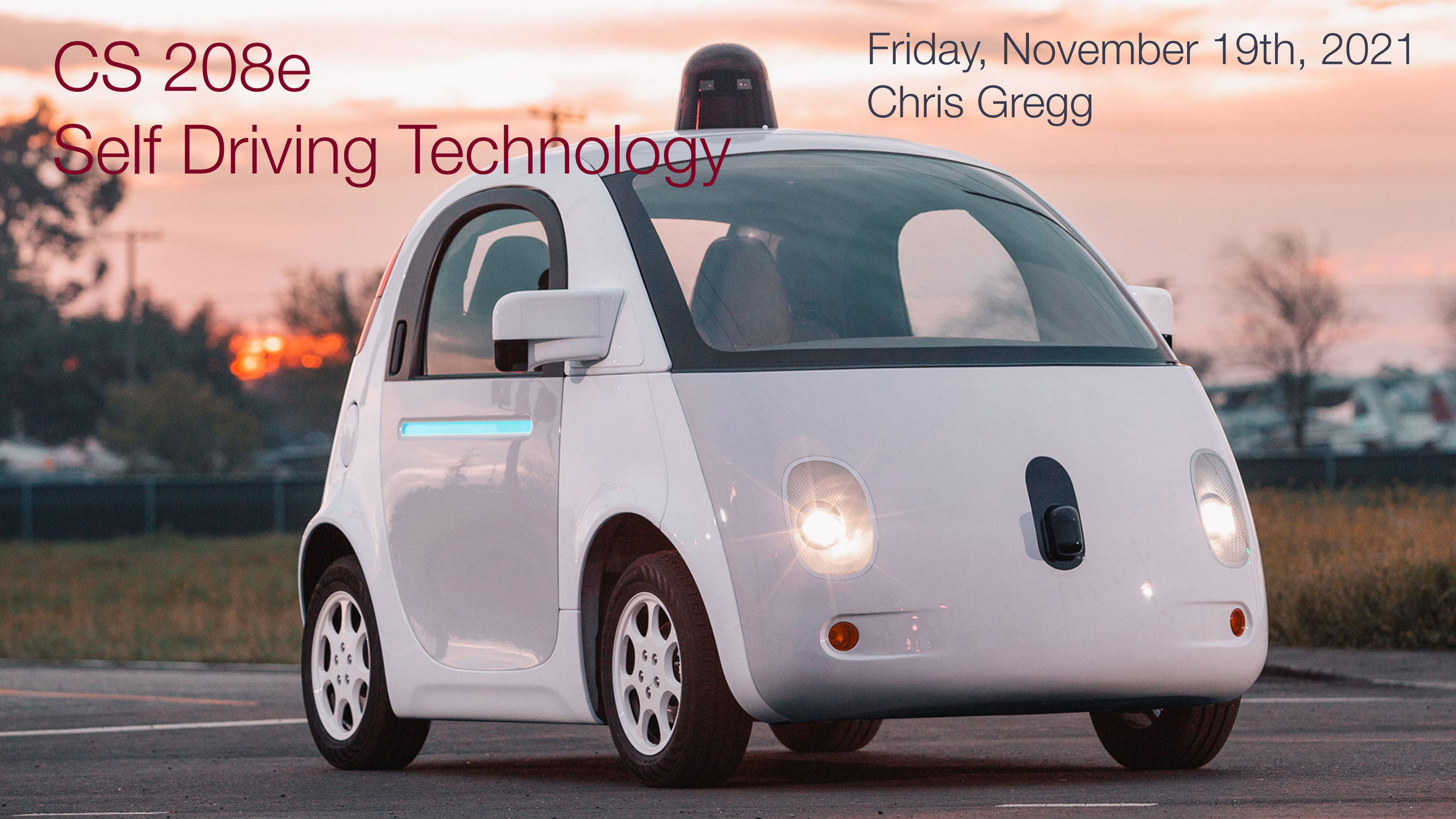
CS 208e
Self Driving Technology

Friday, November 19th, 2021

Chris Gregg



Autonomous vehicles have come a long way just in the last few years!
Is this a "great idea in computer science?"
Perhaps not in the sense that it is one idea, but it is certainly a collection of scientific and engineering breakthroughs and designs that include a *lot* of computer science techniques to make it work.

