Overview
Autonomous Vehicles

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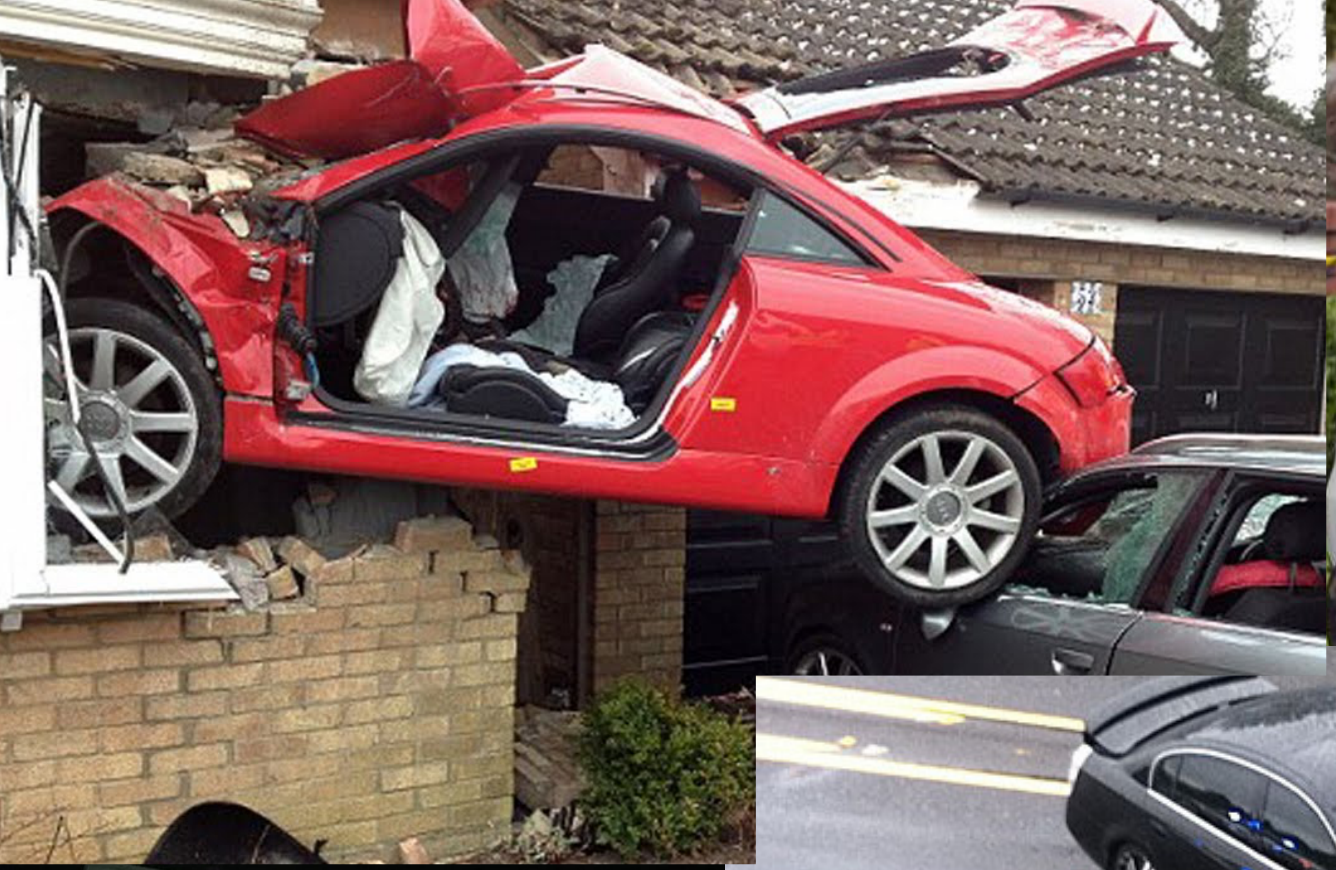
What is the problem?

Driving is hard and wasteful.

Transportation is expensive.

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DENTAL

Human Drivers are the ***Problem***

In the United States (2016)

- 7,277,000 reported crashes
- 3,144,000 people were injured
- 37,461 fatalities (1 fatality every 14 minutes)
  - Leading cause of death for ages 16-22
- 94% of all crashes are due to human error

We should be working on this problem!

https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812580

Why now? Why us?

