Big picture: AV technology continued

Market forces in AV development

Zoox sold out to Amazon. Uber practically gave away its AV division for free to Aurora. Lyft sold to a subsidiary of Toyota. Cruise bought Voyage. Nuro acquired Ike. (I assure you, you're not having a stroke — these are just the quirky names of various AV startups.)

The companies that are still around are hemorrhaging money. Aurora, which absorbed Uber's discarded division, is said to be mulling a sale to Apple or Microsoft. The company went public last year by merging with a special purpose acquisition company (SPAC), and then lost about 80 percent of its value. This is the same company that was started by Chris Urmson, one of the founders of the Google self-driving car project (now Waymo), a guy once called the "Henry Ford of autonomous driving," who said he hoped his kids will never have to get driver's licenses.

source: https://www.theverge.com/2022/10/28/23427129/autonomous-vehicles-robotaxi-hype-failure-expectations

Public Market Performance Of Funded Companies Tied To Autonomous Driving And Related Technologies

Company	Valuation At IPO**	Valuation Today*	% Change
Aurora	$14,000M	$2,611M	-81%
TuSimple	$8,500M	$1,516M	-82%
Luminar	$7,000M	$2,453M	-65%
Embark Technology	$5,160M	$141M	-97%
Velodyne Lidar	$4,000M	$202M	-95%
Aeva	$2,100M	$435M	-79%
AEye	$2,000M	$178M	-91%
Ouster	$1,900M	$148M	-92%
Innoviz	$1,400M	$655M	-53%
Cepton	$1,400M	$370M	-74%
Otonomo	$1,400M	$40M	-97%
Quanergy Systems	$1,100M	$16M	-99%
Arbe	$722M	$361M	-50%
CYNGN	$198M	$32M	-84%
Total	**$50,880M**	**$9,158M**	**-81% average decline**

*Market cap as of Oct. 10, 2022 source Yahoo Finance

**Source: Crunchbase data

crunchbase

source: https://www.forbes.com/sites/johnkoetsier/2022/10/17/self-driving-startups-have-lost-40-billion-in-stock-market-valuation-in-2-years/?sh=58b844b43337

What implication do market forces have on AV safety?

Programming challenges

KEY POINTS

- At least seven Cruise vehicles blocked traffic by clustering in an intersection in San Francisco starting late Tuesday night, blocking traffic.
- Photos and a description of the Cruise robotaxis blocking several lanes of traffic in San Francisco were shared Wednesday on Reddit and Twitter.
- The incident is another example of the difficulty of deploying fleets of self-driving vehicles.