Self Driving Technology Levels

SYNOPSYS®

https://www.synopsys.com/automotive/autonomous-driving-levels.html

LEVELS OF DRIVING AUTOMATION

0	1	2	3	4	5
NO AUTOMATION	DRIVER ASSISTANCE	PARTIAL AUTOMATION	CONDITIONAL AUTOMATION	HIGH AUTOMATION	FULL AUTOMATION
Manual control. The human performs all driving tasks (steering, acceleration, braking, etc.).	The vehicle features a single automated system (e.g. it monitors speed through cruise control).	ADAS. The vehicle can perform steering and acceleration. The human still monitors all tasks and can take control at any time.	Environmental detection capabilities. The vehicle can perform most driving tasks, but human override is still required.	The vehicle performs all driving tasks under specific circumstances. Geofencing is required. Human override is still an option.	The vehicle performs all driving tasks under all conditions. Zero human attention or interaction is required.

THE HUMAN MONITORS THE DRIVING ENVIRONMENT

THE AUTOMATED SYSTEM MONITORS THE DRIVING ENVIRONMENT

Self Driving Technology Levels: Where are we?

What do you think?

Self Driving Technology Levels: Where are we?

Most cars: Level 0 or 1 (cruise control)

Tesla: Level 2

Honda Legend (Japan): Level 3 (for traffic jams)

Waymo: Level 4 (in Arizona and San Francisco*)

No Level 5 vehicles yet

*Waymo in San Francisco:

History

Guesses about when the first self-driving trials happened?

History

In 1925, Houdina Radio Control demonstrated the radio-controlled "American Wonder" on New York City streets, traveling up Broadway and down Fifth Avenue through the thick of a traffic jam

https://en.wikipedia.org/wiki/History_of_self-driving_cars#1920s

History

An early depiction of automated guided cars was Norman Bel Geddes's Futurama exhibit sponsored by General Motors at the 1939 World's Fair, which showed radio-controlled electric cars propelled via electromagnetic fields provided by circuits embedded in the roadway.

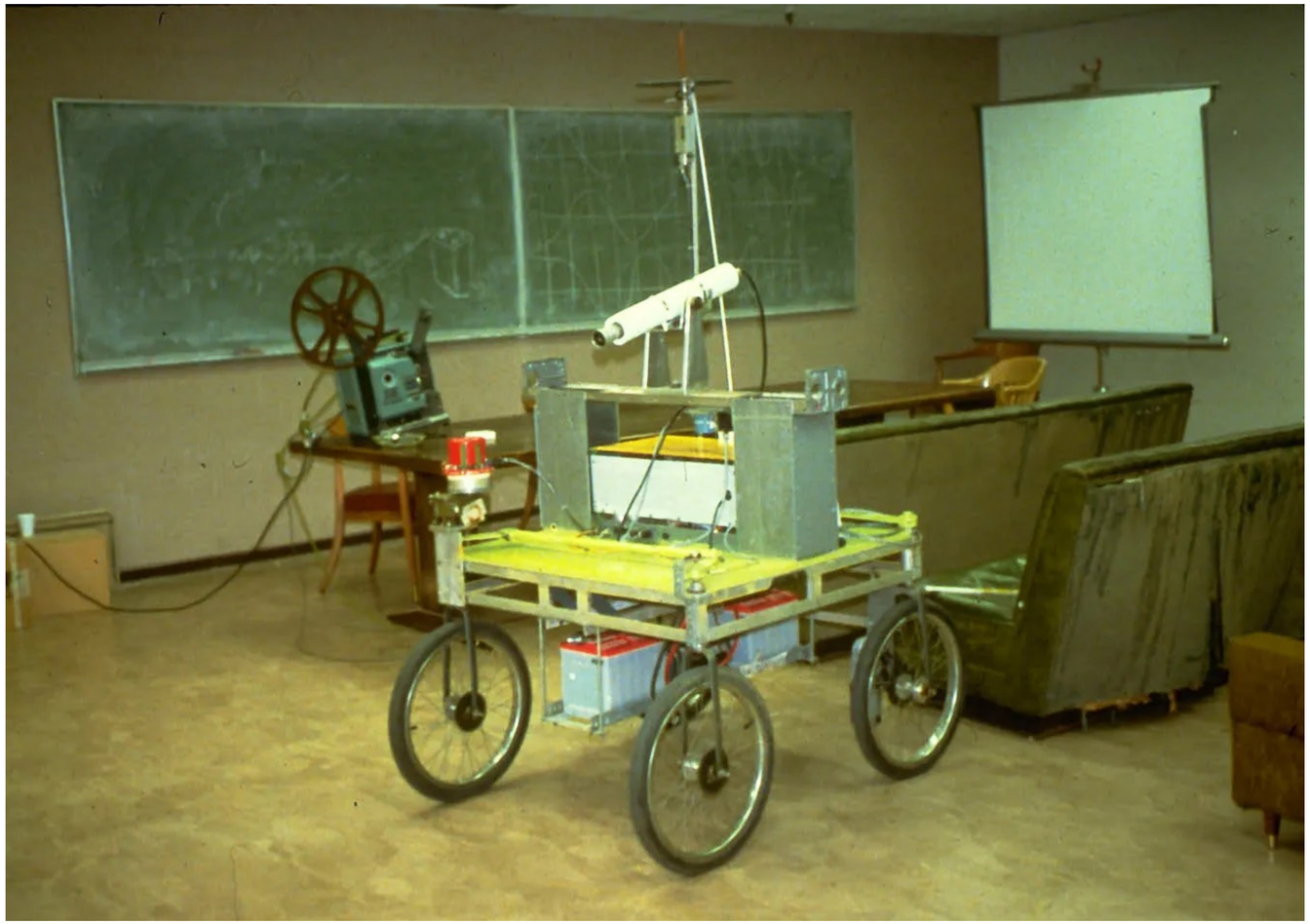
https://en.wikipedia.org/wiki/History_of_self-driving_cars#1930s

