SELF DRIVING CARS – A case Study of CPS / Real-Time Systems

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INTRODUCTION

- A self driving car (autonomous car) is a vehicle that is able to guide itself from an origin point to a destination point by sensing its environment and navigating in real time without any human input and help.

- Individual yields near-full or partial control to artificial intelligence technology
  - Individual decides an activity-travel plan (or tour-specific information)
  - The plan is keyed into the car's intelligence system
  - The car decides on a routing and circuit by using Machine/Deep learning model to complete the plan by analyzing the real time situation and data of the traffic through sensors.

MOTIVATION

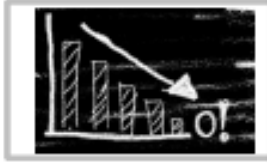
1	*Zero Emission*	- Optimization of traffic flow management - Reduction of fuel cons. and CO2 emission	
2	*Demographic change*	- Support unconfident drivers - Enhance mobility for elderly people	
3	*Vision Zero*	- Potential for more driver support by avoidance of human driving errors	
4	*Increasing traffic density*	- Optimization of traffic flow management - Convenient, time efficient driving via automation	
5	*Economy*	- Ensure unique selling proposition - Attractive products by technological leadership	
6	*Maturity of driver assistance systems*	- Sensors are approved and cost-effective - Actuators (steering, …) in series production	

Figure 1: Motivation behind the usage of Self Driving Car System [1]

HOW IT WORKS?