- Sensing and actuation are (mostly) solved problems
  - Unlike many robotics tasks
- Limited by perception (alg.) and compute (arch./sys.)
  - Current research focus is on AI
    - Needed for advanced autonomy
    - AI needed for collision avoidance is partly ready
  - Gap in research on systems side
    - Needed: software and hardware platform of an autonomous vehicles
    - Keep device costs down while enabling innovation
- Challenges to entry
  - Data and test platform → simulation is improving + Berkeley test vehicles

Basics of Autonomous Vehicles

Levels of Autonomy:
Automotive Engineering Society (AES) Standard

	Name	Description	Steering & Accel.	Env. Monitor	Fallback
1	Driver Assistance	Assistance for **either steering or acceleration** using information about env. with the expectation that human performs all remaining aspects.	Human + System	Human	Human
2	Partial Automation	**Assistance for both steering and acceleration** using information about env. with the expectation that human performs all remaining aspects.	System	Human	Human
3	Conditional Automation	Autonomous driving with the **expectation that human will respond to a request to intervene**	System	System	Human
4	High Automation	Autonomous driving with the **ability to take a safe action (e.g., pull over) if a human cannot intervene.**	System	System	System
5	Full Automation	Autonomous driving **under all feasible roadway and environmental conditions.**	System	System	System

Advanced Driver Assistance Systems (ADAS) vs Autonomous Vehicles

Level 1– Level 3 ADAS Systems

L1: Individual assistance functions

- Collision warning
- Pedestrian detection
- Automatic emergency braking
- Lane detection, lane assist
- Parking assist

