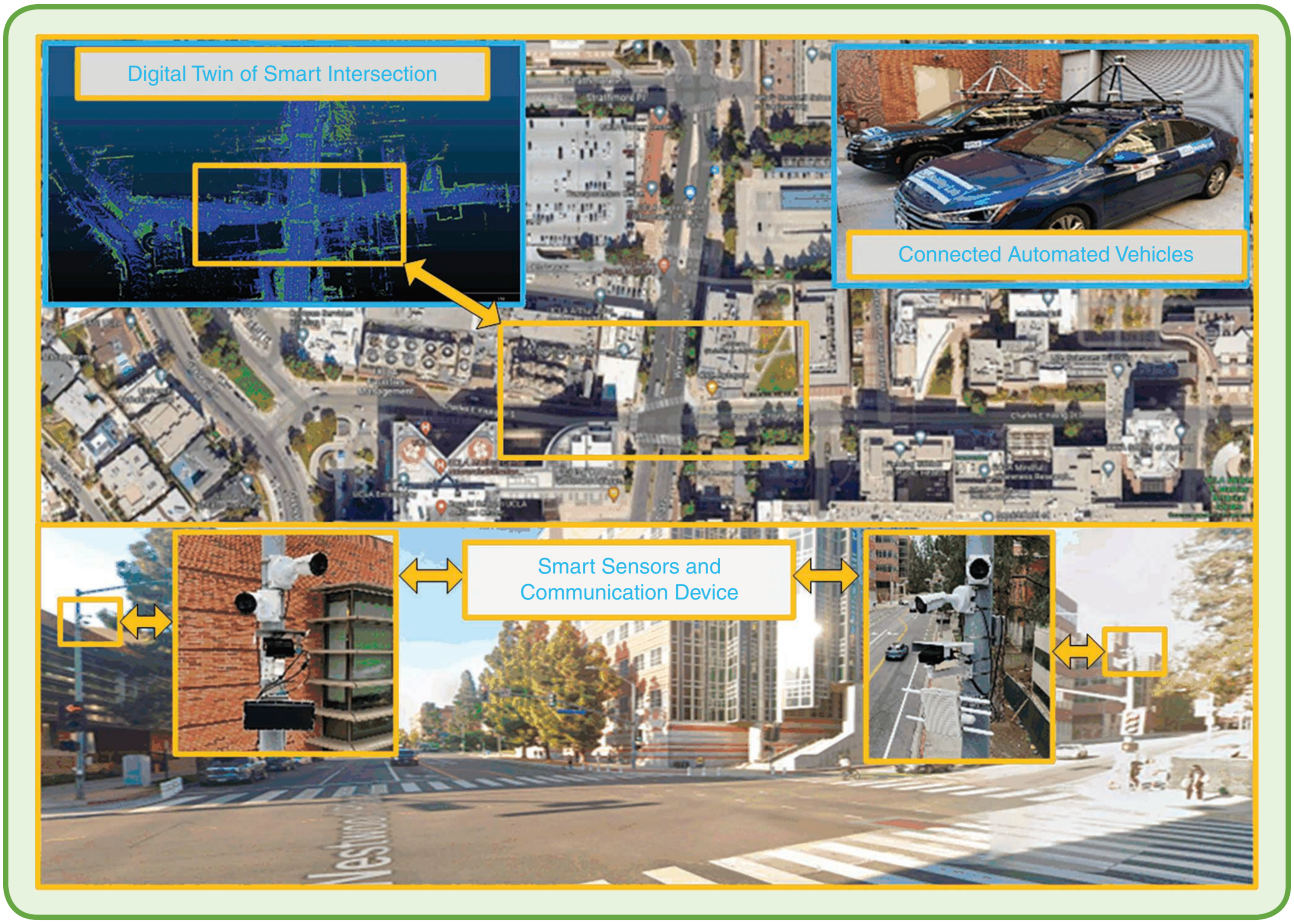

FIG 2 UCLA smart intersection testbed.