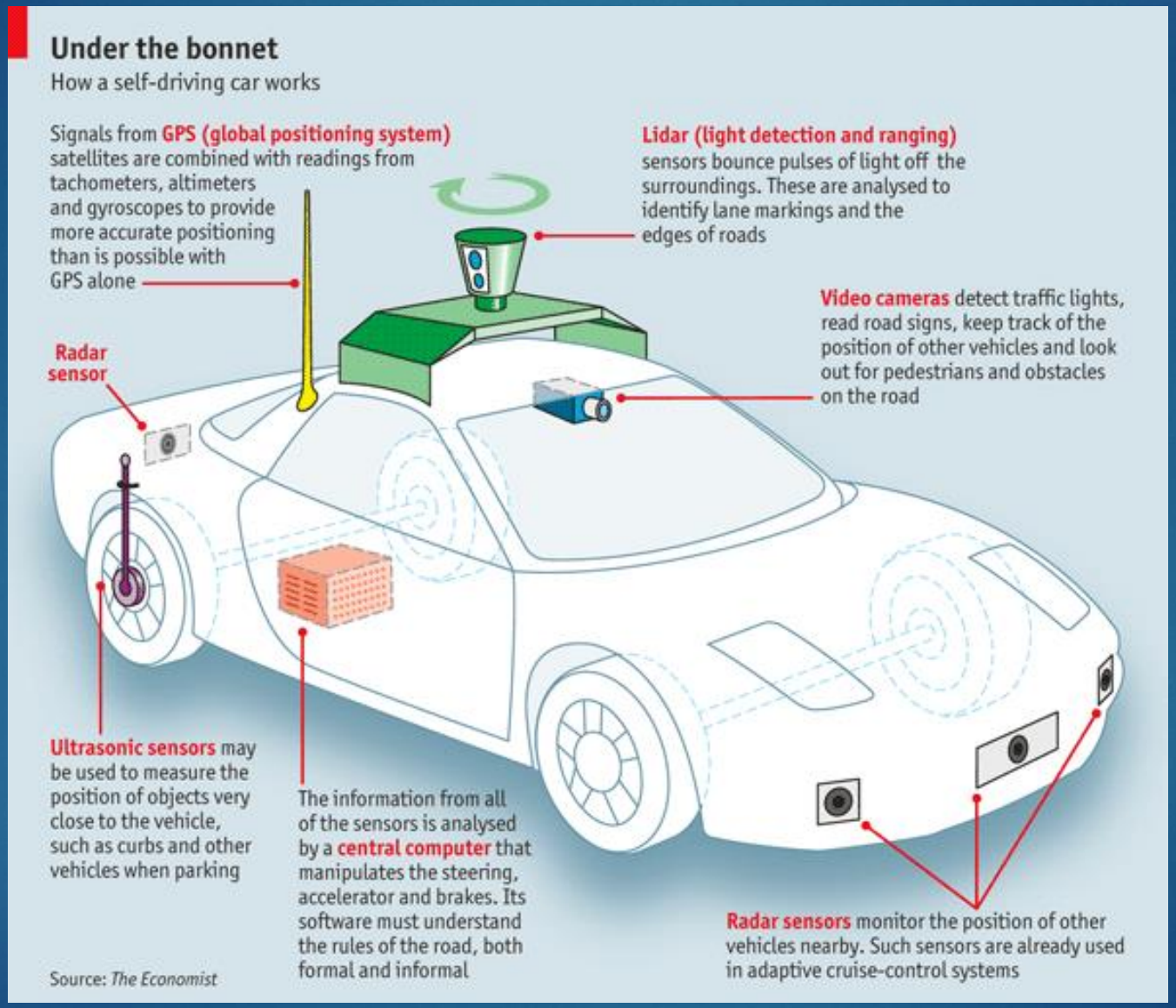


Figure 2: How Self Driving Car Works [2]

- A self driving car system is an autonomous agent.
- It consists of:
  - ✓ Sensor Systems
  - ✓ Actuator Systems
  - ✓ Computation/Artificial Intelligence Systems
- Sensors – Sense the surrounding environment and report. Examples: Vision, Radar, Laser, Vehicle Sensors (Odometer, Fuel Gauge, Oil pressure, Engine Temperature)
- Actuators – Acting upon the environment in real-time. Examples: Steering, Gas / Throttle, Brakes, Vehicle Starting, Lights, Sirens
- Computation – The brains which process sensor data and apply the correct actuation by using AI algorithms to achieve the goal. The main tasks could be listed as : Processing real-time sensor input, Path planning using the AI Models, Actuator manipulation.