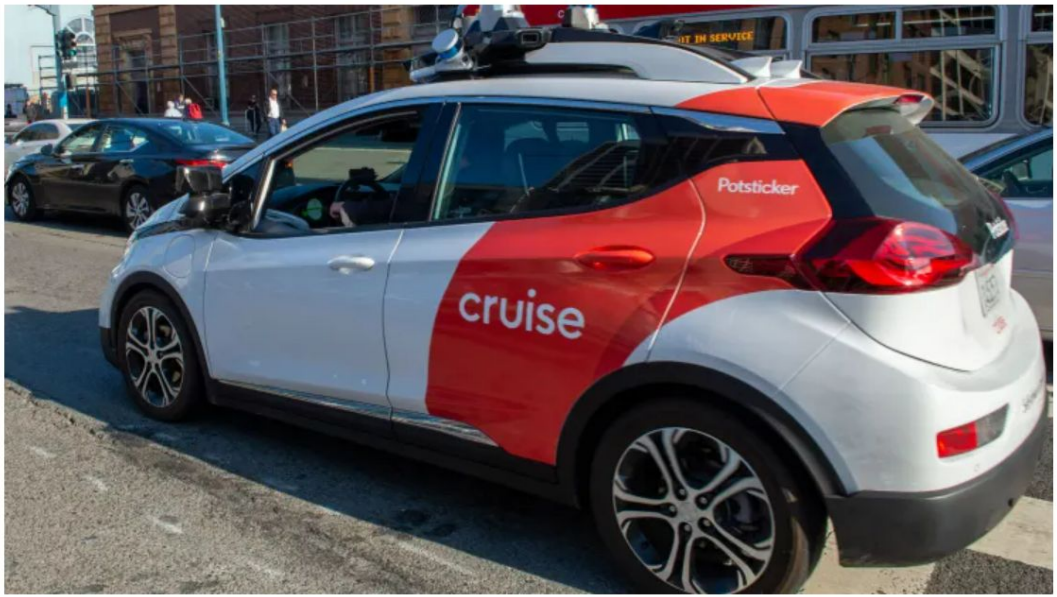
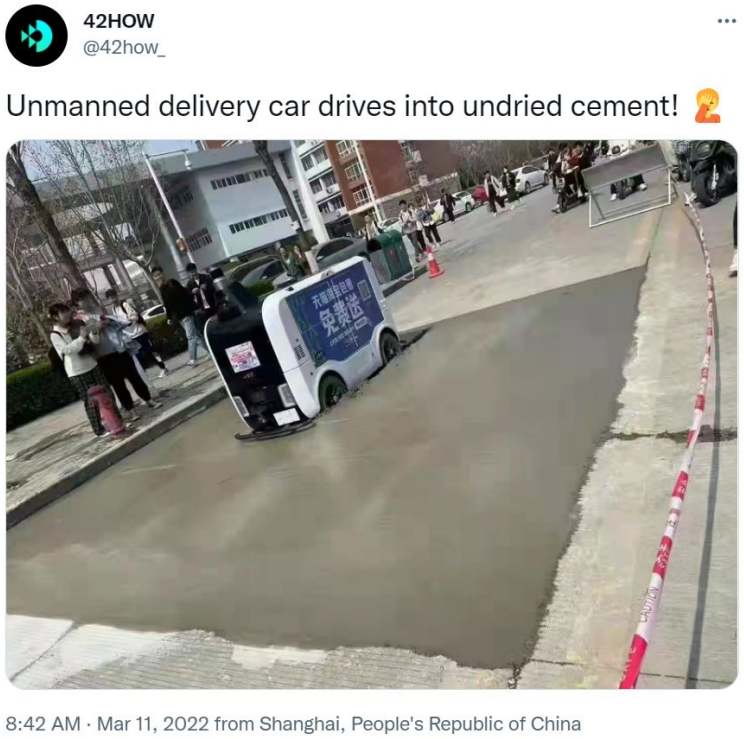


image source

What are some things that computers are better at than humans? What are some things humans are better at than computers?

Unexpected situation challenges



[image source]

source: https://www.cnet.com/roadshow/news/argo-self-driving-car-hardware-upgrade/

