How Do Driverless Cars Work?

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Background

- Ph.D., Yale University (computer science, 1978)
- Developed Computational Geometry, a basic driverless car technology
- J.D., Duquesne University (law, 1981)
- Carnegie Mellon computer science faculty since 1975
- Visiting Professor, University of Hong Kong (2001- )

- Director, Master’s Program in eBusiness Technology
- Annual course, “Internet of Things”
- Expert witness in over 220 court cases involving computer technology, including traffic surveillance
Ford to pump $1B into AI for driverless cars

Former Google and Uber engineers will work with Ford on a system for 2021

Ford plans to spend US$1 billion over the next five years on the development of an artificial intelligence system for driverless cars.

Ford will investment the money in Argo AI, a start-up founded by former leaders from Google and Uber's self-driving car research units, and they will work toward the goal of a system that's ready for deployment in 2021.

The research will be focused on a virtual driver system capable of operating at what's called "SAE level 4." It's one of five levels defined for self-driving cars and specifically describes an autonomous car that's capable of completely controlling the vehicle in almost any condition. After it has been engaged, drivers do not need to pay attention to the driving.

Argo AI will have about 200 employees working on the project once it gets up and going.
Baidu restructure focuses on intelligent driving

Search engine Baidu has announced it will establish an intelligent driving group, headed by company president and artificial intelligence expert Lu Qi.

The move signals Baidu's latest push to transform itself into an AI-first company, days after chairman Robin Li flagged artificial intelligence as a strategic priority.

The newly formed group will comprise three business units focusing on autonomous driving, intelligent automobile, as well as internet of vehicles.

"Self-driving, intelligent transportation and internet of vehicles are major forces for industrial upgrade and they define Baidu's business strategy and core competence," a company statement said.
Future of Driverless Cars

NOW...
OMG, THERE'S NOBODY DRIVING THAT CAR!

THE FUTURE...
OMG, THERE'S SOMEBODY DRIVING THAT CAR!

SEE MORE AT NATETHEROBOT.COM

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Cars Aren’t Safe

- US 2010: 6 million car crashes, 93% human error
- World: 1.3 million deaths per year; 50 million injuries
- 4Ds: Distraction, Drunkenness, Drowsiness, Driver error
- Expected decrease in auto insurance premiums from driverless cars: 75%
Driverless Car History

1925 – Houdina Radio Control Co. demonstrated the “American Wonder” on 5th Ave. in NY

1939 – Norman Bel Geddes guided car at the NY World’s Fair

1950s – General Motors & Radio Corporation of America test automated highways

1990s – VaMP driverless car at Univ. of Munich

1995 – Carnegie Mellon Navlab car goes 5000 km across the U.S. autonomously
Driverless Car History

2009 – Google begins driverless car project

2010 – Four cars drive 16,000 km from Parma (Italy) to Shanghai

2013 – VisLab (Univ. of Parma) vehicles navigate downtown Parma (Italy)

2016 – Uber deploys 20 driverless cars (free) in Pittsburgh (US)
Problems a Car Faces

- Where am I? (location)
- Where should I be going? (route planning)
- What is that in the road?
- What are the other cars doing?
- Am I going to hit something?
- What does that sign say?
- What is the speed limit?
- Can I change lanes?
- Is that a policeman ahead?
Weather
Solution

• Plan a route to the destination
• Generate a “model” of the surroundings
  – Requires multiple types of sensors
• Continuously monitor conditions
• Communicate with nearby cars
• Communicate with the transportation infrastructure
• Receive and process road information
VIDEO:

Priscilla Knox: 
A Ride in the Google Self-Driving Car
Car Sensors

- GPS (global positioning system)
- Rear Camera
- Ultrasonic sensors
- Odometry sensors
- Central computer
- Lidar (light detection and ranging)
- Video cameras
- Radar sensors

SOURCE: SCIENCE ABC
Car Sensors

- Lane Keeping
- Parking Assist
- Blind Spot Detection
- Adaptive Cruise Control & Traffic Jam Assist
- Front/Rear Collision Avoidance
- Cross Traffic Alert & Intersection Collision Avoidance
- Autonomous Emergency Braking & Emergency Steer Assist
- Object Detection, Tracking, Classification
- Scene Capture & Accident Reconstruction

SOURCE: QUANENERGY SYSTEMS
Car Sensors

SOURCE: GOOGLE
VIDEO:

Chris Urmson: TED Talk How a Driverless Car Sees the Road
What the Car Sees
LIDAR

- Calculates distance from the car based on speed of light
- 64 infrared, harmless laser beams rotate at 900 rpm to generate a 3D image.
- 150,000 pulses per second
- Range: 200 meters
- Accuracy: 67 picoseconds = 1 cm!
- Sees through fog
Vision by LIDAR

If not in the line of sight, objects can’t be detected.