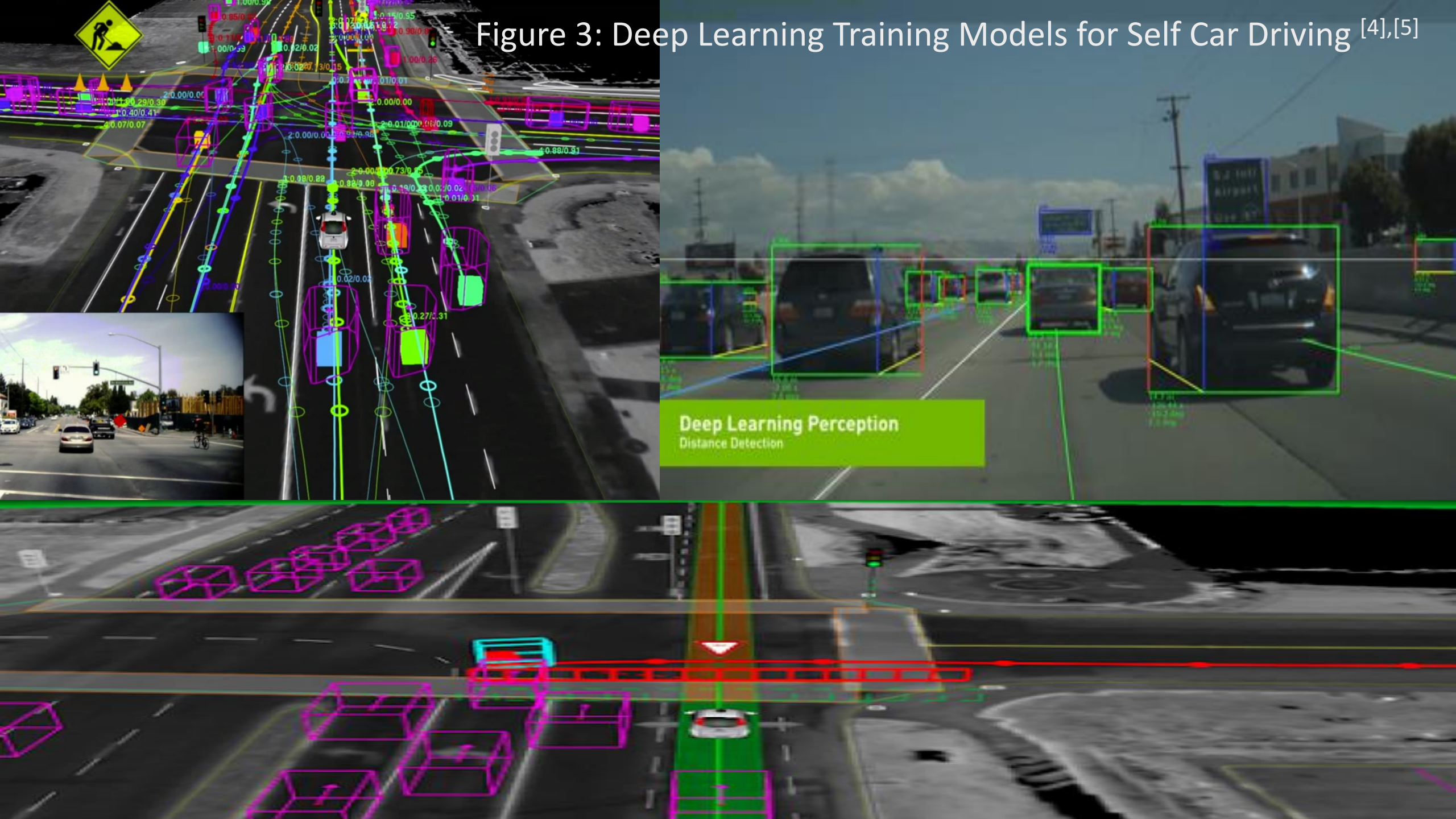
Self Driving Car as a Real Time System

- A self driving car system is a ***Dynamic*** system.
- The nature of tasks arriving in the system are ***Aperiodic*** i.e. type of task, jobs are released at arbitrary time intervals and are ***event driven***.
- It is impossible predict when the brakes need to be applied or when the steering would be turned on beforehand as it all depends on the real time situation. For instance:
  - ✓ How far are the other vehicles, pedestrians?
  - ✓ Is the signal light at a crossing red, yellow or green etc.
- So schedule construction for such type of situations cannot be done ***offline***. Tasks are scheduled on the go.

Machine Learning in Self-Driving Car

- There are three major building blocks in the development of machine learning approach for self-driving cars:
  - ✓ Data preparation
  - ✓ Model generation
  - ✓ Model deployment
- Data preparation focuses on getting the real time data ready for training and testing neural networks, covering topics such as data recording, ground truth labeling, big data storage, etc.
- Model generation involves developing network architectures, training the networks, and evaluating the trained models. A model is considered “trained” if the difference between its outputs and the expected outputs are below a certain threshold value.
- Typically, a trained model is then pruned and optimized for a specific target hardware during the deployment stage, where field tests on testing sites or public roads take place. [3]

Figure 3: Deep Learning Training Models for Self Car Driving [4],[5]



GOOGLE DRIVERLESS

Algorithms used:

- ✓ 3-D imaging with multiple 1064 nm lasers.
- ✓ Edge-Detection Algorithm
- ✓ Motion-Detection algorithm
- ✓ Tracking algorithm

