Investor Event Deck - RSS

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Human Driving Today

The balance between safety & efficiency
How would you define “driving safely” for an AV?

Self-driving cars should be statistically better than a human driver.
Miles Driven

The more miles I drive without a crash, the safer I am

Miles driven here

Not the same as here
Disengagements

Minimize the number of times the ADS fails and requires a takeover

Why it’s insufficient

Similar to miles driven, depends on where & when
Incentive to avoid the tough environments likely to trigger disengagements
How would you define "driving safely" for an AV?

A rules-based argument

The AV only needs to strictly obey the rules of the road
Follow the Rules of the Road
Even if we strictly follow the rules, others around us may not do the same
Follow the Rules of the Road

Even if we strictly follow the rules, others around us may not do the same
How would you define “driving safely” for an AV?

A catch-all

Avoid collisions at all costs
The AV Must Avoid Collisions at All Costs
The AV Must Avoid Collisions at All Costs
So what do we do?
So what do we do?

What do humans do?
Explicit Traffic Rules

Establish **priority of road agent interests** to avoid collisions

- Come to complete stop at red lights
- Don’t cross a double-yellow line
- Obey posted speed limits
- Yield to other road users when posted

**Set limits on vehicle operation**
Implicit Traffic Rules

A **general set of principles** applied by the driver

- Keep a safe distance from the car in front of you
- Drive cautiously under limited visibility
- Don’t drive slow in the fast lane
- Don’t cut off other drivers

**Flexible, culturally dependent**
Responsibility Sensitive Safety

An open, transparent, technology neutral safety model for autonomous driving

RSS digitizes the implicit rules of the road, providing a check on AV decision-making, and a technology-neutral performance benchmark for regulators.
Implicit Rules of the Road
Essential for Navigating Complex Scenarios

Everyone agrees that autonomous vehicles are the future of mobility.
Rules of RSS
Rules to verify AV safety & performance

1. Do not hit someone from behind
2. Do not cut-in recklessly
3. Right-of-Way is given, not taken
4. Be careful in areas with limited visibility
5. If you can avoid a crash without causing another, you must
Responsibility Sensitive Safety (RSS)

**FORMALIZE**

Human notions of safe driving

Keep a safe distance longitudinally & laterally
Responsibility Sensitive Safety (RSS)

**FORMALIZE**
Human notions of safe driving

**IDENTIFY**
A Dangerous Situation

Keep a safe distance longitudinally & laterally
Safe distance compromised in both directions
Responsibility Sensitive Safety (RSS)

**FORMALIZE**
Human notions of safe driving

**IDENTIFY**
A Dangerous Situation

**EXECUTE**
The Appropriate Response

- Keep a safe distance longitudinally & laterally
- Safe distance compromised in both directions
- Brake to restore safe longitudinal distance
What Makes a Safe State?
First and foremost, keep a safe distance from others
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What Makes a Safe State?
First and foremost, keep a safe distance from others

If the silver car slams on the brakes, how much space do I need to avoid hitting it?
What Makes a Safe State?
First and foremost, keep a safe distance from others

We determine safe distance based on the following parameters
What Makes a Safe State?
First and foremost, keep a safe distance from others

We determine safe distance based on the following parameters

- Velocity
- Reaction time
- Braking needed to avoid crash
- Velocity
- Max braking capability
What Makes a Safe State?

First and foremost, keep a safe distance from others
What Makes a Safe State?
First and foremost, keep a safe distance from others

\[ d_{\text{min}} = \left[ v_r \rho + \frac{1}{2} \alpha_{\text{max}} \rho^2 + \frac{(v_r + \rho \alpha_{\text{max}})^2}{2 \beta_{\text{min}}} - \frac{v_f^2}{2 \beta_{\text{max}}} \right] + \]

Any additional acceleration of the blue car during reaction time
The Danger Threshold
The moment just before we reach an unsafe distance longitudinally and laterally

\[ d_{\text{min}} \]
The Danger Threshold
The moment just before we reach an unsafe distance longitudinally and laterally
Proper Response – Longitudinal Danger

Though the silver car initiated the dangerous situation, the blue car still ought to brake to return to a safe distance.
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Proper Response – Longitudinal Danger

Though the silver car initiated the dangerous situation, the blue car still ought to brake to return to a safe distance.
Does it work?
Applying RSS

RSS uniquely solves a number of challenges
For the first time, we have the chance to define in advance and not after the fact, the desired balance of safety, utility, and efficiency of AV’s on the road.
But there’s more to safety than math
Let’s Talk About “Safety”

Life & Death Safety

Psychological Safety

RSS

Trust

A Psychological sense of safety is based on human trust
“The majority of U.S. drivers seek autonomous technologies in their next vehicle, but continue to fear the fully self-driving car.”

75% “of U.S. drivers report feeling afraid to ride in a self-driving car.”

“Psychology research shows people mistrust those who make moral decisions by calculating costs and benefits – like computers do”

April 24, 2017 “Why are we reluctant to trust robots?”
What Do We Mean by “Trust”?

“Firm belief in the character, strength, or truth of someone or something.”

– Source: Merriam-Webster Dictionary Online
The Study
The Journey

- REQUESTING A VEHICLE
- STARTING A TRIP
- MAKING CHANGES TO A TRIP
- HANDLING ERRORS AND EMERGENCIES
- PULLING OVER AND EXITING
Contradictions = Tension

Participants expressed contradictory viewpoints in 7 key areas:

1. Human judgment vs. Machine judgment
2. Personalized space vs. Lack of assistance
3. Make me aware vs. Unburden me from being aware
4. Giving up control of the vehicle vs. Gaining new control of the vehicle
5. How it works vs. Proof it works
6. Tell me vs. Listen to me
7. Following the rules vs. Human interpretation of the rules
Introducing the RSS Concept Experience

Bridging the Gap Between Technical and Psychological Safety
RSS HMI – An Embodiment of Human Trust in an In-Vehicle Experience

HOW IT WORKS

VS.

PROVE IT WORKS

Active Safety Features

- Following Distance
- Pedestrian Awareness
- Right of Way
- Collision Avoidance

Maintaining safe travel speed
HUMAN JUDGMENT vs. SYSTEM JUDGMENT
MAKE ME AWARE

VS.

UNBURDEN ME FROM BEING AWARE
Automated Vehicle Safety
We are Leading the Discussion and Have a Differentiating Solution

Industry
Engaging with customers, competitors and consortia to have an open dialogue on AV safety

Academia
RSS Research Centers at Universities in USA, PRC and EU

Government / NGO’s
Understanding government expectations on transparency and verification of AV safety

Real world
Deploying RSS in our on AV Fleet in very challenging environments