Light pulses reflect off objects.

Painted lines can be detected.

Source: Delphi
LIDAR Sensing Speed

A major league hitter must start his swing when the ball is 10 feet from the pitcher’s hand. The world’s best athletes need two-tenths of a second to react.

Future cars will be able to think 34,346 times faster than any batter.
Front Near-Vision Camera

- See pedestrians & other vehicles
- Detects and records information about road signs and traffic lights
- Differentiates people, bicycles & cars
- Interprets gestures, e.g., hand signals
Optical Cameras

- Mono or stereo-vision
- Watch nearby vehicles, lane markings, speed signs, high-beam lights etc.
- Warn the driver when the car is in danger of a collision with a pedestrian or an advancing vehicle.

- Advanced camera systems predict object trajectories.
What the Car Sees

IDENTIFY STATIONARY OBJECTS

IDENTIFY PEDESTRIANS, THEIR DIRECTION AND SPEED

IDENTIFY VEHICLES, THEIR DIRECTION AND SPEED

SOURCE: MERCEDES
Radar

- Works in all weather conditions
- Handles many functions:

SOURCE: RADARTUTORIAL.EU
GPS Positioning

- GPS estimates may be off by several metres.
- GPS data is compared with sensor map data previously collected from the same location to update the vehicle’s internal map with new positional data.

SOURCE: GOOGLE
Man v. Machine Accuracy

• GPS coordinate accuracy 5-10 meters – insufficient for driving
• Much more detail is needed, obtained from satellites and street scanning. Illegal in PRC.
• Facial recognition
  – Human error: 0.8 percent
  – Machine error: 0.23 percent
• Visibility
  – Human: 50 meters
  – Machine: 200 meters
Recognizing Lanes

Webcam image from top view

Receive the image from the webcam

Gray scale

Create markers

Create the markers for the White Color

Create components (markers that are very close and their forms are like a line)

Create a line equation from the positions of markers

Calculate the slope of the line

Similar slope

Check if there are very close components with a very close line slope

Add the component which has a very close line slope

Check if this component is enough to be considered a lane

Draw the line
Learning to Read Signs
Reading Signs by Neural Networks
V2V Communications

SOURCE: TELEMATICS NEWS
Vehicle-to-Vehicle Cloud
V2V, V2I, I2I Communications

RSU = ROADSIDE UNIT  TMC = TRAFFIC MESSAGE CHANNEL

SOURCE: KAPSCH.NET
Driverless Benefits

- Crash Elimination
- Reduced Need for New Infrastructure
- Improved Energy Efficiency
- Travel Time Dependability
- Productivity Improvement
- New Business Models & Scenario

SOURCE: HCLTECH.COM
Effect of Driverless Cars

A DRIVERLESS CAR: THE PERFECT VEHICLE TO TRANSPORT ME TO...

...THE UNEMPLOYMENT OFFICE...

FUTURE ECONOMY: MANY WILL LOSE JOBS TO COMPUTERS

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Ethical Issues

What should the car do?
What should the bus do?
Should they negotiate?
Suppose it’s a school bus?

SOURCE: NOAH GOODALL
Vehicle Hacking Potential

Also: jamming radar, spoofing V2I and V2V, blinding LIDAR with IR

SOURCE: HARMAN
Hong Kong not ready for trial of driverless cars, government says, as Singapore aims for fully autonomous taxi fleet by 2018

Experts claim driverless taxis could replace cabbies in less than a decade, but government says hardware and software advancements likely needed first

Driverless technology is not yet developed enough to justify the government facilitating a trial in Hong Kong, the Transport and Housing Bureau has told the Post.

The bureau said it was aware of the use of driverless cabs in other places and would continue to keep a close eye on such technology, but was not yet ready to implement any trial in Hong Kong.

“As far as Hong Kong is concerned, the government keeps an open mind and will facilitate the trial and development of such technology subject to safety and legal considerations, which has to be assessed on a case-by-case basis,” a bureau spokeswoman said.