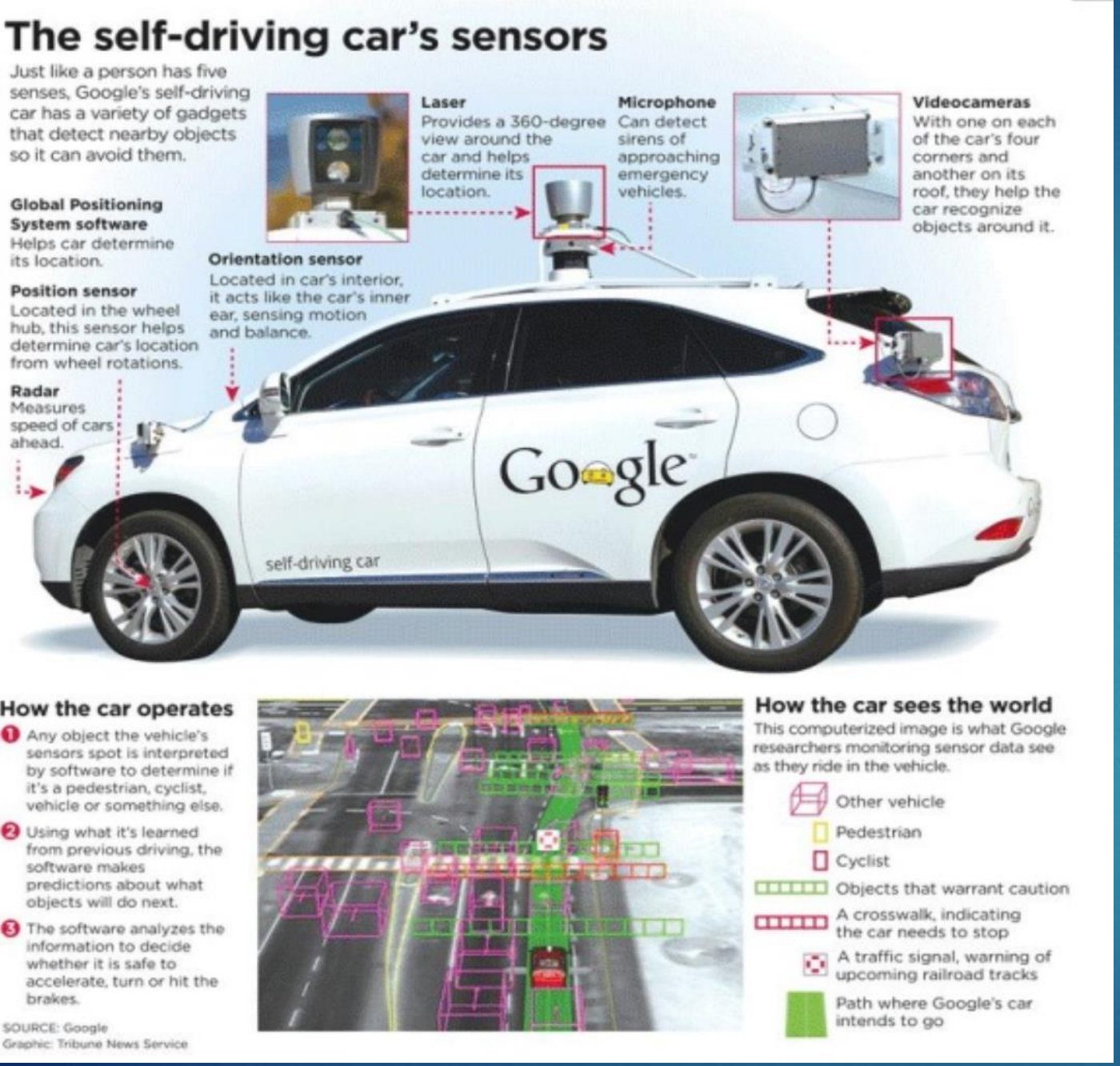


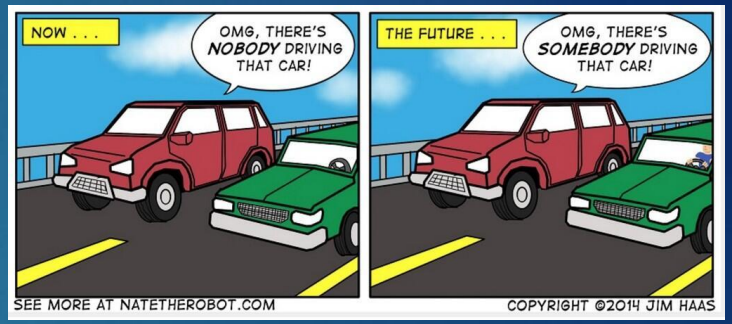
Figure 4: Google Driverless [6]

FAULT TOLERENCE FEATURES

- The ultimate goal of self driving car is to achieve convenient and safe everyday autonomous driving.
- Therefore, it cannot be assumed that there will be a trained engineer taking over when the autonomous system fails. A single point of failure should not lead to an unsafe state of the vehicle.
- To achieve this, making the vehicle computing platform fault-tolerant in real time is most essential.
- Fault-tolerance is defined as the ability of a system to deliver the expected service even in the presence of faults.
- For a self driving car system to be fault-tolerant, it must be able to detect, diagnose, confine, mask, compensate and recover from faults.
- As a result, the models are designed in such a way that enables the system to switch into
  - ✓ a fail-operational mode on the failure of a critical subsystem to bring the vehicle to a safe state and stopping

Benefit of Self-Driving Car

- Managing traffic flow to increase road capacity.
- Relieving vehicle occupants from driving allowing them to concentrate on other tasks or to rest during their journeys.
- To avoid accidents
- Increasing roadway capacity by reducing distances between cars.
- The current location of vehicle can be determined using GPS.
- Fuel-efficient driving, save 10-15% fuel.



Drawback of Self-Driving Car

- If the vehicle is using internet which has less security then from hackers point of view, the vehicle can be switched off on the road.
- Hackers can change the route in real time, which is plotted in the system.
- In case of failure of main sensor and backup sensors, the vehicle can create a chance of accidents in highly rare cases.

SAFETY & CHALLENGES

- Self-Driving Cars must learn to identify countless objects in the vehicle's path, from branches and litter to animals and people.
- Other challenges on the road are tunnels that interfere with the Global Positioning System (GPS), construction projects that cause lane changes or complex decisions, like where to stop to allow emergency vehicles to pass.[7]
- The systems need to make instantaneous decisions on when to slow down, swerve or continue acceleration normally.
- There are also serious concerns that the software used to operate autonomous vehicles can be hacked.
- Thus, Self-driving cars must have fail-safe mechanisms, usually encountered under the name of Safety Monitors. These must stop the autonomous control once a failure or malicious activity is detected.

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THANK YOU!