The hardware

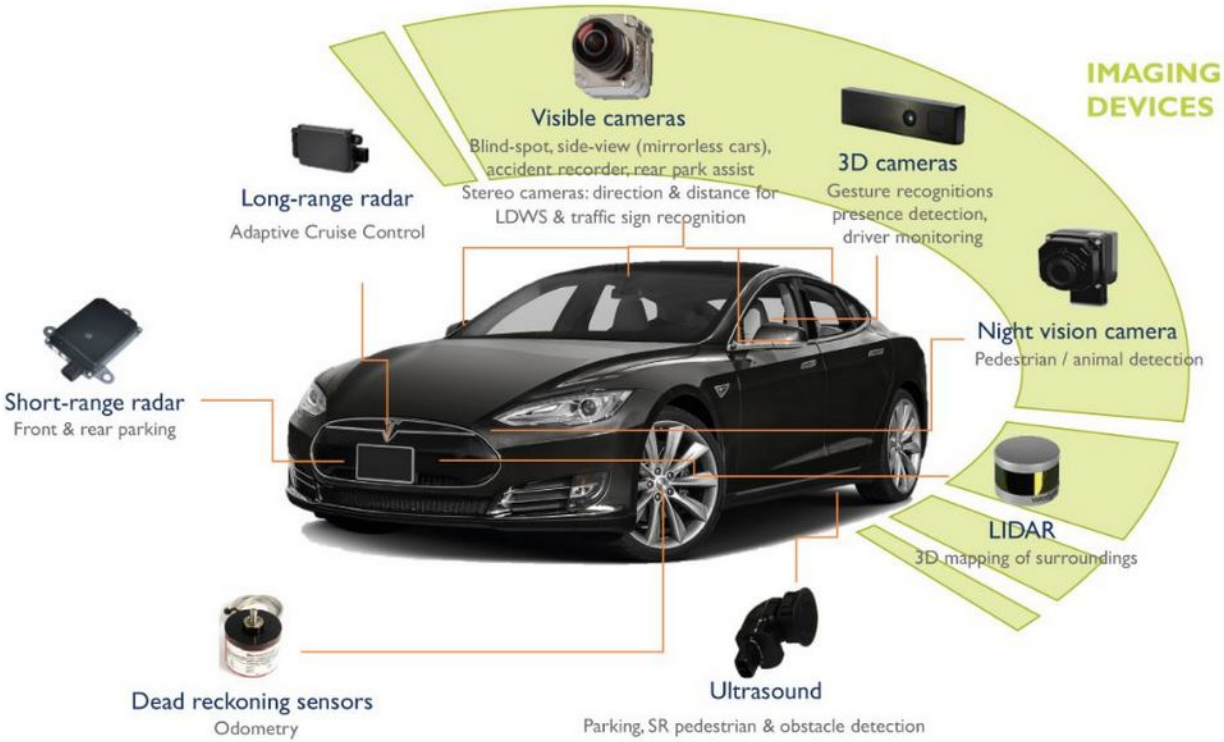
There are tons of improvements in this next generation of Argo hardware.

Argo

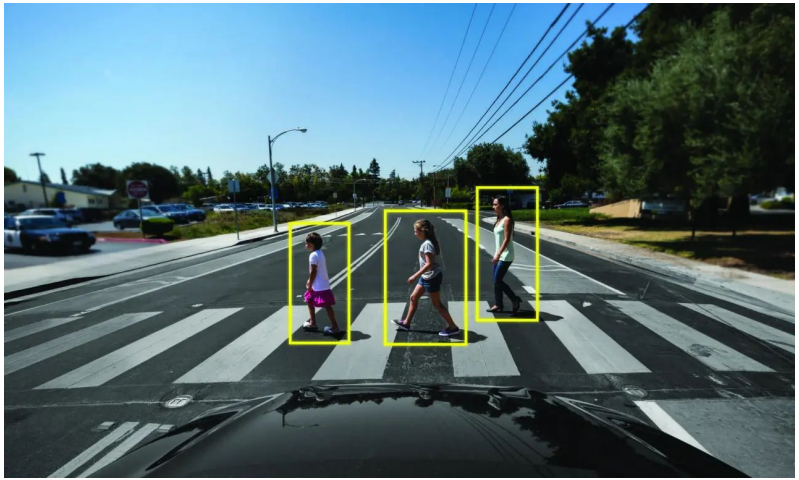
Sophisticated sensors are expensive. What is the advantage to having multiple sensors (and multiple kinds of sensors) on an AV?

Sensor fusion

source: https://www.eetimes.com/the-outlook-for-robocar-sensors-in-2018/



Camera perception / Stereo camera for depth



[image source]

