Yisheng Lv, Editor

Infrastructure Perception and Control Laboratory

EDITOR'S NOTE

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

Mission

U.S. Department of Energy national laboratories host world-class advanced computing and modeling capabilities. The National Renewable Energy Laboratory (NREL) inaugurated the Infrastructure Perception and Control Laboratory (IPC Lab) to advance mobility reach into real-world applications.

The IPC Lab aims to develop and share open frameworks for the processing and messaging of the state space of all objects to accelerate the benefits of IPC integrated with connected and automated vehicles (CAVs), saving lives and energy (Figure 1).

The IPC Lab hosts the latest infrastructure-based sensing and control technologies, expertise, and experience to support mobility and built-environment research and development. The IPC Lab tests various devices and provides statistical performance evaluations in various environments. This introduces real-world constraints into pioneering research. The IPC Lab also gradually introduces researchers' newly developed technologies into the real world through its three-tier lab structure.

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History

The IPC Lab was established in early 2023 by NREL. This lab was inspired by several past and current projects at NREL. In a regional mobility project in collaboration with Oak Ridge National Laboratory and the city of Chattanooga, TN, USA, NREL developed and deployed a real-time traffic signal control algorithm based on camera-based sensors and real-time probe vehicle data. The project team conquered numerous challenges from the field when integrating different technologies.

In an ongoing IPC project, NREL partners with the city of Colorado Springs, CO, USA, and developed an IPC computational framework and associated software referential engine that uses infrastructure-based sensors to create 3D digital representations of intersection traffic, including vehicles, bicycles, and pedestrians. This work will contribute to a recent Strengthening Mobility and Revolutionizing Transportation grant to the city of Colorado Springs from the U.S. Department of Transportation to protect vulnerable road users and

QUICK FACTS

Infrastructure Perception and Control Lab

Affiliation: National Renewable Energy Laboratory (NREL)

Website: https://www.nrel.gov/transportation/ipc-lab.html

Established: 2023

Research Focus: Infrastructure-based perception and control

Director: Qichao Wang

Dr. Wang is a computational transportation scientist at NREL. His work mainly involves transportation systems modeling, simulation, control, and optimization leveraging advanced computing.

Contact Information:

Address: 15013 Denver West Parkway, Golden, CO 80401 USA

Phone: 303-275-4367

Email: qichao.wang@nrel.gov

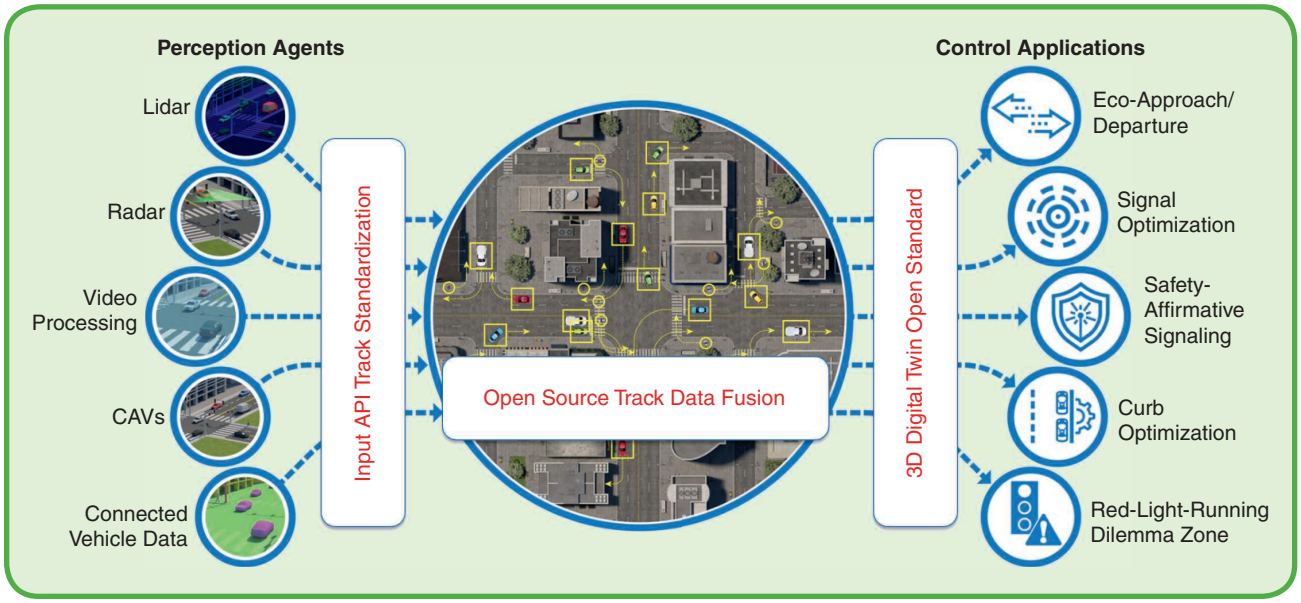

FIG 1 The cooperative perception pipeline. API: application programming interface.

emergency responders, guard against red-light runners during periods of low traction and reduced visibility, and optimize for emission and travel time reductions.

