Introduction to Autonomous Car Vision summary

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Artificial Intelligence &
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Autonomous Car Vision

- Introduction
- Industry leaders
- Autonomous car system
- Open source datasets
- Applications
- Existing challenges
- Conclusion

Introduction

- With several **driving assistance techniques** being implemented and **sensors** being placed, the car provides a **safe environment** for the driver in order to **avoid crash or damage**.

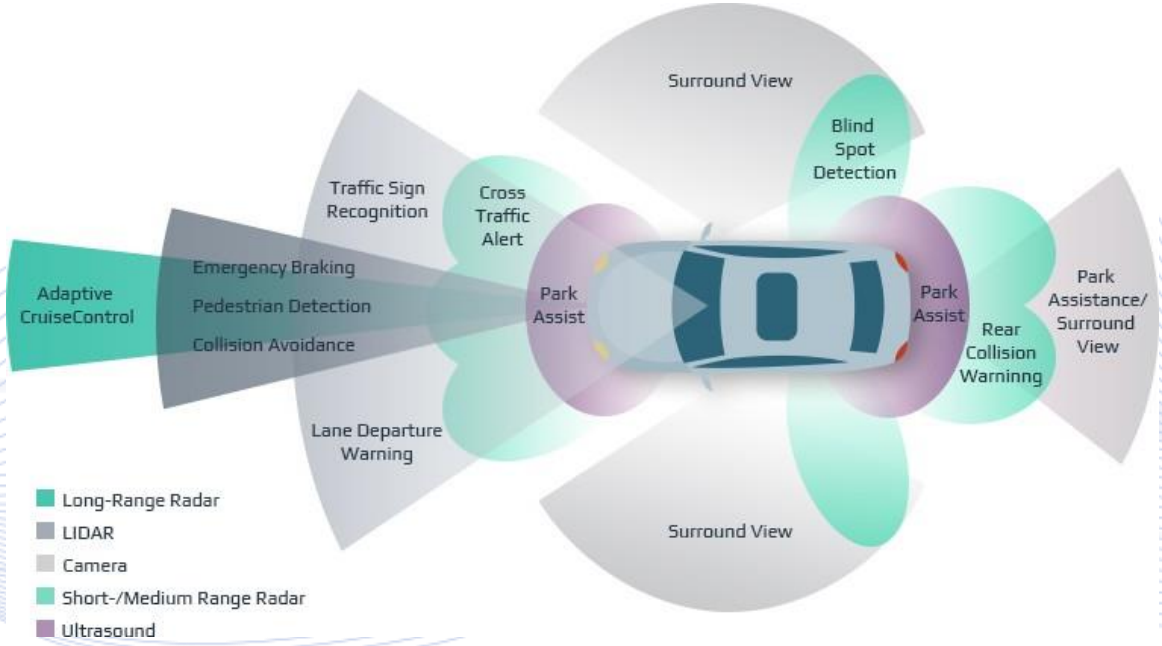


Figure: Autonomous car sensors. https://www.intellias.com/sensor-fusion-autonomous-cars-helps-aoid-deaths-road/

Introduction

Autonomous cars are now able to

- understand their environment and what's relevant information (**perception**),
- construct or update a map of an unknown environment while simultaneously keeping track of their location in it (**Localization & Mapping - SLAM**),
- plan their mission or trajectory and behavior (**planning & control**) as well as
- **predict** and estimate the motion of other objects in the surrounding space.