L2: combining them

L3: vehicle takes over driving functions, but driver must be ready to take over

Level 4 – Level 5 Autonomy

Levels of Full Autonomy

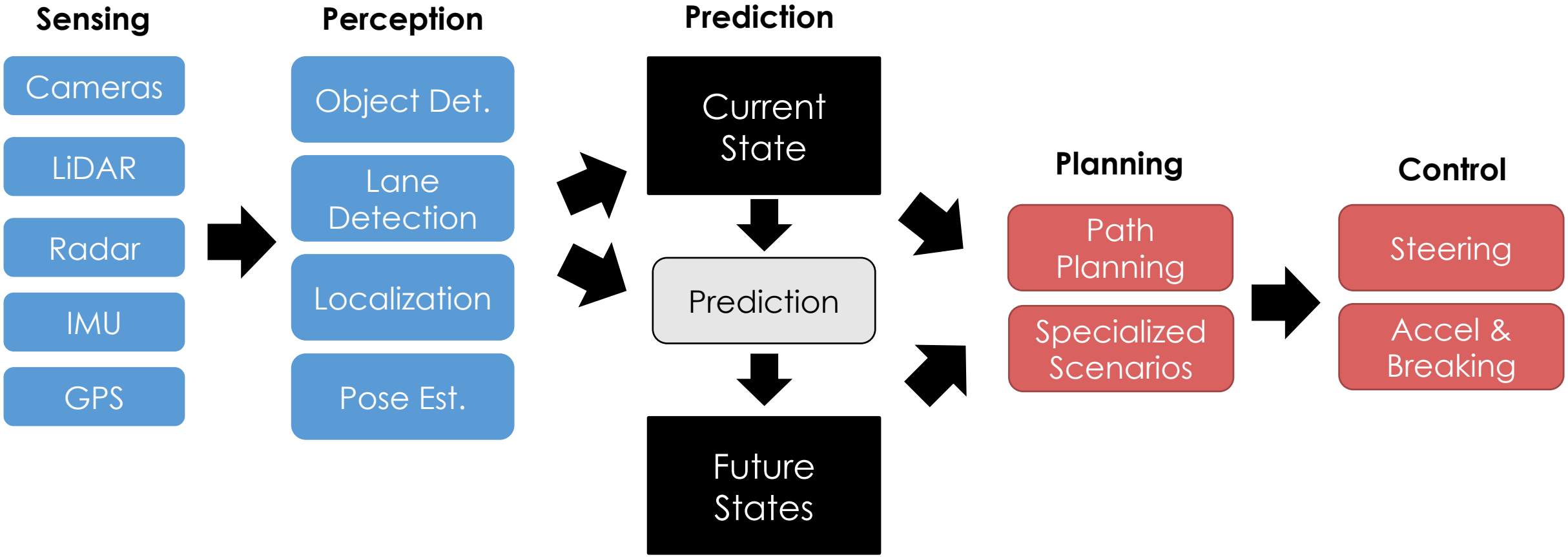
Level 4

- Full autonomy in constrained situations

Level 5

- Fully autonomous in all situations

Cartoon Autonomous Vehicles Pipeline



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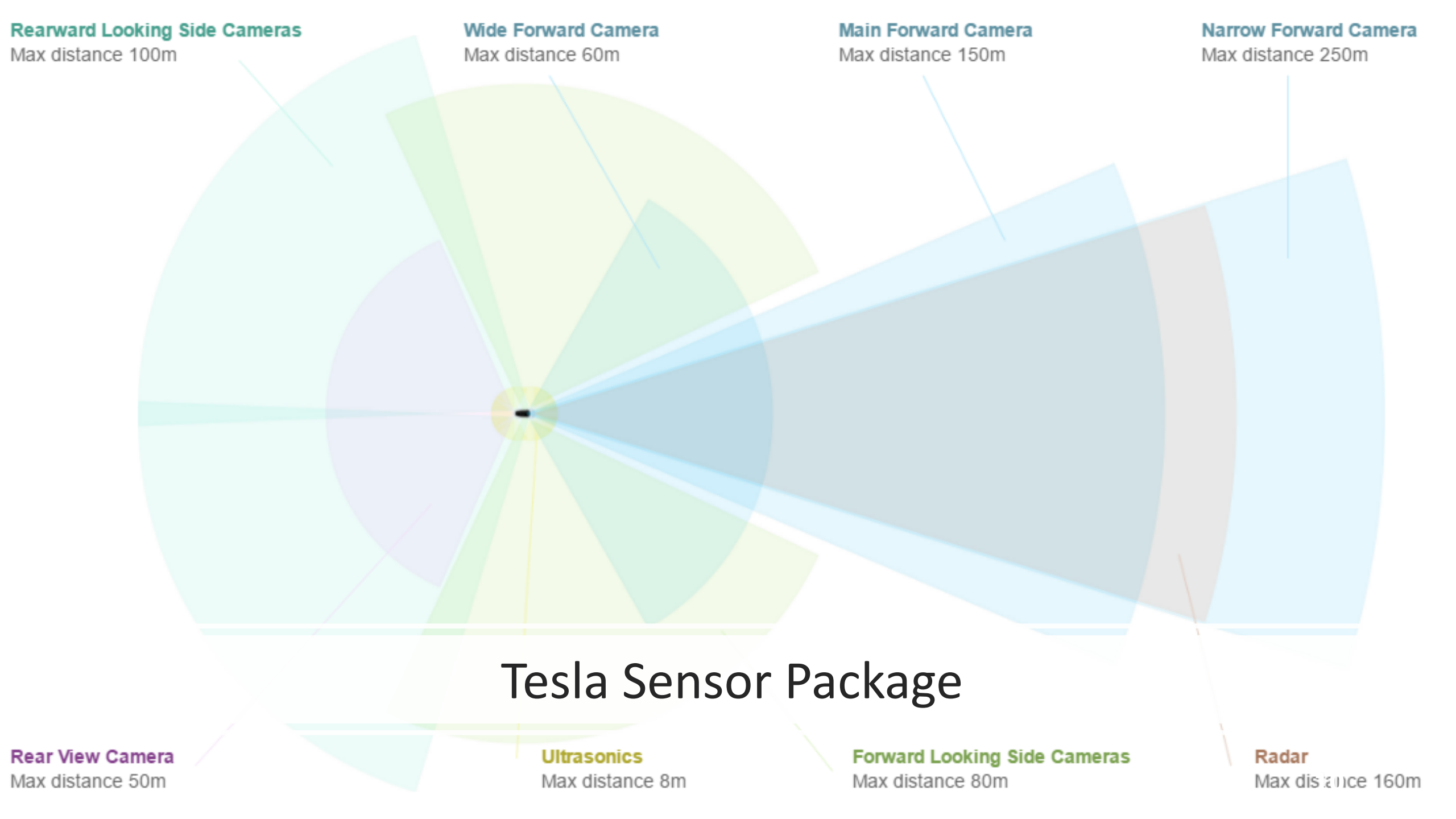


