Safe Autonomous Driving and *Humans:*
Issues and Prospects

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University of California at San Diego
http://cvrr.ucsd.edu/LISA
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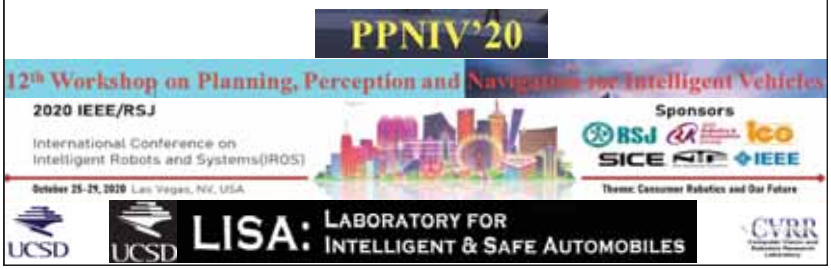


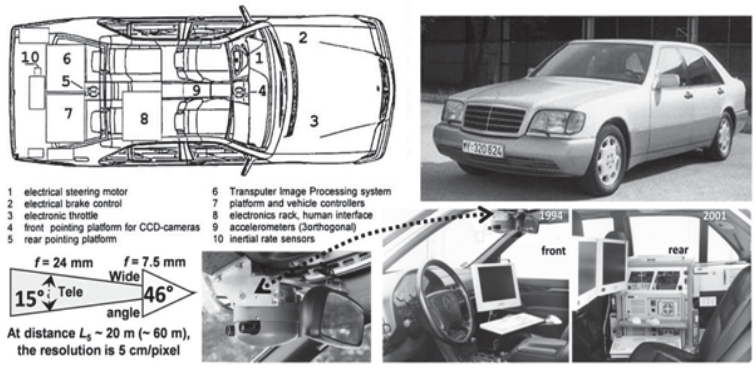
Safe Autonomous Driving and *Humans:*
Issues and Prospects

PPNIV'20

Outline:

- *Celebrating Accomplishments of the PPNIV community*
- *A brief (rear view) look: 1980s till 2015*
- *Recognition of some critical elements*
- *Age of Safe Autonomous Driving*
- *Making of Safe AV: Understanding and Predicting Human behavior*
- *Exciting journey continues !*

Vision for Intelligent Vehicles: Past 1980-2000



Ernst Dickmanns, "The development of machine vision for road vehicles in the last decade." *IEEE Intelligent Vehicles Symposium*, 2002

Vision for Intelligent Vehicles: Past 1980-2000

Days 6-7-8: July 28th, 29th, 30th, 1995 Las Vegas and drive to San Diego

Driving Time: 9:00am - 1:45pm

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Segment Autonomy State:
    Autonomous Driving Percentage:  99.8%  (322.99 / 323.5 miles)
    Longest Autonomous Segment:     59.36 miles
    Avg Speed:                      70.37 mph