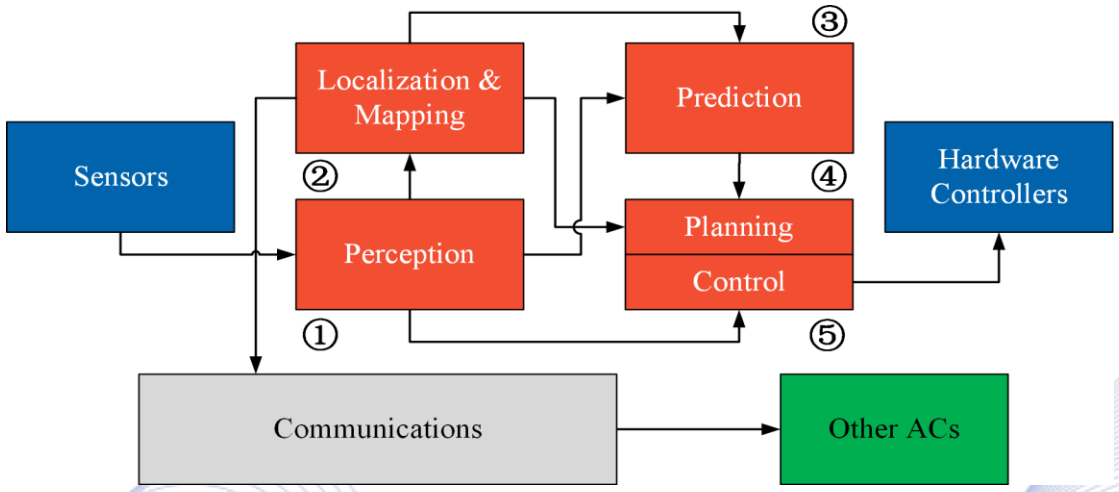


Figure: HKUST autonomous car system architecture [1].

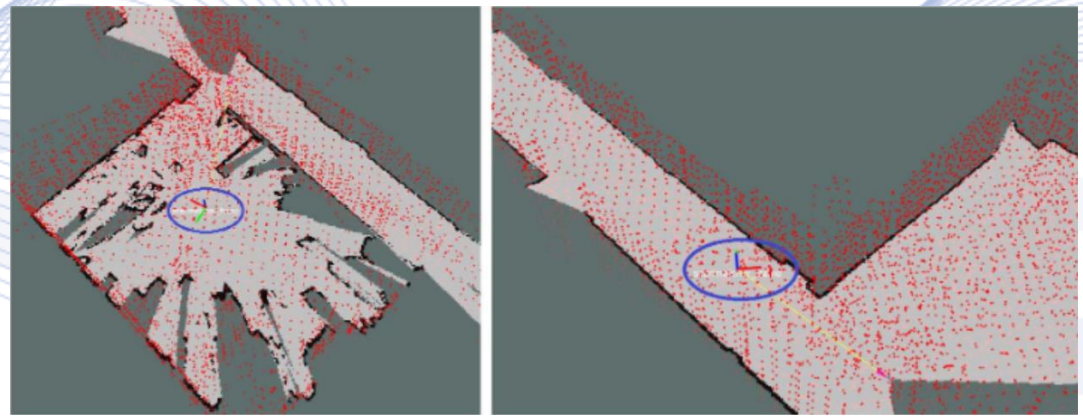


Figure: Kim, Pileun, Jingdao Chen, and Yong K. Cho. "SLAM-driven robotic mapping and registration of 3D point clouds." *Automation in Construction* 89 (2018): 38-48.

Industry leaders

- The global autonomous vehicle market size is projected to be valued at $54.23 Bn in 2019 and is projected to garner $556.67 Bn by 2026, registering a CAGR of 39.47% from 2019 to 2026 [1].
- A second report states that the global self-driving car market is expected to expand at a CAGR of 36.2% leading to global revenue of $173.15 Bn by 2023 [2].
- A third report forecasts that by 2050, the autonomous vehicle industry could be worth a staggering $7 trillion [3].

[1] https://www.alliedmarketresearch.com/autonomous-vehicle-market

[2] https://www.marketwatch.com/press-release/self-driving-car-market-global-industry-trends-share-size-and-forecast-report-by-2023with-cagr-of-362-2019-09-03

[3] https://www.forbes.com/sites/danielaraya/2019/01/29/the-challenges-with-regulating-self-driving-cars/#10140e89b260

Industry leaders

Which country is doing best?

