OAK RIDGE National Laboratory

Artificial Intelligence Applications in Transportation: Opportunities and Examples

Transportation Research Board
Executive Session

January 15, 2020

Rich Davies
Deputy Director
ORNL Sustainable Transportation Program

ORNL is managed by UT-Battelle, LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

Discussion Topics

- Drivers for artificial Intelligence (AI) in transportation
- Review select applications
  - Opportunities
  - Specific Examples
- AI and high performance computing innovations perspective

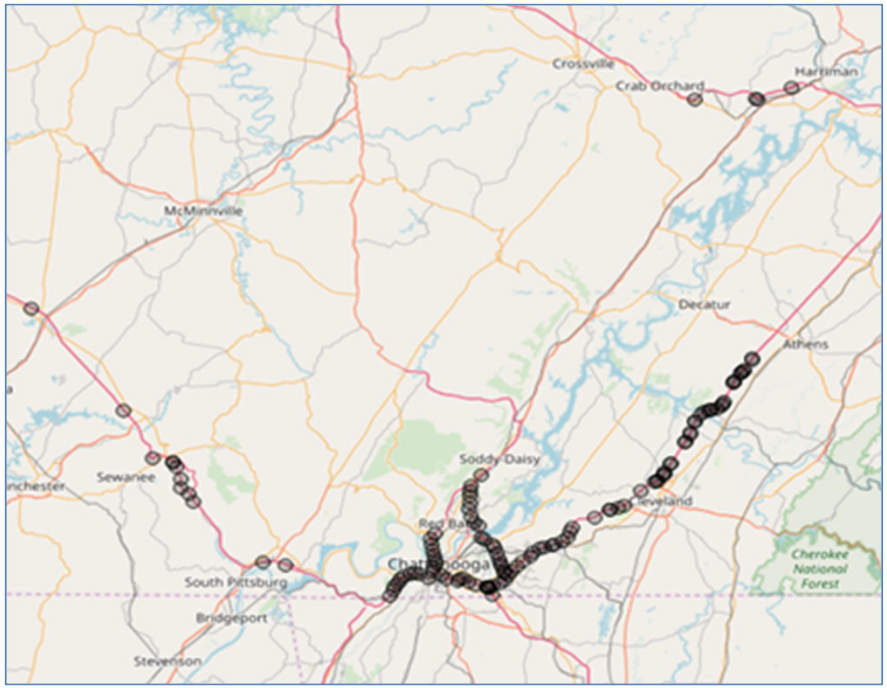
R&D questions driving our application of AI at all scales

Mobility scale	Core S&T questions
Vehicle component	How do we deliver 350 kW at 800 V+ for fast charging, range, and 10x power density?
Vehicle	What communications and cybersecurity provides optimum safety and efficiency?
Mobility system	How do we bidirectionally control 15 million vehicles in near-real time?
System of systems	How can we coordinate and optimize ground mobility at the national scale?
	How can we optimize across all mobility systems and external influences (e.g., weather)?

Prognostics and diagnostics

- Opportunity:
  - Improve reliability of intelligent transportation systems using AI for prognostics and diagnostics of sensors
- Example:
  - Diagnose failed or failing roadside equipment used for real-time highway monitoring and control
    - e.g., radar, cameras, crosswalk equipment

Cyber-physical control of vehicles and infrastructure requires a reliable "digital twin"



<u>214 radar detector sensors</u>

Located every half-mile on average
Receiving 2 GB file daily
30s data from RDSs
Lane occupancy, speed, and classification