Tesla Sensor Package

Sensors – Top View

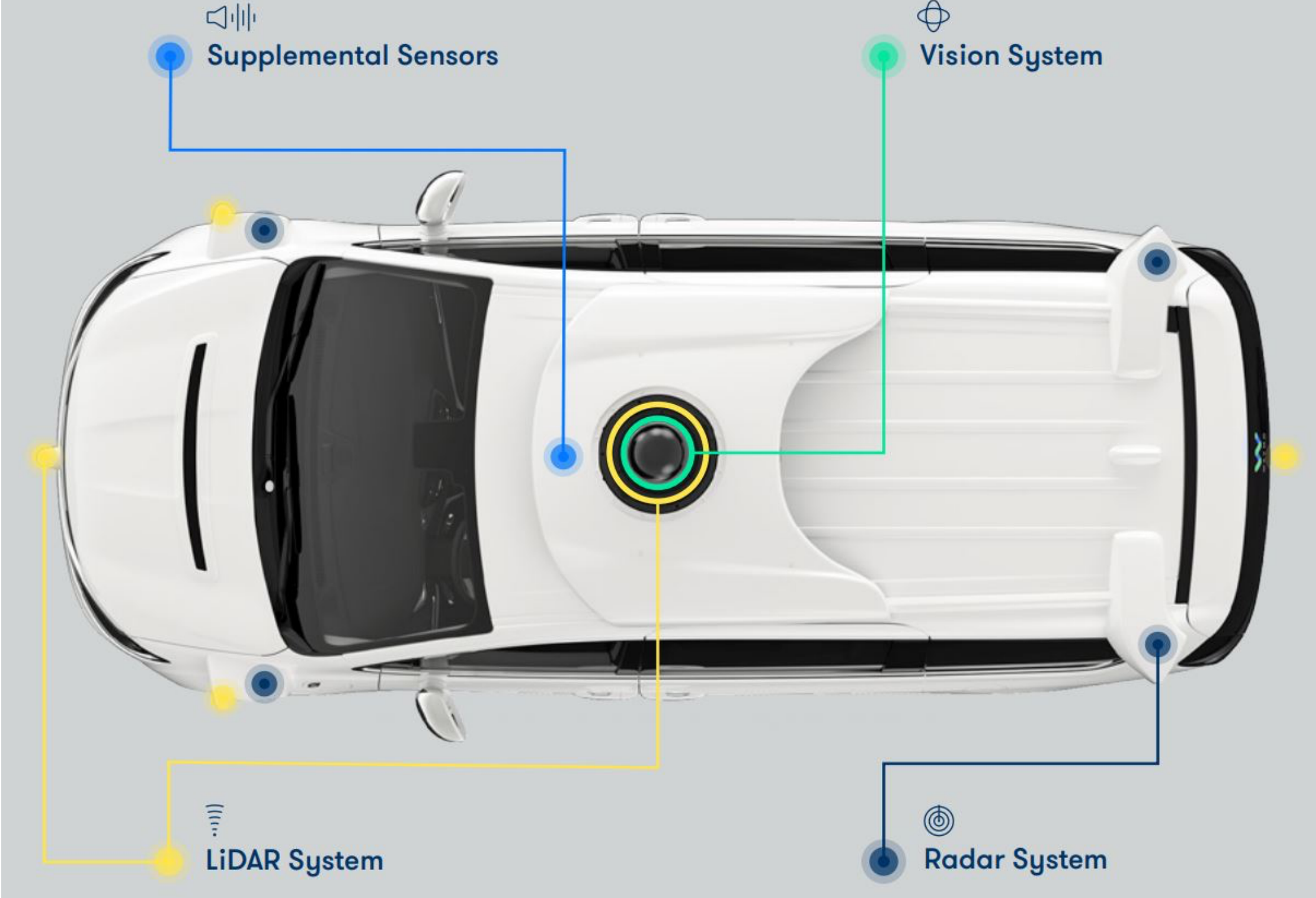
360° LiDAR

Camera array

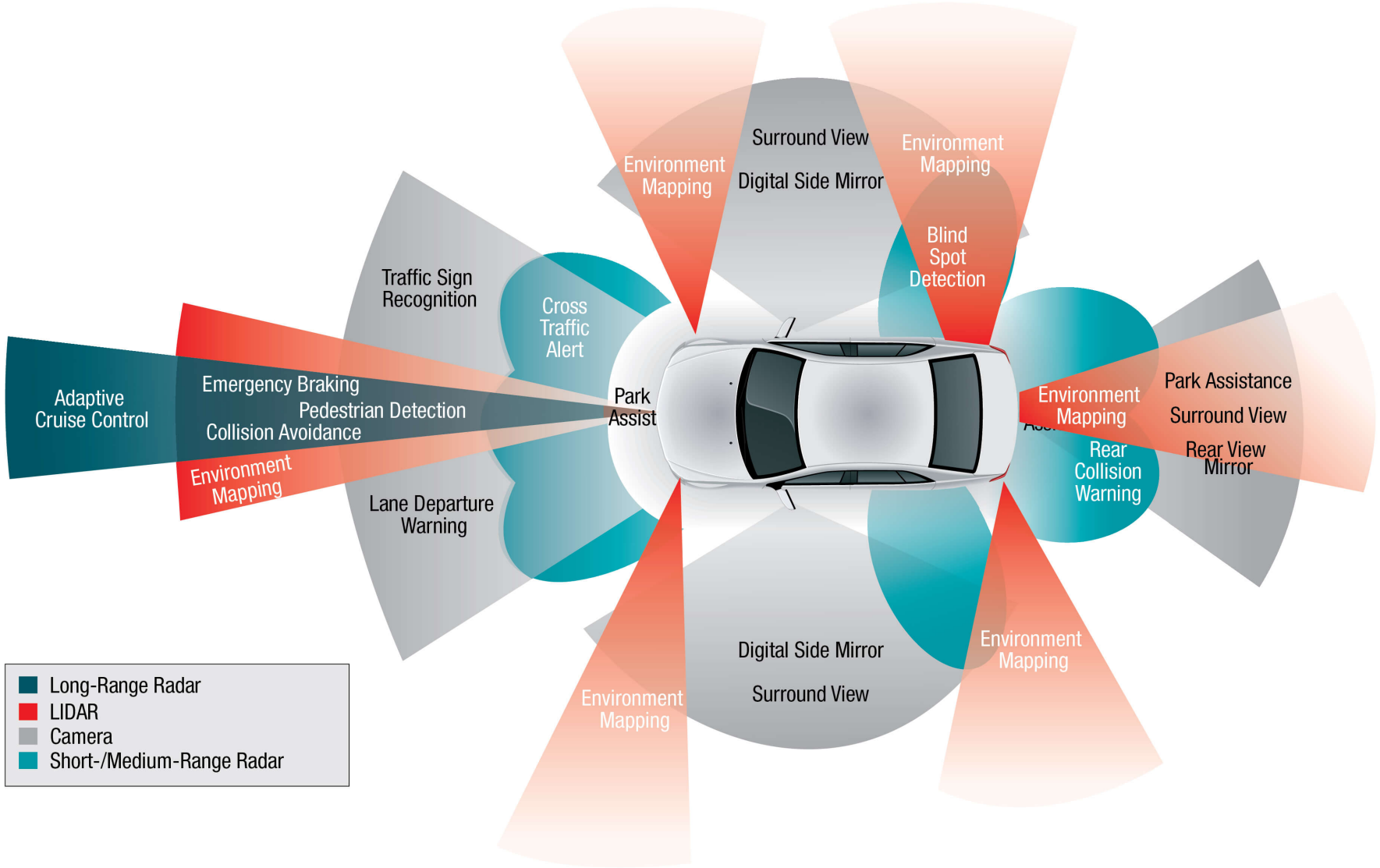
Stereo camera pairs

LiDAR & Radar

Waymo


Supplemental Sensors
Vision System
LiDAR System
Radar System

Sensors and Their Uses



Sensor Comparison

Sensor	Relative Cost	Resolution	Strengths	Weaknesses
LiDAR	Highest	Mid-range	Depth data 360° view	Susceptible to weather (fog, rain, snow etc.)
Camera	Least expensive	Highest	Traffic lights, pedestrians, signage	Darkness, glare, fog,
RADAR	Cheap	Low	Robust in bad weather	Low Resolution
SONAR	Cheap	Very low	Robust in weather, darkness, brightness	Very Short Range

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Applying DNN to Integrated Sensor Data