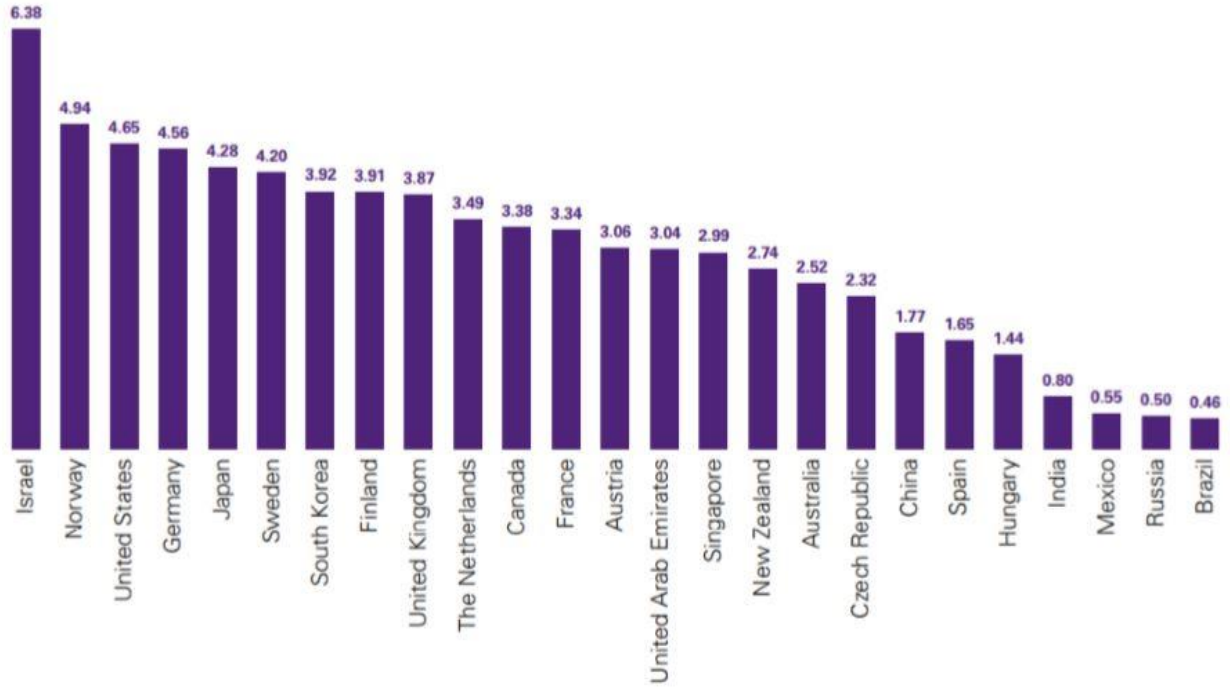


Figure: Technology and innovation

Industry leaders

Key automobile industry players:

