PacTrans STAR Lab Research on Connected and Autonomous Vehicle Systems

Yinhai Wang
PacTrans STAR Lab
University of Washington
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Email: yinhai@uw.edu   Tel: 206-616-2696
PacTrans Introduction

PacTrans theme is *Providing Data-Driven Solutions for the Diverse Mobility Challenges in the Pacific Northwest*

It has five primary partners:

- Oregon State University
- University of Alaska Fairbanks
- University of Idaho
- University of Washington (lead)
- Washington State University

Two educational partners

- Boise State University
- Gonzaga University

PacTrans Website: [http://www.pactrans.org/](http://www.pactrans.org/)
PacTrans Introduction

PacTrans is willing to collaborate with you all on research, education, workforce development, tech transfer, and outreach.

You are invited to our Region 10 Transportation Conference on Oct. 11, 2019 in Seattle!
PacTrans STAR Lab

Smart Transportation Applications and Research Laboratory (STAR Lab): More 101

Website: http://www.uwstarlab.org/  
Tel: 206-543-STAR (7827)
Recent Research Focus

- Data Quality Control
- Digital Roadway Interactive Visualization and Evaluation Network (DRIVE Net)
- AI Applications in Transportation Engineering
- Autonomous Vehicle Navigation
- Mobile Device based Data Collection and Knowledge Discovery
- Energy Efficient Traffic Sensing and Control Technologies
- Vehicle Routing Using Data from Connected Vehicles
- UAV-based Transportation Data Collection
- Technical solutions to transportation safety challenges
All Added People Are in Cities

World Urban and Rural Populations

Demand-Supply Gap Goes Bigger

From the Bureau of Transportation Statistics, *National Transportation Statistics 2018*
Cities Are Very Crowded

Traffic Safety Challenges

Future Mobility?

What is the key?
Autonomous Vehicles

Image source: http://img3.imgtn.bdimg.com/it/u=306527957,607024432&fm=27&gp=0.jpg
Connected Vehicles

Data collected from connected vehicles provide insights into the performance of the city.

Transit vehicles leverage connected vehicle technologies for transit signal priority.

Connected vehicle data supports advanced traffic signal operations.

Image source: USDOT, Beyond Traffic: The Smart City Challenge.
Smart Road Infrastructure

Image source: https://www.2025ad.com/latest/computing-and-autonomous-driving/
Transportation Bigdata Analytics
ASCE CAV Impact Committee
Critical Technologies Needed

- Sensors and Sensor Networks
- Fast and Reliable Communications
- Accurate Positioning and Navigation Systems
- Data Storage, Quality Control, and Analytics
- Data Integration and Indexing
- Data-Driven Science Framework
- Open Source and Open Structure Data Platform
- E-Science Computational Models
- Cyber Security Solutions
- Visualization and Communication Tools
- …
Mobile Unit for Sensing Traffic (MUST)
Mobile Unit for Sensing Traffic (MUST)

- Detects Media Access Control Addresses
- Detects Road Surface and Environmental conditions
Visibility Detection, Warning, and Control
MUST Sensor Applications

- E-8 Corridor Travel Reliability Monitoring in Norway
Bus Collision Avoidance System

TRB Transit IDEA with WSTIP
Images from Transit Video Cameras

- Interior Camera
- Exterior Camera
- Driver Perspective
- Camera Detection Range
Methodology for Near Miss Detection

Stage 1: Pedestrian detection using deep learning (HOG)

Stage 2: Pedestrian tracking and motion estimation using KLT in image coordinate

Stage 3: Relative position and relative speed estimation in the real-world coordinate

Stage 4: Near-miss detection using time-to-collision and distance-to-safety as the indicators

Example Detection Results

- Sample frames showing the detected near-misses in transit onboard videos

To identify hotspots

Safety Applications

- Assist in the evaluation of a commercial collision avoidance system (MobilEye Shield+): typical patterns of false-positives