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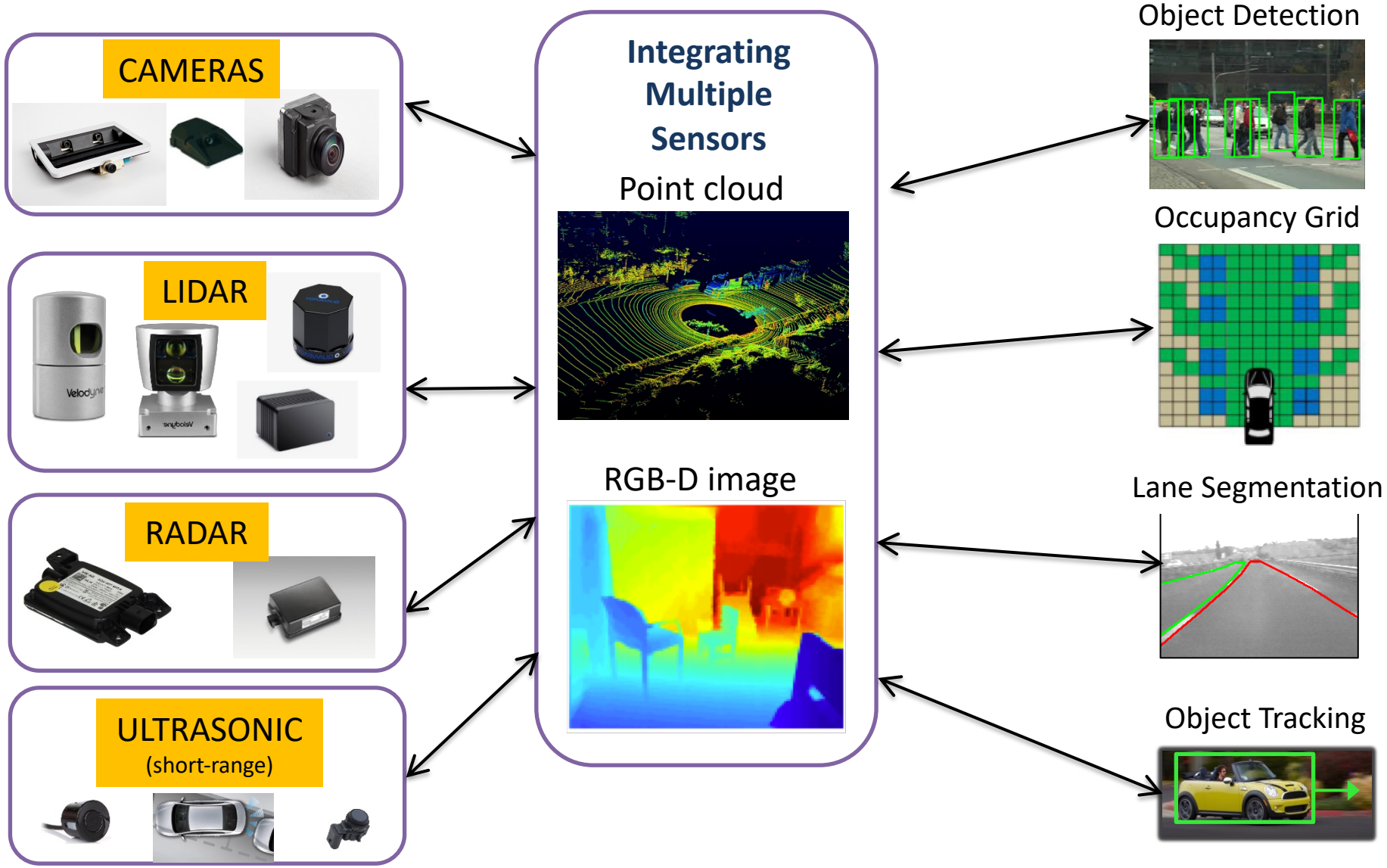
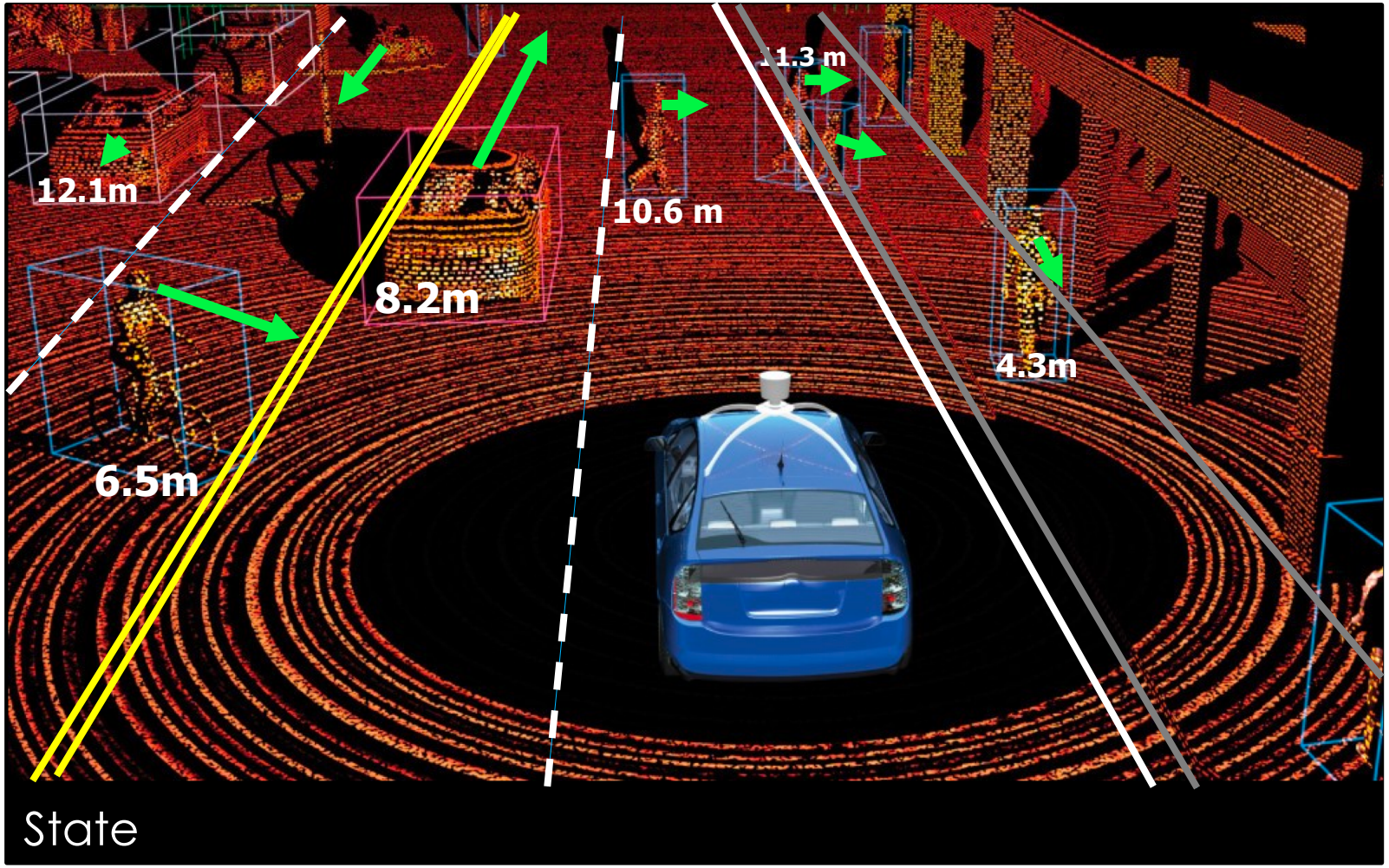