Google

TOYOTA

Ford

GM

BMW

TESLA

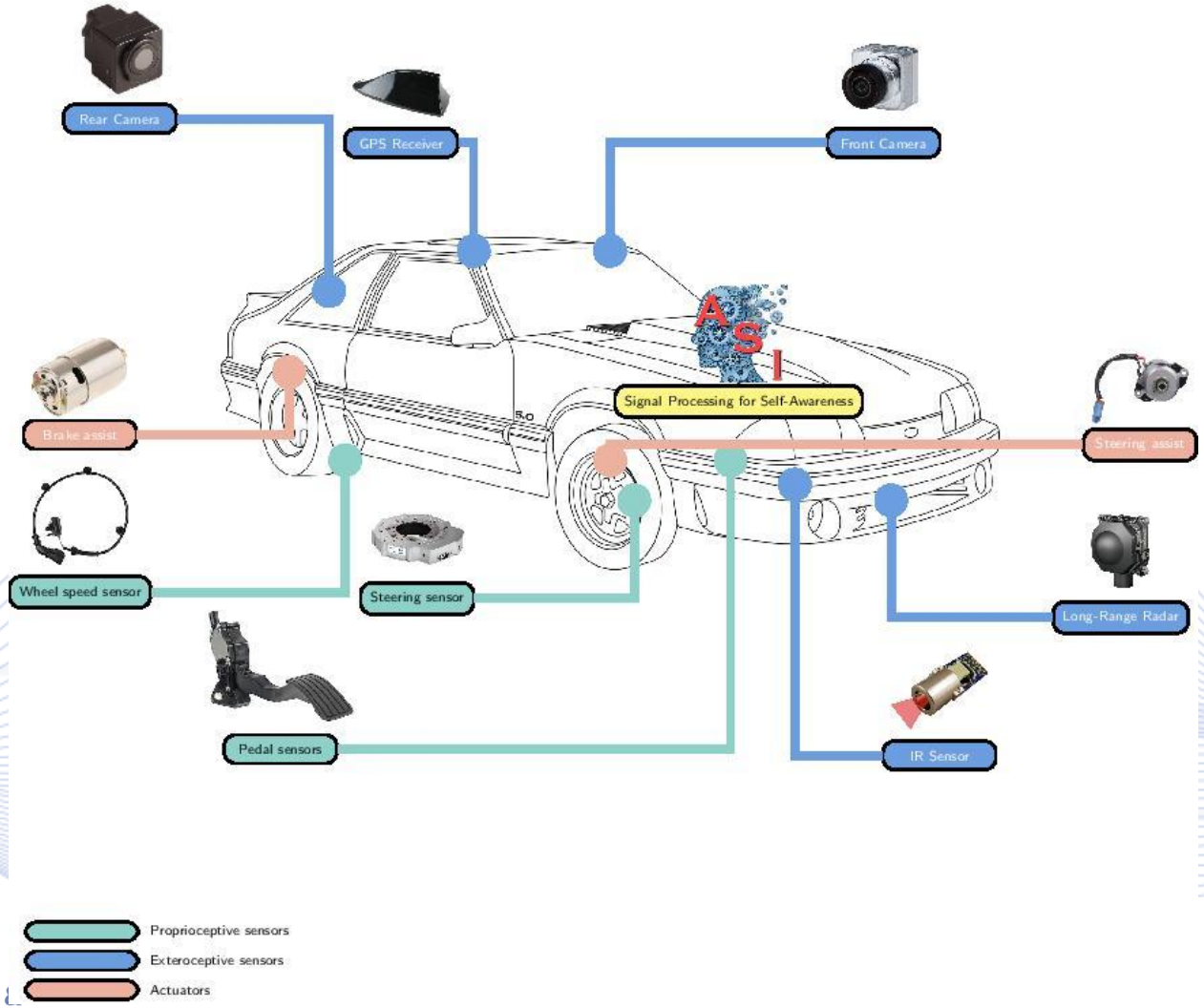
Industry leaders

Which companies are developing autonomous cars?

(a) (b) (c)

Figure: The state of the art autonomous cars; (a) Waymo (b) Uber; (c) Apollo.