Total Autonomous State (including Pittsburgh to Washington D.C. segment):
    Autonomous Driving Percentage:  98.2%  (2796.87 / 2849.13 miles)
    Longest Autonomous Segment:     88.98 miles
    Avg Speed:                      63.8 mph
```

Todd Jochem, Dean Pomerleau, Charles Thorpe, "Vision Guided Lane Transition," *IEEE Intelligent Vehicles*, 1995.

Seeking Full Autonomy, *2003-2009*

DARPA Grand Challenge I
Barstow to Primm
March 13, 2004

142 miles
10 hours

DARPA Grand Challenge II
Desert Classic
October 8, 2005

132 miles
10 hours

DARPA Grand Challenge III
Urban Challenge
November 3, 2007

60 mi
6 hou

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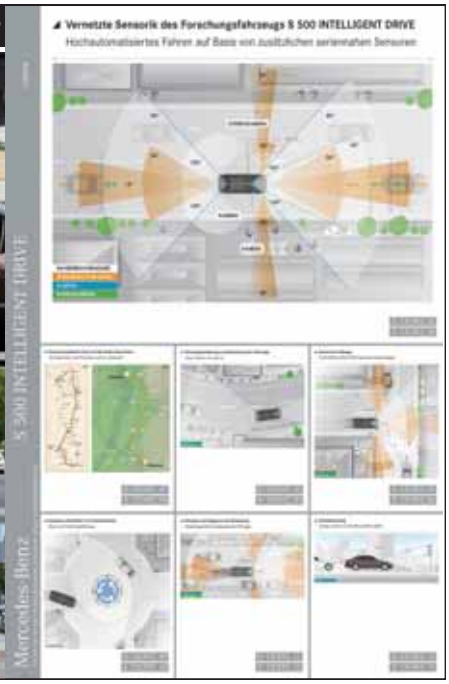
2014 Birth of a new age ?



Self Driving Cars 2015

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Quest for Fully Autonomous Driving

UCSD *Seen this?*

Union of Concerned Scientists

POLICY BRIEF

June 2017

Maximizing the Benefits of Self-Driving Vehicles

Principles for Public Policy

HIGHLIGHTS

Self-driving vehicles have the potential to improve the safety, accessibility, and convenience of transportation substantially, but they also may increase energy use, transportation-related pollution, and roadway congestion. Public policy must take into account both the positive and negative potential of this emerging technology on communities and the environment. Doing so will help ensure that the introduction and use of self-driving vehicles reduce oil consumption and global warming emissions, improve public health and safety, and enhance mobility for all.

Autonomous, or self-driving, vehicle technology may be the most significant innovation in transportation since the mass introduction of automobiles in the early 20th century. Whether the widespread adoption of self-driving vehicles results in positive outcomes in the years ahead will depend largely on how public policy guides the introduction of this emerging technology today. The potential benefits include safer roads, more affordable transportation, improved access to jobs, and a cleaner, healthier environment. Without well-crafted policy, though, self-driving vehicles could increase vehicle miles traveled and global warming emissions, worsen congestion, exacerbate air pollution, and put millions of Americans out of work (Litman 2016).

UCS has outlined a set of principles that policymakers, businesses, and other stakeholders can follow to shape the introduction of self-driving vehicles in ways that reduce oil consumption and global warming emissions, protect public health, and enhance mobility for all.

1. Make Transportation Safer for Everyone, Not Just Motorists

While self-driving vehicles have the potential to reduce vehicle-related fatalities, this is not a guaranteed outcome (Kockelman et al. 2016). Vehicle computer systems must be secure from hacking, and rigorous testing and regulatory oversight of vehicle programming are essential to ensure that self-driving vehicles protect both their occupants and those outside the vehicle. Therefore, public policy related to self-driving vehicles must improve safety for all Americans, whether they are driving, walking, or biking.