Typical Approach to State Representation



Accurate 3D Models

- Individual object detection localization, and pose estimation
- High-resolution maps
- Object trajectories

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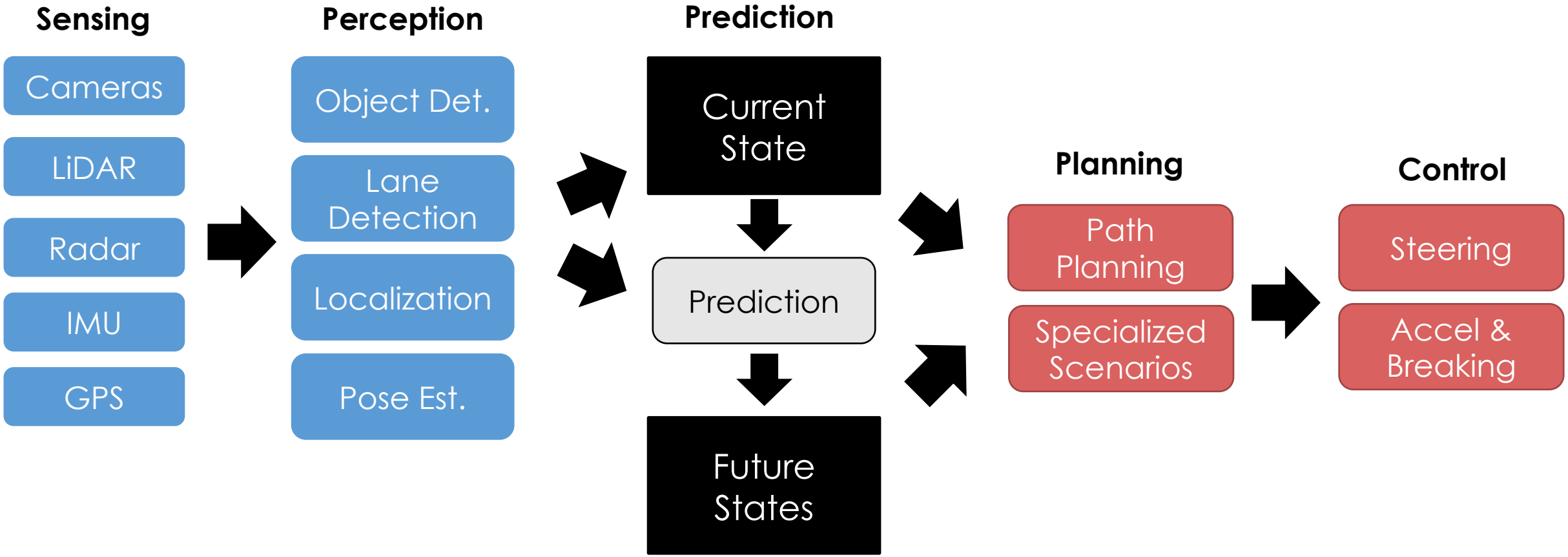
GO
GO
STOP
STOP
STOP
3 MPH
7 MPH
20 FEET
POLICE CAR
2 MPH
2 MPH
FEET
0 MPH
3 FEET
Waymo

Cartoon Autonomous Vehicles Pipeline



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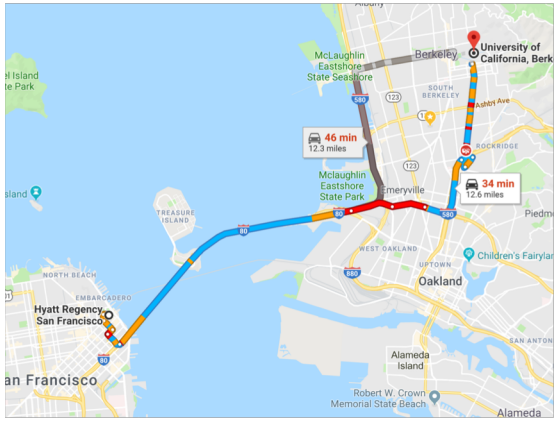
Classic Hierarchical Approach

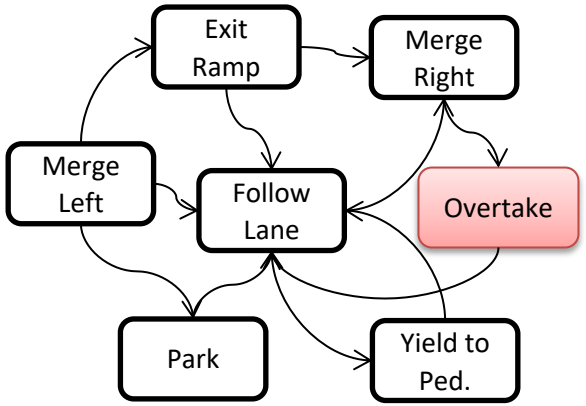
Decompose motion planning and control into stages