Autonomous car architecture



Autonomous car architecture

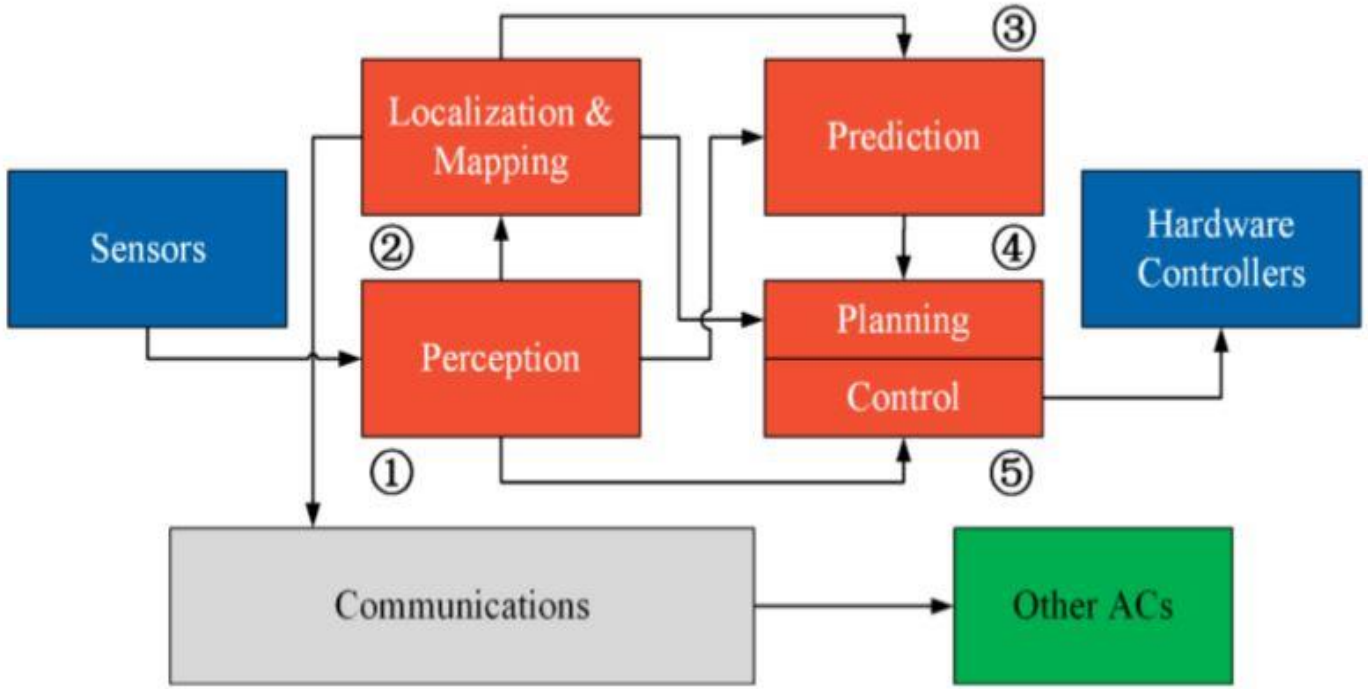
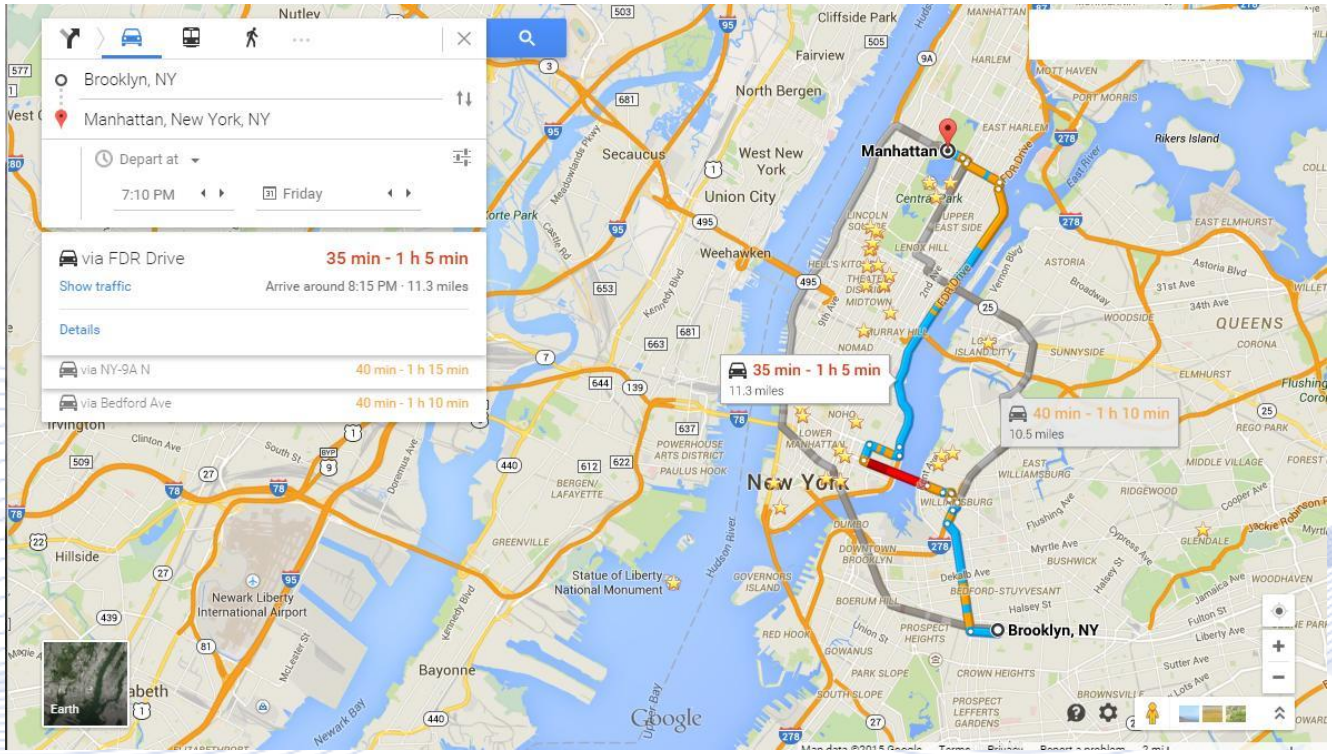


Figure: Autonomous car system architecture

Autonomous car mission planning

- Google maps path planning.