Towards Human-Centered Autonomous Driving

What happens if the vehicle makes a mistake?

What happens if the vehicle doesn't know it made a mistake?

What happens if the vehicle refuses to let go ?

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Towards Human-Centered Autonomous Driving

Does the vehicle understand state, preferences, intentions, abilities of humans in the vehicle?

Does the vehicle understand state, intentions, abilities of surrounding vehicles?

Does the vehicle understand state, intentions, abilities of humans driving surrounding vehicles?

Does the vehicle understand state, intentions, abilities of humans around the vehicle?

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Human-Centered Autonomous Driving: LISA Research Agenda

Ohn-Bar, Trivedi, Humans in the Age of Self-Driving Vehicles, *IEEE Trans. Intelligent Vehicles*, 2016.

UCSD LISA Publications http://cvrr.ucsd.edu/publications/index.html CVRR

LISA Research: *Four Points*

Big Picture:
Safe, Stress-free, Efficient, Enjoyable Driving/Riding

Long-Term Goals:
Human *cohabitation* with intelligent robots

Holistic *Distributed Cognitive* Systems Perspective:
Learning from Naturalistic Driving Studies, Predictive, Attentive, Holistic Systems

Open Issues:
Fail-safe, Control transitions, Trustworthy, Performance Metrics, standards, evaluations, multi-agents, cooperation, Reliable communication links, security, *etc. etc.*

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LISA-T: for Safe Autonomous Driving

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LISA-T: for Safe Autonomous Driving

Key Research Contributors

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LISA-T: for Safe Autonomous Driving

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Continuous Situational Awareness

A Rangesh, N Deo, K Yuen, K Pirozhenko, M Trivedi, H Toyoda, P Gunaratne, "Exploring the Situational Awareness of Humans inside Autonomous Vehicles," *IEEE International Conference on Intelligent Transportation Systems* 2018

Continuous Situational Awareness

Ashish Tawari, Andreas Mogelmose, Sujitha Martin, Thomas Moeslund, and Mohan M. Trivedi, "Attention Estimation by Simultaneous Analysis of Viewer and View," IEEE Intelligent Transportation Systems

Control Transitions in Autonomous Vehicles

Control needs to be transferred to driver during failure modes

To determine when and how to alert the driver, we need to continuously estimate readiness to take-over

A Rangesh, N Deo, K Yuen, K Pirozhenko, M Trivedi, H Toyoda, P Gunaratne, "Exploring the Situational Awareness of Humans inside Autonomous Vehicles," *IEEE International Conference on Intelligent Transportation Systems* 2018

Control Transitions in Autonomous Vehicles

Driver foot activity:

- *How close are the driver's feet to vehicle controls?*

Driver gaze activity:

- *Where is the driver looking?*
- *Are they situationally aware?*

Driver hand activity:

- *How close are the driver's hands to vehicle controls?*