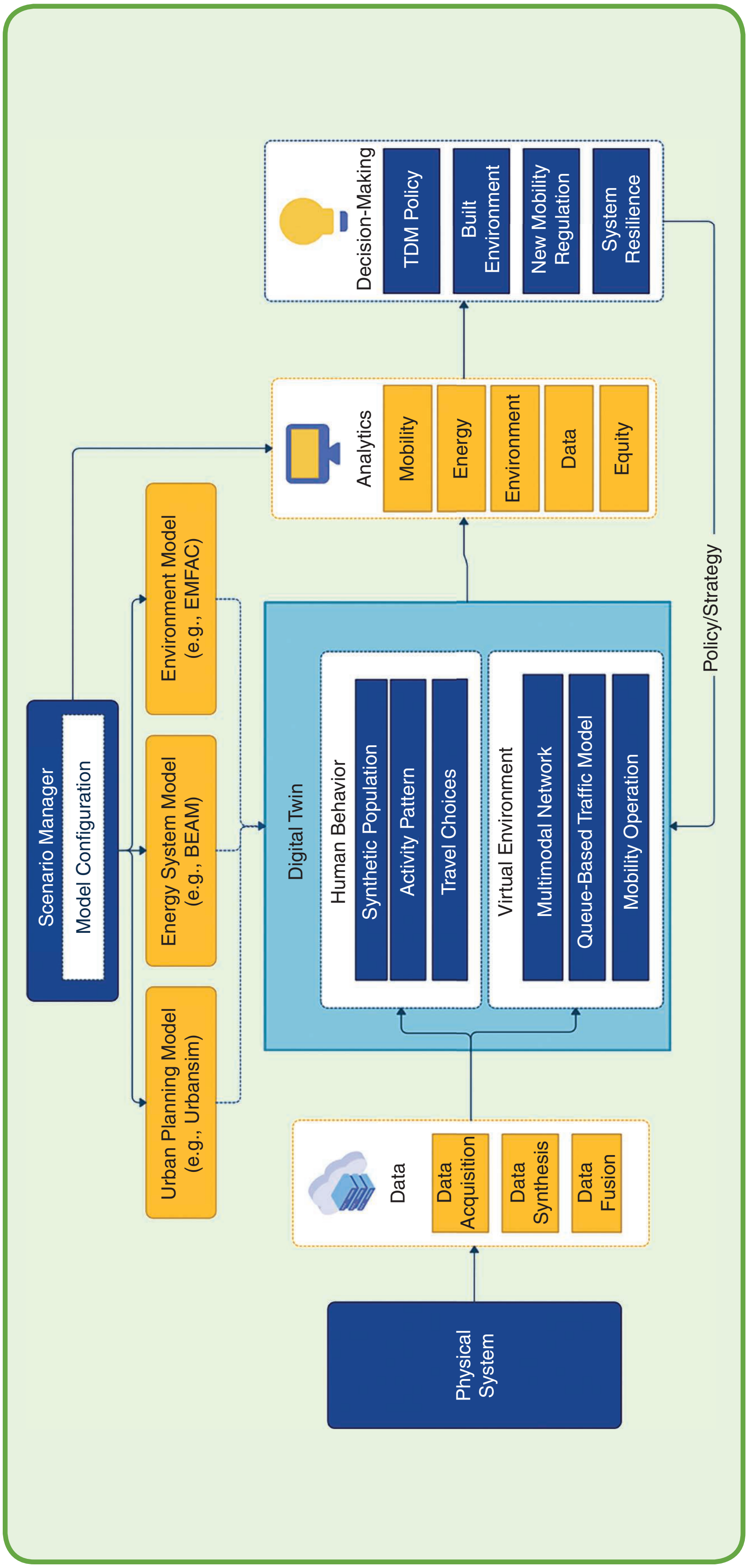

FIG 3 MADS. TDM: travel demand management.

challenges by integrating traditional transportation theories with data science, AI, and new technologies.

Mobility Analytics and Decision Sciences

In the context of smart cities, transportation systems have increased in complexity due to vehicles and infrastructure communicating and interacting with each other. Efficient modeling is essential for developing and assessing transportation solutions. Our mobility analytics and decision sciences (MADS) research framework uses analytical and computational system theories to describe and control the complex dynamics of these networks. Figure 3 presents our MADS framework, which combines digital twins with real-world systems, supported by scenario managers, analytics, and decision-making tools.

Central to MADS are digital twin models, illustrated in Figure 4. We've constructed a large-scale agent-based simulation for Los Angeles County, a digital testbed that models the movement of millions of entities in high detail. This model has been used for various interdisciplinary studies, including the evaluation of at-scale deployment of connected and automated vehicles in southern California, policy recommendations for telework, and electric vehicle charging infrastructure planning.

Human Trajectory Generation and Anomaly Characteristics

This research line focuses on modeling typical human movement patterns (as shown in Figure 4) to identify anomalous activities within large datasets of human trajectories. By combining transportation theories, machine learning, AI, social science, and computational simulation, we aim to produce realistic human movement models for large cities. These models consider both external factors (like weather or construction) and internal factors (such as personal preferences or social connections). Another goal is to automatically generate transportation systems digital twins and simulation models with minimal human input for different geographic regions and use such resources for urban mobility pattern analytics.

Safety and Risk Sciences Group

Partnering with the UCLA Garrick Institute of Risk Sciences, our Safety and Risk Sciences Group has pioneered comprehensive research pathways addressing the safety, reliability, and security of autonomous transportation systems. With a primary emphasis on intelligent vehicles and modern mobility solutions, we have actively facilitated an evolution in the sector. We've aided stakeholders—from government agencies to manufacturers—in conceptualizing, developing, and implementing robust frameworks that promote reliable and safe transportation systems.

