Bring Automated Driving Toward Reality
with Vehicle Teleoperation

January 2021

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Many Fundamental Challenges Remain

- **Algorithms**: Handle vast range of possibilities on the road?
- **Software**: Make extremely large & complex in-car SW auto grade?
- **Integration**: Interact with other roadway actors?
- **Security**: Tackle unique new challenges?
- **Safety**: Validate safety in a tractable manner?
- **Standards**: Safety, validation, security, software quality, ……

Results:

1. Difficult to know how safe self-driving cars really are
2. High vehicle costs, with reliability and manageability concerns
Teleoperation for Smoother Transition & Broader Solutions

TODAY
Human-Based Teleoperation Emerged and Growing

- Move human drivers off vehicles
- Broad & growing application: robots, mining, delivery, trucking, fleets, ...
- Human intelligence complements automation
- Distribute driving intelligence between on-board and off-board

EVOLUTION
Teleoperation Automation Grows

- Off-board AI becomes more powerful, reducing the burden and need of human teleoperators over time
- Human teleoperators extend operational domains of self-driving cars
- Growing flexibility in distributing driving intelligence off board

ULTIMATELY
Fully Automated Teleoperation

- Fully automated teleoperators replace most human teleoperators
- Highest flexibility in distributing driving intelligence off board
Vehicle Teleoperation Architecture Considerations

Distribute Intelligence | Enable Collaboration | Evolve Intelligence
Manage Intelligence | Measure Performance

Distribute Driving Intelligence Between Vehicle and Cloud

Cloud-Based Teleoperation Platform

Edge-Based Teleoperation Platform

Onboard Teleoperation Platform
What data should be sent to teleoperator? and in what quality?

- Human-intelligible visual data (up to 1.7 Mbps per camera)
- Object & distance detection
- Raw data (~177 Mbps per camera) or results of onboard preprocessing
- Data from multiple cars

What data should be processed locally?

- Radar:
  - Objects, distance, & speeds, good visibility

- LiDar:
  - 3D object view, shape, depth, low visibility

- Camera:
  - Detailed 360 view

Several terabytes of data per hour of driving

Remote Situational Awareness for Vehicle Teleoperation
Learn from local data to train ML models

Collaborate with each other to learn (e.g., federated learning)

Send learned knowledge (pre-trained models) to the cloud

Build final models based on knowledge not raw data from vehicles

Edge Learning for Self-Driving and Teleoperation
Thank You!

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