Camera mounting positions

3. Wide-angle camera for traffic light detection.

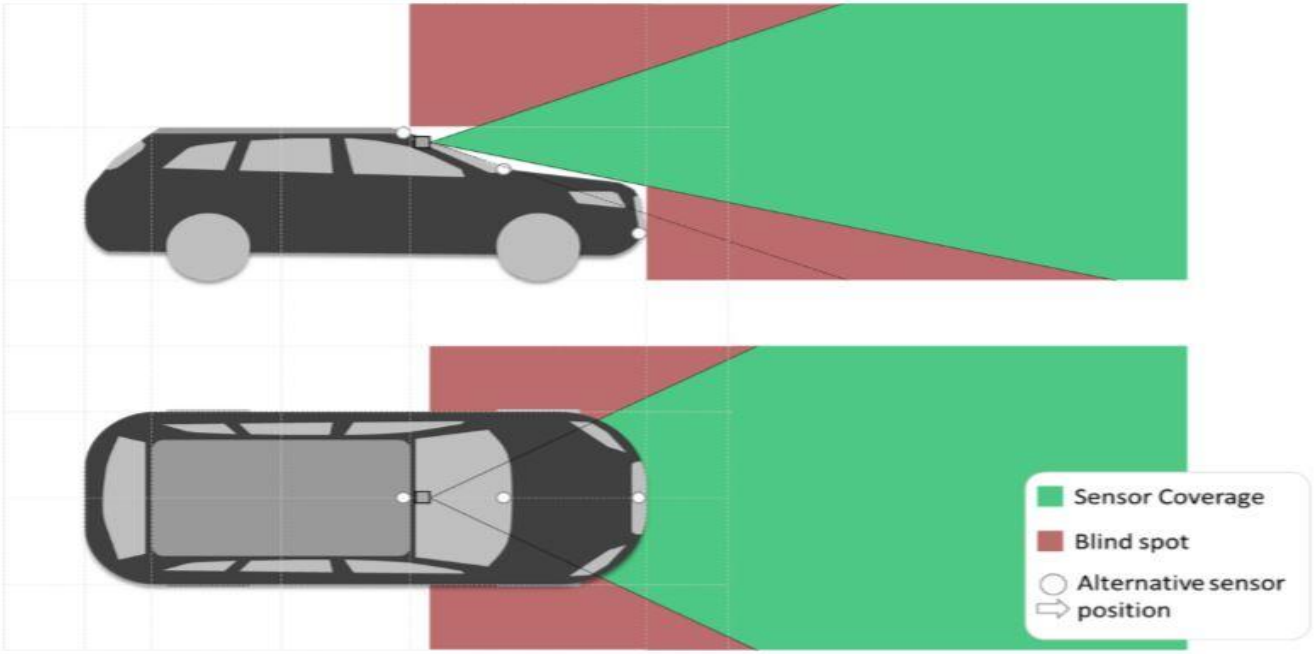


Figure: Wide angle camera for traffic light detection.