Human–Vehicle Interaction

Most autonomous systems are deployed in a "mixed" environment, in which they will interact with nonautonomous systems. Autonomous cars will share the streets with human-driven cars, and/or with pedestrians and bicycles. Autonomous systems may also depend on humans for operation, such as an onboard safety driver who should take over control when needed and/or remote operators. Humans will also interact with autonomous systems as users, such as in automated cars operating as mobility-as-a-service (MaaS) or autonomous passenger ferries. Finally, these systems will interact with society in a broader sense, which involves societal acceptance and trust.

Over the past years, we have conducted extensive studies into the multifaceted interactions between autonomous and nonautonomous entities. Our groundbreaking research has shed light on the challenges and dynamics arising when autonomous vehicles coexist with human-driven vehicles, pedestrians, and cyclists in shared spaces. We have also looked into the aspect of human reliability in the face of different levels of automation of automated driving systems (ADS).

Risk Management and Decision Making

Risk can be assessed and managed from different perspectives: e.g. functional risk, operational safety risk, and enterprise risk. Risk assessments and modeling are necessary processes in the development of autonomous systems for comparing designs, informing risks to regulators and society, and developing risk-mitigation strategies. Autonomous systems include new hazardous events and complexities that may require new risk frameworks. Moreover, the connected aspect of the systems and data availability allows for applying online dynamic risk models. These models can assist in decision making during operations, informing operators or software about the safer course of action in real time.

We pride ourselves on our innovative approach to autonomous transportation risk evaluation, which has led to the creation of state-of-the-art frameworks. Our lab has introduced tools and methodologies that cater specifically to the unique challenges posed by modern urban environments, marked by the introduction of automation, connectivity, and electrification technologies, as well as various advanced business solutions for new mobility (e.g., ride sharing). A salient example of our endeavors in this space is a project funded by the USDOT National Highway Traffic Safety Administration, in which our team delves deep into a comprehensive risk assessment of ADS MaaS operations to identify safety risks inherent to level 4 ADS MaaS operations and elucidate the fleet operator's role and corresponding activities in mitigating such risks. This meticulous approach ensures that we not only identify potential pitfalls but also provide tangible solutions for a safer urban mobility landscape.

Legal and Regulatory Challenges in Intelligent Transportation

Autonomous systems pose legal and regulatory challenges. Regulators face the challenge of developing or

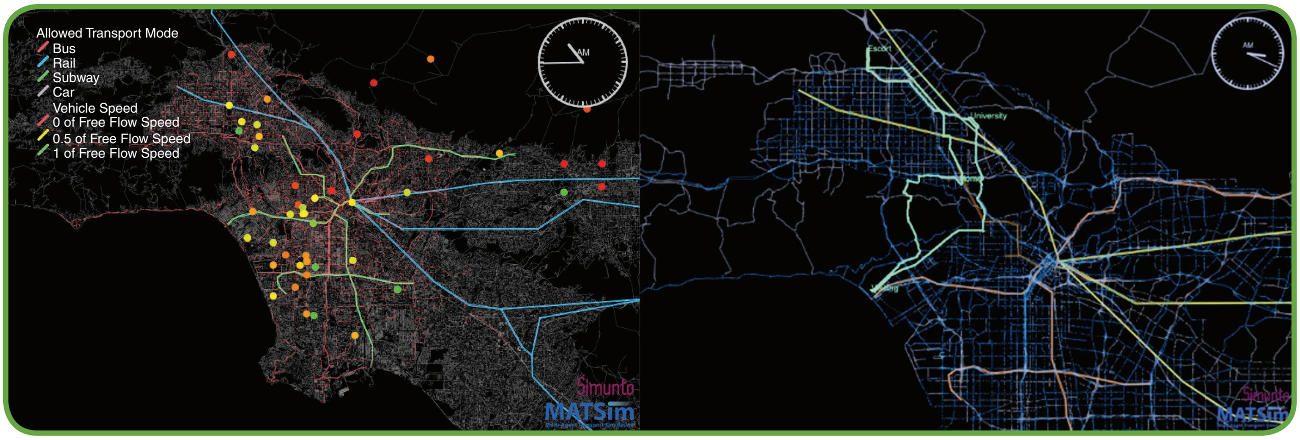

FIG 4 Multiscale urban system modeling and analysis.

adapting existing regulations to accommodate autonomous and semi-autonomous systems, and to keep up with the pace of technology development. The legal and regulatory challenges range from assessing the risks of autonomous systems' operational designs (e.g. having a driver onboard or being constantly monitored remotely) to developing and enforcing novel procedures for systems' operations, and the definition of liability aspects should an incident occur.

Addressing the legal complexities of the rapidly evolving transport sector, our group has provided foundational insights and guidelines for regulatory bodies. We have collaborated closely with stakeholders to identify potential operational pitfalls and provide actionable solutions. Key contributions include identification of safety hazards of automated passenger and commercial vehicle operations and comprehensive guidelines ensuring the safe deployment and operation of autonomous vehicle fleets in urban environments.

About the Author

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EDITOR'S COLUMN *(continued from page 3)*

your article is accepted or not, it is a great exploration of academic research and an important force to promote progress of this discipline. In the days to come, we will continue to bring more valuable content and services to our readers.

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