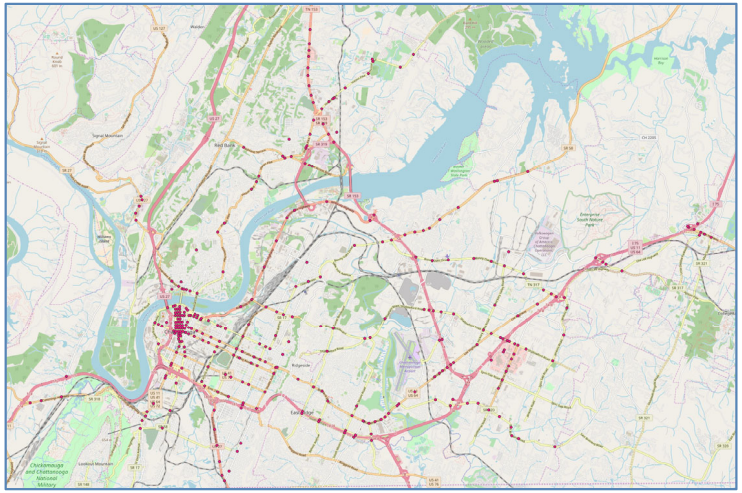
Infrastructure health monitoring

- Opportunity:
  - Monitor roadway and infrastructure health for improved maintenance and quality
- Examples:
  - Perform image recognition using on-vehicle cameras to identify roadway and infrastructure damage
  - Analyze vehicle steering and breaking to locate consistent driver-to-driver object avoidance

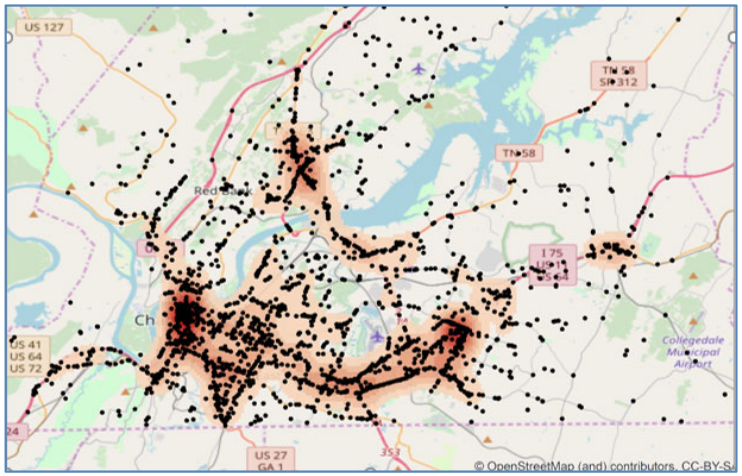
Coordinated traffic control

- Opportunity:
  - Use digital twin to inform a cyber-physical traffic control system of large-scale traffic regions to optimize:
    - Energy efficiency
    - Emissions
    - Safety
- Examples:
  - Implement cyber-physical control of traffic signal phase and timing; ramp metering
  - Inform/instruct connected vehicles and fleets

Map of Chattanooga illustrating the locations of the traffic signals



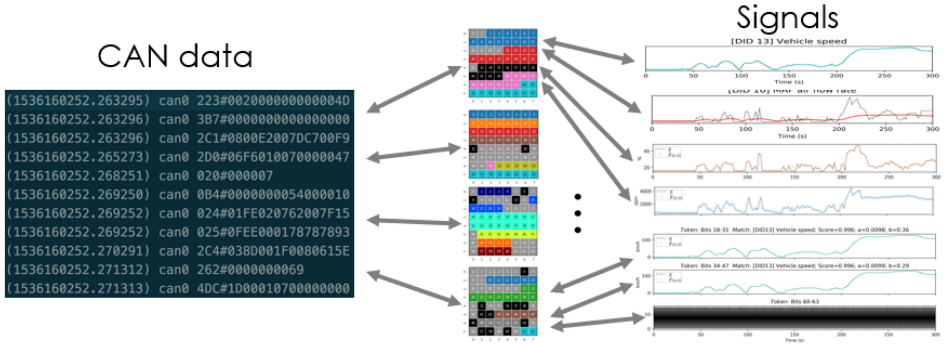
Control system must consider nearly 12,000 accidents per year in Chattanooga



Communications and Cybersecurity

- Opportunity:
  - Enable greater efficiency and safety with increasingly complex on-vehicle and V2X communication
    - Introducing greater need for cybersecurity
- Examples:
  - Detect intrusion of on-vehicle communications using AI-enabled device and edge computing that alerts drivers of the intrusion

Proprietary Controller Area Network (CAN) enables control system communications



Deploying single-board hardware devices detecting intrusion using machine learning