Lidar mounting positions

1. Single lidar on roof center

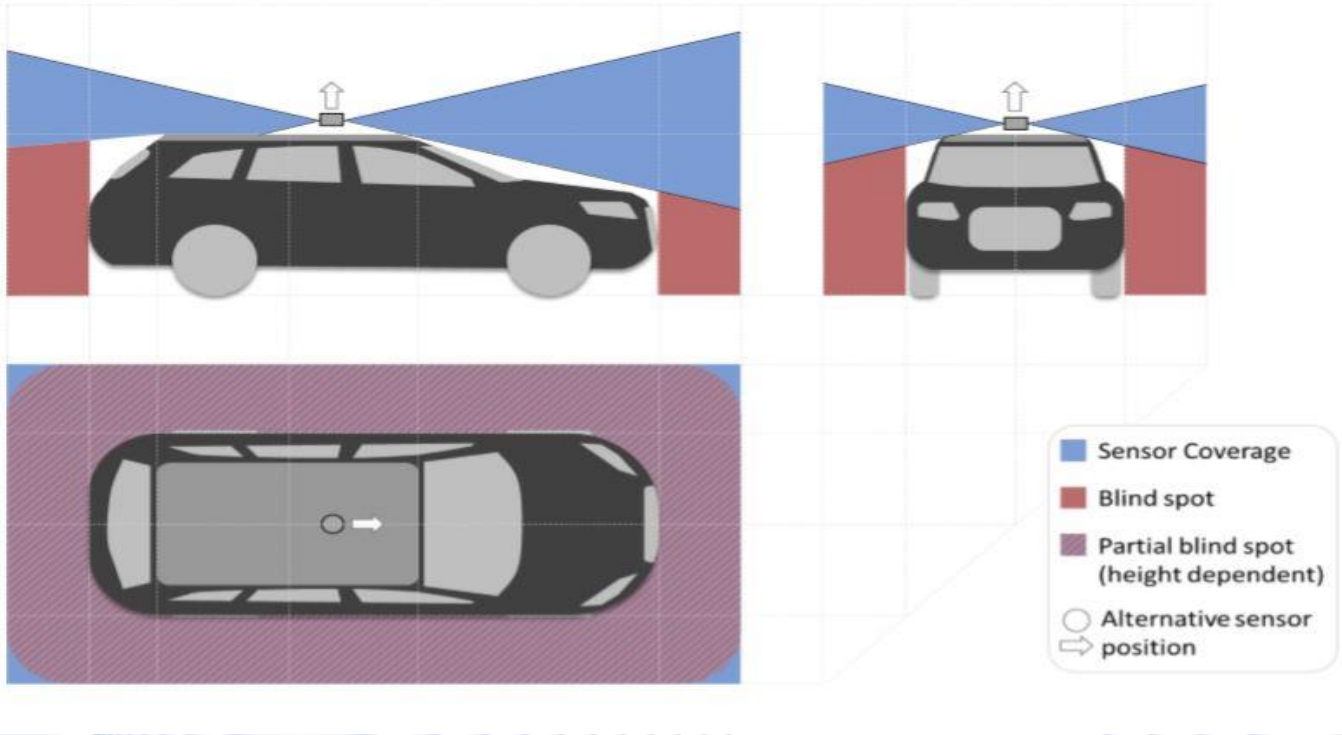


Figure: Single lidar on roof center.

Object detection & tracking

Lane detection involves lane marking detection and free space detection.

(a) (b)

Figure: Lane detection; (a) lane marking detection; (b) free space detection.

Object detection & tracking

Pedestrian detection can be either bounding box-level or instance/pixel-level [6].