History

In 1953, RCA Labs successfully created a system with a miniature car guided and controlled by wires laid in a pattern on a laboratory floor. The system sparked the imagination of Leland M. Hancock, traffic engineer in the Nebraska Department of Roads, and of his director, L. N. Ress, state engineer. The decision was made to experiment with the system in actual highway installations.

https://en.wikipedia.org/wiki/History_of_self-driving_cars#1950s

History



Stanford Cart: People have been dreaming about self-driving cars for nigh a century, but the first vehicle that anyone really deemed “autonomous” was the Stanford Cart. First built in 1961, it could navigate around obstacles using cameras and an early version of artificial intelligence by the early 70s. One problem: It needed 10 to 15 minutes to plan every one-meter move.

https://www.wired.com/story/guide-self-driving-cars/

History

In the 1980s, a vision-guided Mercedes-Benz robotic van, designed by Ernst Dickmanns and his team at the Bundeswehr University Munich in Munich, Germany, achieved a speed of 39 miles per hour (63 km/h) on streets without traffic.

https://en.wikipedia.org/wiki/History_of_self-driving_cars#1980s

History

In 1995, Carnegie Mellon University's Navlab project completed a 3,100 miles (5,000 km) cross-country journey, of which 98.2% was autonomously controlled, dubbed "No Hands Across America".[41] This car, however, was semi-autonomous by nature: it used neural networks to control the steering wheel, but throttle and brakes were human-controlled, chiefly for safety reasons.

https://en.wikipedia.org/wiki/History_of_self-driving_cars#1990s

Darpa's Grand Challenge, 2004

At the break of dawn on March 13, 2004, 15 vehicles left a starting gate in the desert outside of Barstow, Calif., to make history in the DARPA Grand Challenge, a first-of-its-kind race to foster the development of self-driving ground vehicles. The immediate goal: autonomously navigate a 142-mile course that ran across the desert to Primm, Nevada.
https://www.darpa.mil/news-events/2014-03-13

"Every vehicle in that first Grand Challenge in 2004 crashed, failed, or caught fire" https://www.wired.com/story/darpa-grand-urban-challenge-self-driving-car/

https://en.wikipedia.org/wiki/DARPA_Grand_Challenge_(2004)

Darpa's Grand Challenge, 2005

The second driverless car competition of the DARPA Grand Challenge was a 212 km (132 mi) off-road course that began at 6:40am on October 8, 2005, near the California/ Nevada state line. All but one of the 23 finalists in the 2005 race surpassed the 11.78 km (7.32 mi) distance completed by the best vehicle in the 2004 race. Five vehicles successfully completed the course.

https://en.wikipedia.org/wiki/DARPA_Grand_Challenge_(2004)

2012: On the open roads

The world's first self-driving test took place on 1 May 2012 in Las Vegas. Google had previously mapped the area and selected a route for the test, which the DMV agreed to.