- *What activity are their hands performing?*
- *What object are they interacting with*

A Rangesh, N Deo, K Yuen, K Pirozhenko, M Trivedi, H Toyoda, P Gunaratne, "Exploring the Situational Awareness of Humans inside Autonomous Vehicles," *IEEE International Conference on Intelligent Transportation Systems* 2018

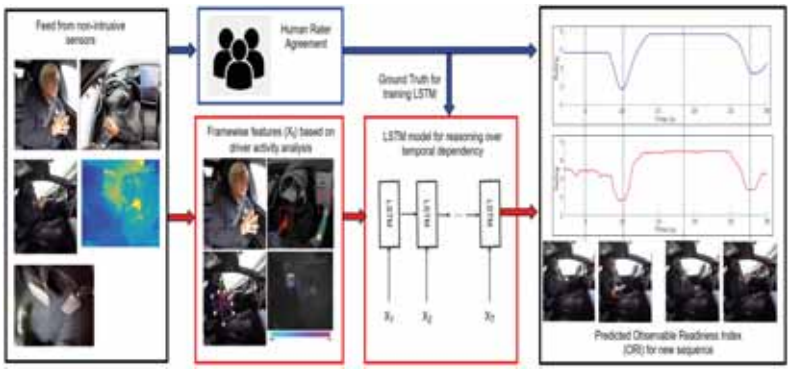
N. Deo, M. Trivedi. "Looking at the Driver/Rider to Predict Take-Over Readiness." *IEEE Trans Intelligent Vehicles, 2019*. UCSD Invention disclosure 2019-139

Looking at Hands

Kevan Yuen and Mohan M. Trivedi, "Looking at Hands in Autonomous Vehicles:A ConvNet Approach using Part Affinity Fields," *IEEE Transactions on Intelligent Vehicles*, 2020.

Control Transitions in Autonomous Vehicles

Observable Readiness Index (ORI) Estimation



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Control Transitions in Autonomous Vehicles

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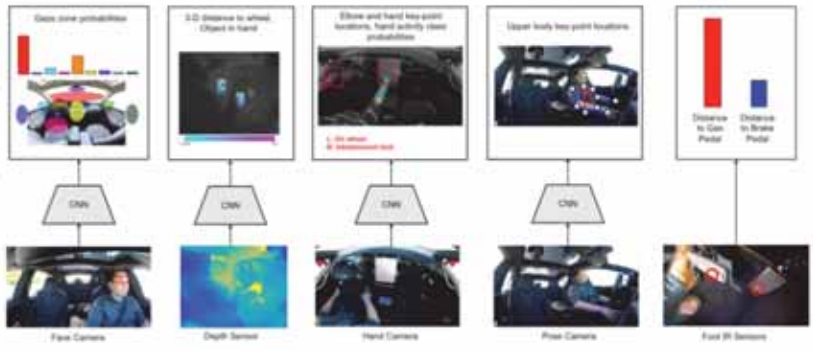

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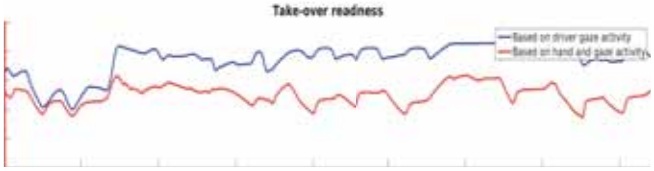

A Rangesh, N Deo, K Yuen, K Pirozhenko, M Trivedi, H Toyoda, P Gunaratne, "Exploring the Situational Awareness of Humans inside Autonomous Vehicles," *IEEE International Conference on Intelligent Transportation Systems* 2018

N. Deo, M. Trivedi. "Looking at the Driver/Rider to Predict Take-Over Readiness." *IEEE Trans Intelligent Vehicles, 2019.*
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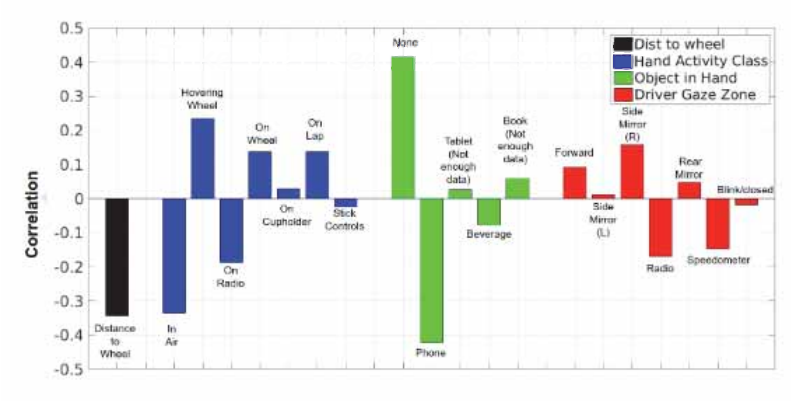
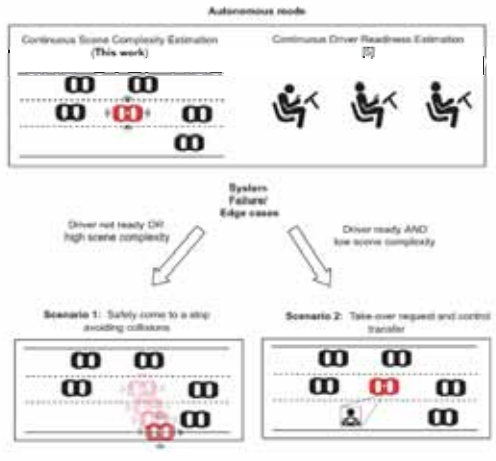
Rider Activity Correlations with Observable Readiness Index (ORI)



A Rangesh, N Deo, K Yuen, K Pirozhenko, M Trivedi, H Toyoda, P Gunaratne, "Exploring the Situational Awareness of Humans inside Autonomous Vehicles," *IEEE International Conference on Intelligent Transportation Systems* 2018

N. Deo, M. Trivedi. "Looking at the Driver/Rider to Predict Take-Over Readiness." *IEEE Trans Intelligent Vehicles, 2019.* UCSD Invention disclosure 2019-139

Exploring Control Transition and Driving Scene Complexity



N Deo, N Meoli, A Rangesh M. Trivedi, "On Control Transitions in Autonomous Driving: A Framework and Analysis for Characterizing Scene Complexity," *ICCV Workshop on Autonomous Driving*, 2019.

Take over Time Prediction

Takeover Time Prediction for Autonomous Vehicles: A Machine Learning Approach, UCSD Invention SD2021-070, 2020

Safe Autonomous Driving: Exciting journey continues !

Safe Autonomous Driving (AD) => Autonomous Vehicles + Humans

AD = Distributed Cognitive Systems: *Human-Vehicle Teams*

Research Explorations:

- Multiple Intelligent Agents,
- Holistic Situation Perception with Multimodal Sensors
- Understanding *Behavior and Interactions*
- *Predicting Intentions*
- Continuous Risk *Assessment*
- *Smooth/Safe Control Transitions, Fail-safe operation modes,*
- *Large Naturalistic Driving Studies and Sharable Datasets*
- *Evaluations, Metrics, and Benchmarks*
- *Reliability, Robustness and Scalability*

Thanks !

LISA Publications http://cvrr.ucsd.edu/publications/index.html