Route Planning



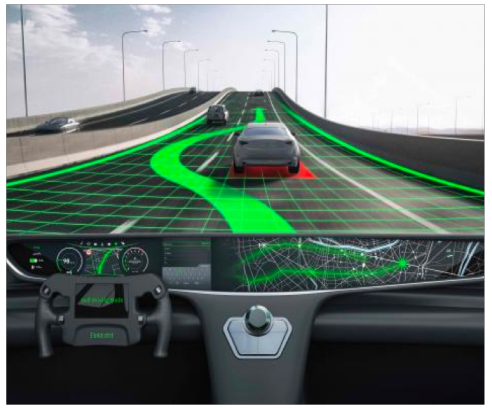
Road Networks
Traffic Information
Obstacles …

Behavior Planning



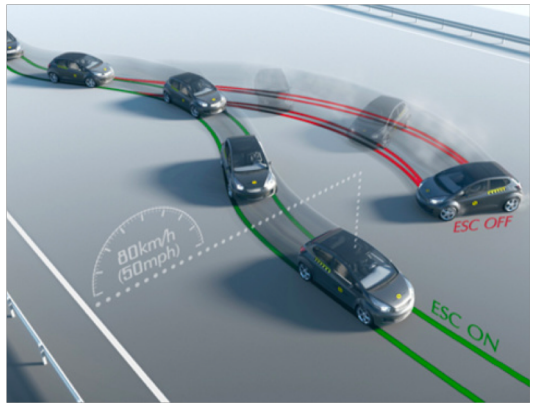
Sequence of roads and intersections

Path Planning



Target State Configurations

Local Control

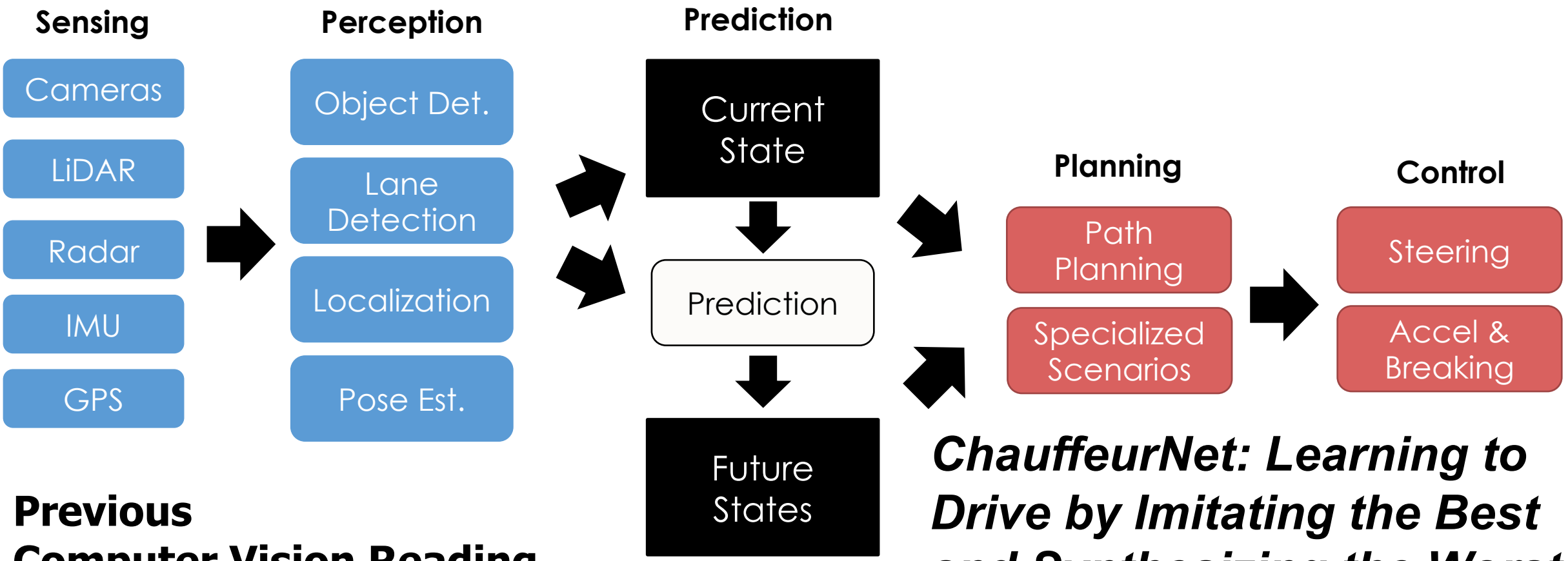


Detailed Path to Follow

1. Model of the world around the car including predicted future states.
2. Model of the vehicle's dynamics.

The Architectural Implications of Autonomous Driving

– Presented by Sukrit



Previous Computer Vision Reading

ChauffeurNet: Learning to Drive by Imitating the Best and Synthesizing the Worst

– Presented by Dequan