Safety Applications

- Assist in the evaluation of a commercial collision avoidance system (MobilEye Shield+): examples of late detections identified as false-negatives

### Safety Applications

- **Cost-benefits estimation for collision avoidance systems**

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<th>Lower Bound of Annual Total Net Benefit ($) LBV X NV</th>
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Smart Road Stickers (SRS)

- Similar in nature and form to a typical road stud/pavement marker
- Capable of two-way communication via LoRa and/or NB-IoT
- Solar-powered low power consumption design
- Sensor fusion technologies
- Currently exploring 3-D printing of case/cover
Smart Road Stickers (SRS)

Two types of SRS:
- Roadway version: SRS-R
- Parking version: SRS-P

SRS-R

SRS-P
SRS Applications
Dynamic Road Capacity Allocation

AM Peak

PM Peak
SRS Applications
Work Zone and Vehicle Protection

Work Zone and Disabled Vehicle Protection
SRS Applications
Ped/Bike Detection and Protection

CAV Testbed in the Smart Cities Context
SRS Applications
Ped/Bike Detection and Protection
SRS Applications
Parking Occupancy Detection and Management
CAVs Will Generate Lots of Data

Age of Big Data

Traffic Sensors +

Transportation Big Data!
CAVs Will Generate Lots of Data

Transportation Big-Data Streams

Source: https://tse4-mm.cn.bing.net/th?id=OIP.yeHZbk4h825ZqvRznN_NJQEsCo&pid=15.1&P=0&w=306&h=173
Challenges with New Data

- Mass quantity in amounts
- Subjecting to various errors
- Often not directly for the work you want to do
- Inconsistent in data formats
- Varying in resolution
- Targeting different kinds of objects

Need new methods, new tools, and new skills to take advantage of these data for your research and practice.
Extra Challenges to Transportation Professionals

- **Transportation theory**
  - Mathematical equation driven
  - Based on small and possibly biased samples
  - Location specific
  - Lack of field validation and application guidance

- **Transportation professionals**
  - Mostly trained as civil engineers
  - Weak in IT and database knowledge
  - Typically make empirical decisions without sufficient data support
  - Static and isolated system view

- **Transportation infrastructure**
  - Instrumented to some extent, but no general guidance on using the sensor data
  - Data are not efficiently shared
The ongoing research addressing those needs at the PacTrans STAR Lab is called Digital Roadway Interactive Visualization and Evaluation Network (DRIVE Net: www.uwdrive.net)

- DRIVE Net is an online platform for data sharing, analysis, visualization, and decision support
- Designed for big data and large-scale system analysis
- Followed the e-Science principles
- Built with free open source software packages
DRIVE Net Architecture
Fat-Server Thin-Client Framework

- No plug-in and installation is required at the client side except a basic browser.
- There is less security concern since all the data are manipulated and computational tasks are performed at the server side.
- Mature frameworks for building thin-client web application could be reused to boost development productivity.
- DRIVE Net 3.0 can be accessed at: http://www.uwdrive.net or http://wsdot.uwdrive.net
DRIVE Net: Traffic Flow Map
DRIVE Net: LOS Map
DRIVE Net: Congestion Report
DRIVE Net: Incident-Induced Delay Analysis
DRIVE Net: Emission
DRIVE Net: Safety Performance Measurement
DRIVE Net: Congestion Analysis
DRIVE Net: Travel Time Reliability Analysis
LSTM-based Congestion Prediction

Actual Congestion map          Predicted Congestion map

07/29/2016 12:00:00
Complicated Systems Are also Vulnerable

Security and Privacy Issues:

- How to balancing accessibility and security?
- How to prevent service providers to track users?
- How to protect the MaaS platform from cyber attacks?

Thanks for your attention!

Acknowledgment
Thanks to the UW STAR Lab research team. The presented projects were partly funded by Washington State Department of Transportation (WSDOT), PacTrans, and China Natural Science Foundation. We appreciate their funding support!