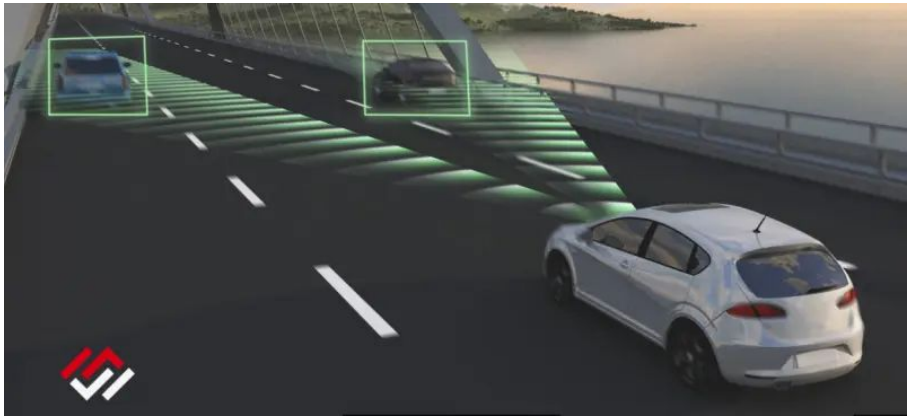
Foresight's separated camera imaging solution.

[image source]

Radar vs. Lidar

(**Ra**dio/**Li**ght **D**etection **a**nd **R**anging)

Distance detection (effective at different distances/for different resolutions)



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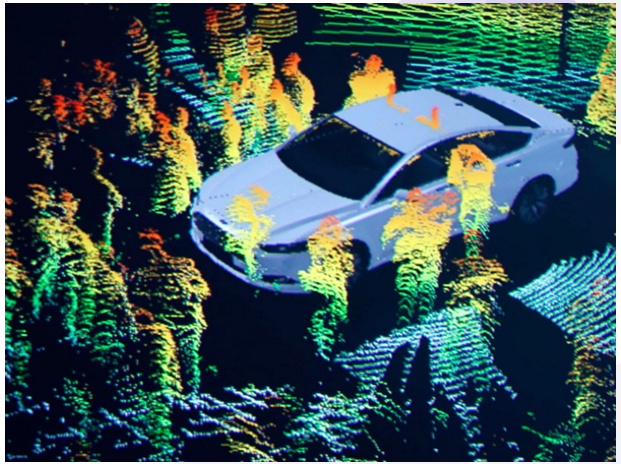


image source

The computer

image source

image source

Also the computer

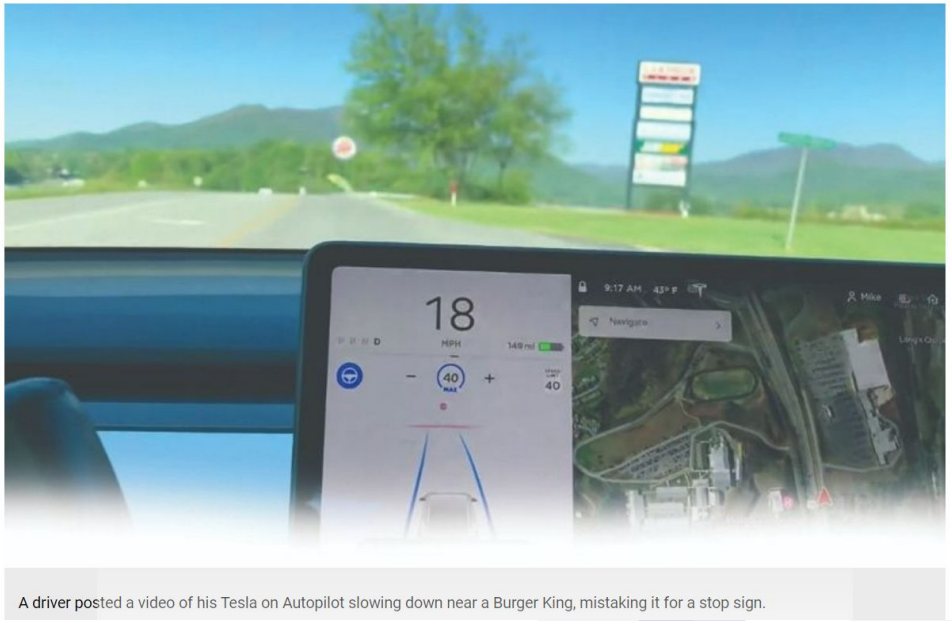
Tesla unveils its new supercomputer (5th most powerful in the world) to train self-driving AI

Fred Lambert | Jun 21 2021 — 3:30 am PT

image source

Perception challenges

Figure 1: A real image of a truck with a reflective surface (Source)



A driver posted a video of his Tesla on Autopilot slowing down near a Burger King, mistaking it for a stop sign.

image source

image source (w/ more edge cases!)