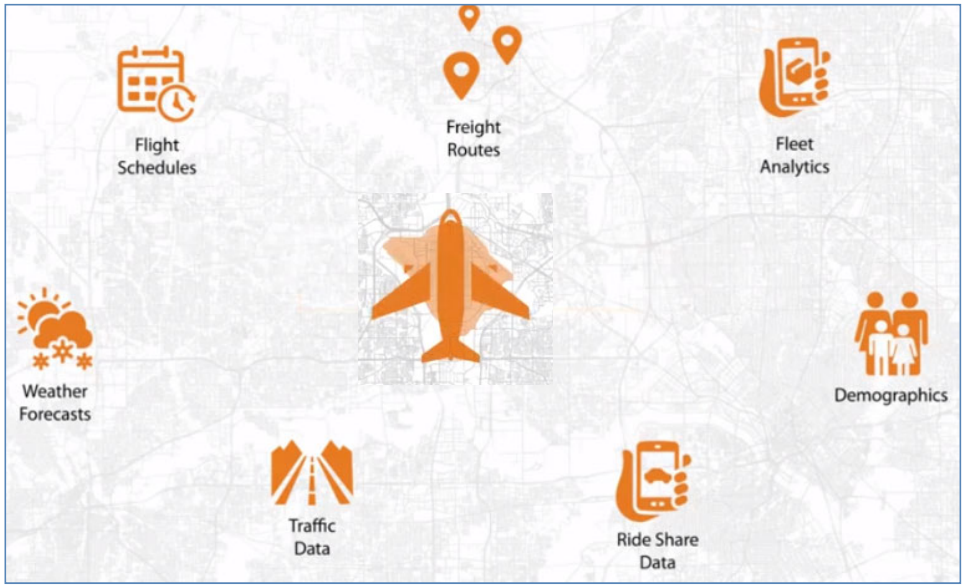
Freight and logistics optimization

- Opportunity:
  - Enable greater convenience and affordability with the rise of e-commerce
    - Driving a major increase in parcel delivery
- Example:
  - Minimize congestion, energy consumption, and emissions within a geofenced area with regionally coordinated parcel delivery
    - Unified curbside management

Multimode optimization

- Opportunity:
  - Improve the efficiency of transportation hubs (e.g., airports) using multimodal digital twins for control across a system of systems
- Example:
  - Develop a "digital twin" model of Dallas/Fort Worth airport and apply AI to optimize the air-to-ground transportation interface
    - Maximize the value of passenger and freight mobility per unit of energy, time, and/or cost

