Autonomous Driving: The Good The Bad and The Ugly

Who's TuSimple?

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TuSimple

When do you launch the product?
Building an autonomous truck
4 pillars of autonomous driving
Algorithms

Infrastructure

Process

Product
Algorithms

• “Typical” challenges
  • Detection, tracking, localization, pose estimation, planning, control...

• More for trucks!
  • Wider, and longer (430% of a Camry), slow accelerate/decelerate
  • Fuel matters
Perception for trucks

- Absence of "superior" controllability
- Long horizon motion planning
- Long term behavior prediction of others
- Long range perception
A superior pilot uses his superior judgement to avoid situations which require the use of his superior skill.

-- Frank Borman
Front 66.8 m 54.1 mph
Merge front 9.1 m 59.6 mph
Merge back 26.1 m 61.0 mph

Autonomous Driving On

Speed Limit 65
The more boundless your vision, the more real you are.

--Deepak Chopra
650m away
From algorithm to product

• Effective algorithms always have an impact on products

• Why most academic papers are not applicable
  • False positive/false negative cost
  • Indirect implications/narrow application
  • Computational/implementation cost
Infrastructure and process
What do we need

• Infrastructure
  • Big data, deep learning
  • Simulation, real-time systems

• Process
  • Data annotation, vehicle testing
  • Continuous integration, benchmarking
What do we REALLY need
On big data
Trucks can generate big data cheaply

- **Mileage accumulation:**
  - 45 miles/hr * 20hr/day * 25day/mo = 22,500 miles/mo

- **Cost-per-mile**
  - $1.8/mile operating cost - $1.6/mile revenue = $0.2/mile

- **Sampling density**
  - Fixed routes (1D structure)
On data digestion
“Divide and conquer”? 

- Software engineering methodology 
- Easy to scale-up the dev team 
  - 3x resources = 3 problems to be solved (patched) simultaneously 
- Steady progress 
  - Regression test
“Divide and conquer” won’t work

• AI systems are not typical software systems
  • Every node contributes to the noise, without making an error
  • Team division precludes architectural evolution

• How many cases must a system fix, before you call it level-4?
  • Every “fix” is a technical debt, making future fixes harder
TuSimple’s design philosophies

• AI engineering is missing

  coding : software engineering

  algorithm : AI engineering
TuSimple’s design philosophies

• All about **generalization**
  • Each corner case is a reminder
  • Regression tests
The evolution of autonomous driving systems
The Kardashev scale

Type I civilization: $10^{16}$ W

Type II civilization: $10^{26}$ W

Type III civilization: $10^{36}$ W
## Comparable infrastructure & process

<table>
<thead>
<tr>
<th></th>
<th>Single vehicle</th>
<th>5 vehicle fleet</th>
<th>50 vehicle fleet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Raw data transfer</strong></td>
<td>Flash disk</td>
<td>Command-line + networking</td>
<td>Fully automated pipeline</td>
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<td><strong>Algorithm deployment</strong></td>
<td>In vehicle deploy/debug</td>
<td>Manual deployment of packages</td>
<td>Fully automated pipeline</td>
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<td><strong>Road testing</strong></td>
<td>Superior driver</td>
<td>Superior driver + protocol</td>
<td>Protocol-based test + conservative AI</td>
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<tr>
<td><strong>Data digestion</strong></td>
<td>Naked eye</td>
<td>Hashtag</td>
<td>Statistical learning based development</td>
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No matter how much funding, or how many algorithm geniuses you have, you can’t build a level 4 product with shaky infrastructure/process.
The missing evaluation metrics
§ 227.50. Reporting Disengagement of Autonomous Mode.

(a) Upon receipt of a Manufacturer’s Testing Permit or a Manufacturer’s Testing Permit - Driverless Vehicles, a manufacturer shall commence retaining data related to the disengagement of the autonomous mode. For the purposes of this section, “disengagement” means a deactivation of the autonomous mode when a failure of the autonomous technology is detected or when the safe operation of the vehicle requires that the autonomous vehicle test driver disengage the autonomous mode and take immediate manual control of the vehicle, or in the case of driverless vehicles, when the safety of the vehicle, the occupants of the vehicle, or the public requires that the autonomous technology be deactivated.
Interpretations

How far are we to achieve driverless automation?

disengagements are not related to safety. Our test drivers routinely transition into and out of autonomous mode many times throughout the day, and the self-driving vehicle’s computer hands over control to the driver in many situations that do not involve a failure of the autonomous technology and do not require an immediate takeover of control by the driver.

and other vehicles drifting into the AV’s lane. _____ regularly reviews autonomous mode disengagements to assess which events are required to be reported. Most of our disengagements do not involve a failure of the autonomous technology and do not require an immediate takeover of control by the driver. As our self-driving technology continues to grow more
Two types of the fleet

• Validation
  • Stable release of hardware + software
  • Sufficient coverage of the operational design domain
  • Significant sampling density
Two types of the fleet

• Development
  • Expected to fail
  • Rapid iterations
  • Specific domains and scenarios to check
Understanding interventions

• Inefficient maneuvers: benign
  • waiting too long, detour, slowing down, stopped at the roadside

• Traffic rule violations: costly
  • Stopped in the lane, failed to yield

• Accidents: critical
We need a better MPI metric

- Why do we care?
  - Regulators, insurance companies, investors, and AI companies
Thanks