Equipment and Facilities

The IPC Lab has three tiers, including a 460-ft^2 indoor space, a 1.44-mi test track in collaboration with the Colorado State Patrol, and the public roads in Colorado Springs. The lab is configuring a trailer that serves as a mobile lab.

The indoor space is used for prototyping, modeling, simulation, analysis, and visualization. It hosts

- *Sensors:* EVO radar, mechanical lidar and solid-state lidar, cameras, real-time kinematics (RTK) GPS, perception software, and edge devices (Figure 2)
- *Controller systems:* an advanced traffic controller cabinet, bus interface unit cards, serial interface unit cards, a Siemens M60 controller, a Siemens Blade controller, and an Econolite Cobalt controller
- *Interactive visualization:* a Varjo XR-3 headset and 3ds Max software
- *Communication:* Cohda MK6 units
- *Software:* Vissim, Aimsun, Simulation of Urban Mobility, Synchro, Vistro, Cohda MKx SDK.

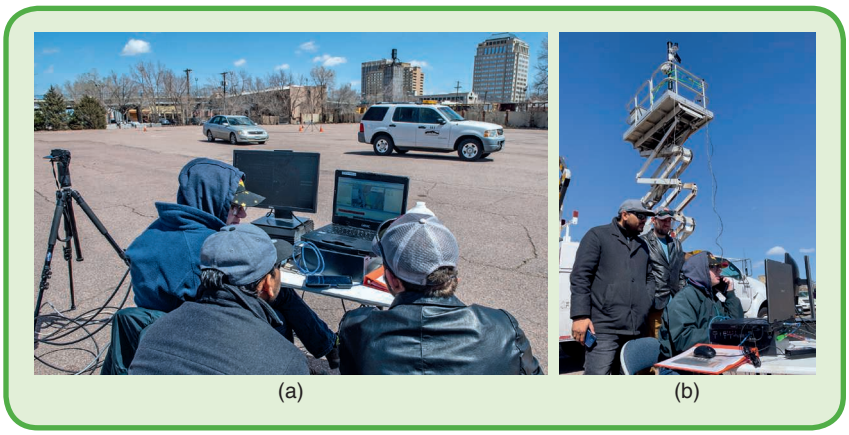

FIG 2 Field data collection using lidar, radar, and RTK GPS. (a) Testing vehicles equipped with RTK GPS. (b) Lidar and radar sensors installed on a truck mounted scissor lift.

FIG 3 The IPC Lab test track.

The data infrastructure channels real-time information from the track and public roads into digital twins empowered by NREL's high-performance computing systems.

The IPC Lab is also equipped with a 3D printer that can print customized enclosures and tools. The IPC Lab has access to professionally operated drones, including a Parrot ANAFI Ai.

The test track is owned by the Colorado State Patrol Academy and located adjacent to the NREL South Table Mountain campus (Figure 3). The IPC Lab is allowed to use the track for testing and research. This enables vehicle-in-the-loop testing in a protected environment. The equipment from the indoor lab space can be installed on the trailer and deployed at the test track.

After testing technologies in the protected track environment, the IPC Lab moves them to public roads through its local partnership. The public roads provide a high volume of traffic and comprehensive field settings for deployment data collection. The IPC Lab is in a long-term partnership with Colorado Springs and has controller equipment and sensors that are identical to most of the intersections in the city (Figure 4). This configuration allows for safe transfers from small-scale lab testing to citywide deployment and demonstration.

The three-tier lab structure is interconnected through the trailer (mobile lab) in the physical world. Information flows through all three tiers via the NREL Energy Systems Integration Facility data infrastructure and visualization capability. The data infrastructure channels real-time information from the track and public roads into digital twins empowered by NREL's high-performance computing systems. This provides real-world-data-informed computational models for computational transportation science research. The physical nature of the IPC Lab also directly supports experimental research and development in real-world environments. Combined, the IPC Lab is targeted at bridging theoretical (often virtual only) research to rapid field deployment.

FIG 4 An instrumented intersection in Colorado Springs.

Future Directions

The IPC Lab is part of NREL's Mobility Infrastructure and Information Interdisciplinary Integration Initiative (MI5), led by Stanley E. Young, an advanced transportation and urban scientist who was instrumental in establishing the lab. The MI5 also envisions expansion to include the Human Behavior Adoption Lab, Automated Mobility Platforms Lab, and Big Mobility Data for Planning, Operations, and Energy Lab.

Disclaimer

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