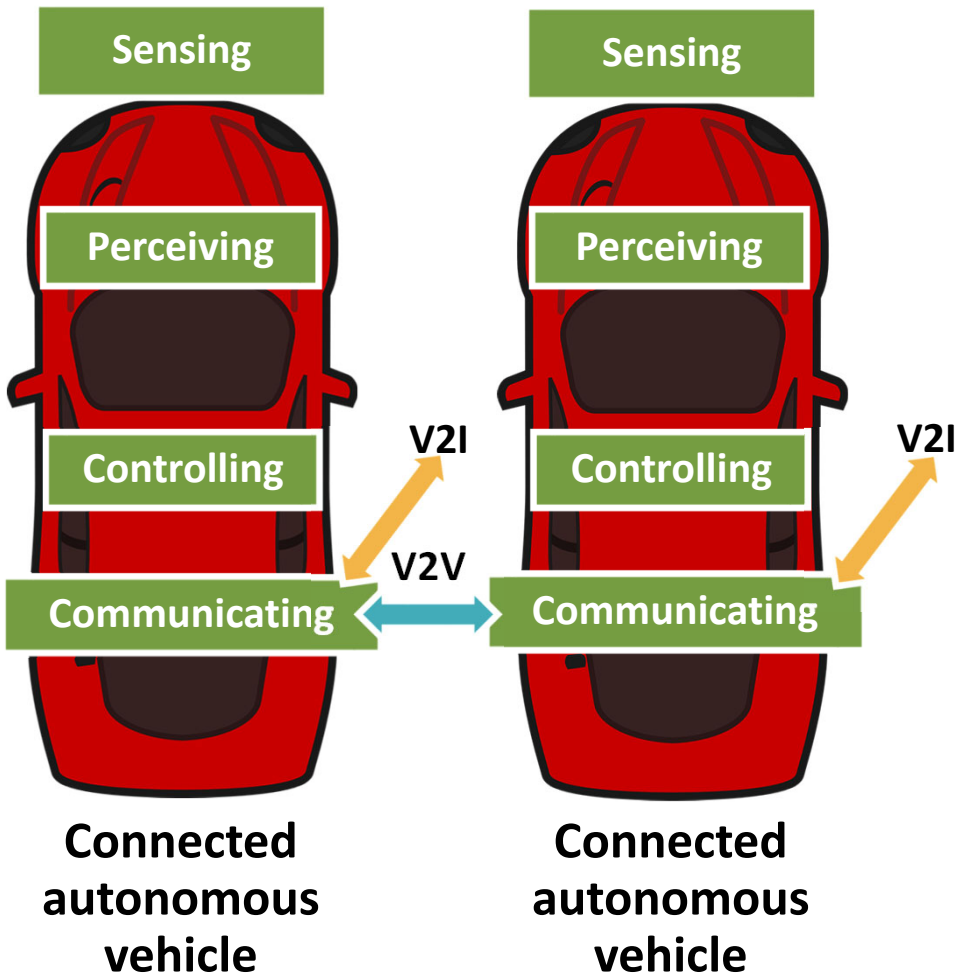
Partnership around the DFW Airport



https://www.athena-mobility.org/

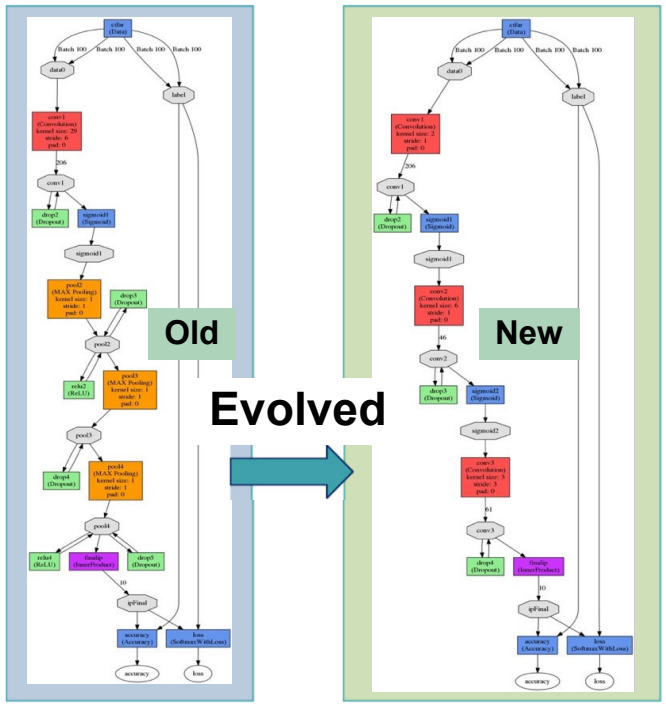
Perception and control of automated vehicles

- Opportunity:
  - Deploy connected and automated vehicles (CAVs) capable of safety and energy-efficiency that far surpass human driven vehicles.
- Example:
  - AI that ingests camera, lidar, and radar sensor data, fuses this data to 3D maps, weather, etc., and delivers the perception and basis for controls and communications



AI and High Performance Computing innovation continues

menndl
Multinode Evolutionary Neural Networks for Deep Learning



- Deep learning (DL) must be tailored to an application, requiring months of manual effort and a significant amount of expertise
- MENNDL works by evolving a population of DL neural networks to an **application within hours and with very little expertise**
- Scaled to 4,000+ nodes/27,000 GPUs of Summit
  - 152.5 petaflops measured with MENDDL in 2018
- First exaflop computers scheduled to come online in 2021
  - ORNL Frontier and ANL Aurora
- Quantum and neuromorphic computing will bring new tools and approach

Summary

- AI likely to enable transportation technologies at all scales
- Many opportunities are currently being exploited
  - Diagnosing failed or failing sensors with prognostics and diagnostics
  - On-vehicle cameras for infrastructure health monitoring
  - Cyber-physical control of highway traffic
  - Detecting cyber intrusion of V2X and on-vehicle communications
  - Regional optimization of parcel logistics
  - Optimize the air-to-ground multi-modal operations of major airports
  - Perception, control, and communications for CAVs
- AI innovations in transportation are likely to accelerate

Thank-you