Building customer trust – how much testing is enough?

Through our testing, which to-date encompasses more than 180 hours and approximately 2,300 miles in a dense urban area, we have results that suggest there may be a societal benefit to creating a standardized communications method.

image source

In the final stage, real-world testing generates the miles logged and near misses encountered to either validate system safety or to refine requirements with fresh data for simulations. In later phases of development, we will test the vehicle's ability to independently perform safety fallback maneuvers with the goal of removing safety operators when the Virtual Driver System is ready.

Continuous testing and system improvements using multiple sources will help to ensure our self-driving systems are safer.

Not all mileage is created equal: with millions of miles available for training sets from our partners at the Virginia Tech Transportation Institute, we are working to collect novel data while working with the industry to create baseline datasets for simulation. Going forward, data collection will be in accordance with our event-driven storage and retention policies as defined in Data Recording (above). Continuous testing and system improvements using multiple sources will help to ensure our self-driving systems get even safer.

Mileage math

Sources:

- # of drivers
- # of miles
- CA mileage reports
- NHSTA traffic safety facts

- Companies working on self-driving cars are required to give the state of California regular reports on how many miles they drove and how many disengagements from autonomous mode there were (number of times a human intervened).
- Tesla reported, for 2019, only one autonomous drive in the state, of a mere 12.2 miles, and no disengagements. For comparison, Waymo reported nearly 1.5 million miles and Cruise claimed more than 830,000 for 2019, according to *Forbes*.
- That's interesting since CEO Elon Musk has said he has used Tesla Full Self Driving (FSD) during the past year.

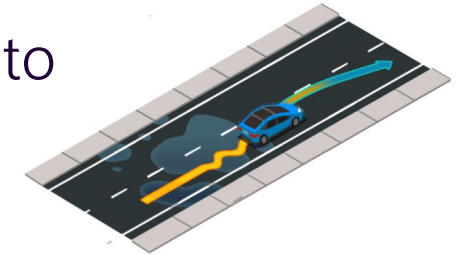
Every year companies working on autonomous cars in California have to file a report to the state, stating the number of miles they traveled during their drives and their disengagements (how many times the human behind the wheel had to take over). Recently, companies including Waymo and Cruise have balked about the disengagement data point, saying it doesn't reflect the true power of their systems. Frankly, miles aren't much of an indicator, either, since these drives take place in only certain areas.

Simulation benefits

- Cheaper
- Can inject scenarios
- Can use road testing to refine simulation

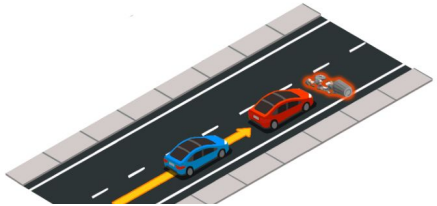
NHTSA-inspired pre-crash scenarios

We have selected 10 traffic scenarios from the **NHTSA pre-crash typology** to inject challenging driving situations into traffic patterns encountered by autonomous driving agents during the challenge.



Traffic Scenario 01: Control loss without previous action

- **Definition**: Ego-vehicle loses control due to bad conditions on the road and it must recover, coming back to its original lane.



Traffic Scenario 02: Longitudinal control after leading vehicle's brake

- **Definition**: Leading vehicle decelerates suddenly due to an obstacle and ego-vehicle must react, performing an emergency brake or an avoidance maneuver.

image source

Questions to ask about simulation-based testing

What, other than sufficient testing, is necessary for arguing that an AV is safe?