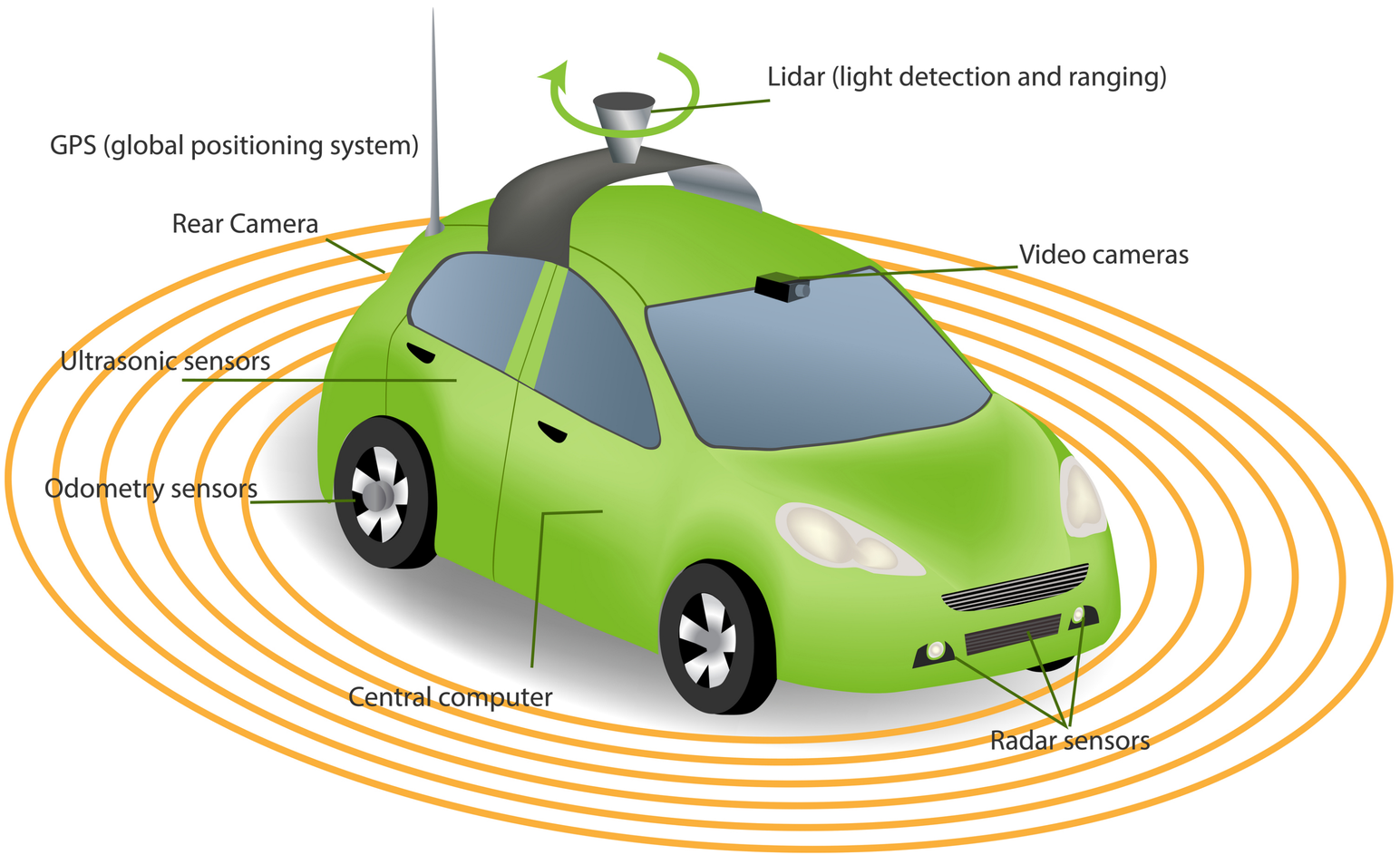
Google had already tested autonomous vehicles for over 1 million kilometers on closed roads

"In smooth, everyday traffic, the Prius worked perfectly. [the examiner] noted that the car detected and stopped for pedestrians and merged smoothly onto a freeway up to the local speed limit. At crosswalks, he called it "extra cautious—designed for safety.""

https://spectrum.ieee.org/how-googles-autonomous-car-passed-the-first-us-state-selfdriving-test

The Technology

- Hardware:
  - Cameras
  - Lidar
  - Maps
  - Radars
  - GPS
  - Fast processors
- Software:
  - Signal analysis
  - Artificial Intelligence



The Technology: Testing

- Autonomous vehicles must be tested, preferably on real roads with real traffic
- Problems?
  - This can kill people!

> **Self-driving Uber kills Arizona woman in first fatal crash involving pedestrian**
>
> **Tempe police said car was in autonomous mode at the time of the crash and that the vehicle hit a woman who later died at a hospital**

The Technology: Testing

- Autonomous vehicles must be tested, preferably on real roads with real traffic
- Problems?
  - This can kill people!
  - Laws have had to be written to allow testing on roads. From the California DMV:

AUTONOMOUS VEHICLES

The DMV administers the Autonomous Vehicles Program and issues permits to manufacturers that test and deploy autonomous vehicles on California public roads. Learn more about the program, regulations, and applying for a permit.

Self-Driving a Tesla around the Berkeley Hills

Some companies are letting their customers do a bunch of testing — is this ethical? (legal??)

How Disruptive Will Autonomous Vechiles Be?

28 Reasons why driverless tech will be the most disruptive technology in all history

by Thomas Frey | Sep 19, 2019 | Future of Transportation

https://futuristspeaker.com/future-of-transportation/28-reasons-why-driverless-tech-will-be-the-most-disruptive-technology-in-all-history/