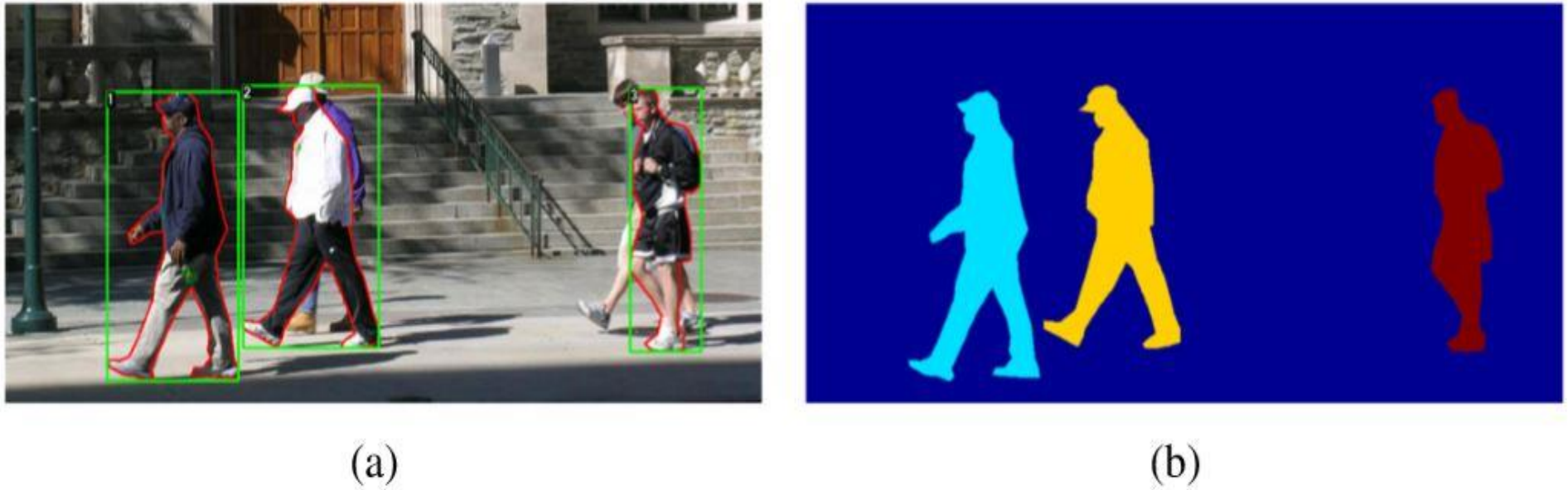


Figure: Pedestrian detection; (a) 2D bounding box-level detection; (b) instance/pixel-level detection.

[6] https://www.cis.upenn.edu/jshi/ped_html/

Object detection & tracking

Vehicles include cars, trucks, buses, etc.

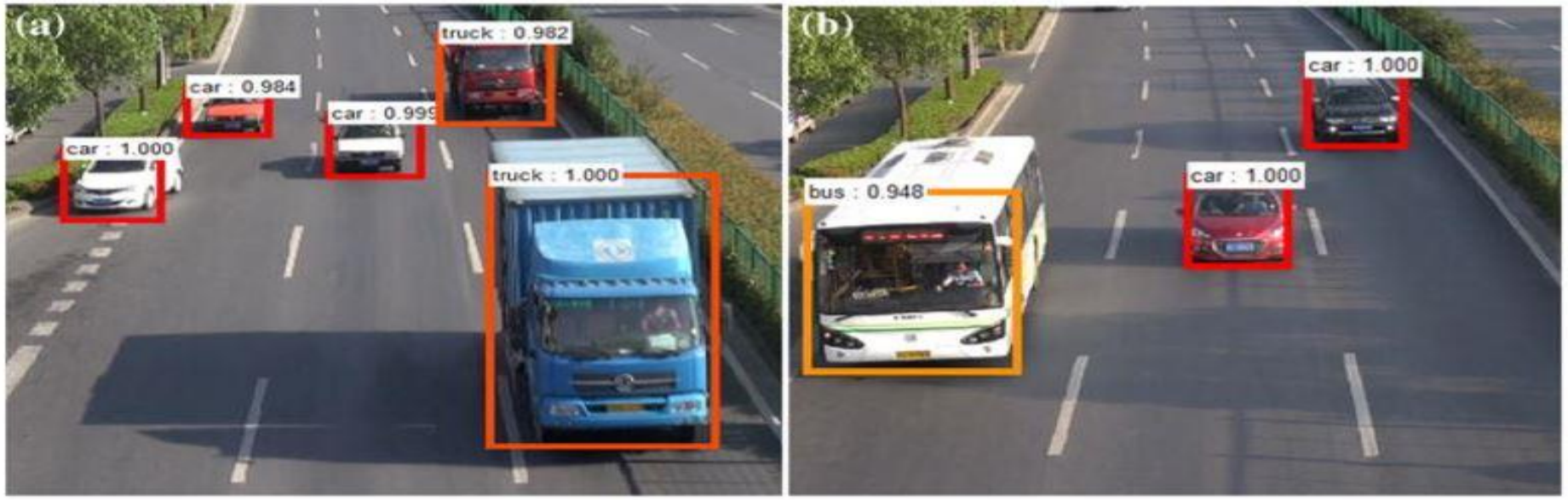


Figure: Vehicle detection.

Object detection & tracking

Traffic light and signage detection also involves classification process.

Figure: Traffic light and signage detection.

Depth/disparity estimation & 3D geometry reconstruction

Depth estimation can be achieved using either a single movable camera or an array of synchronized cameras [7].

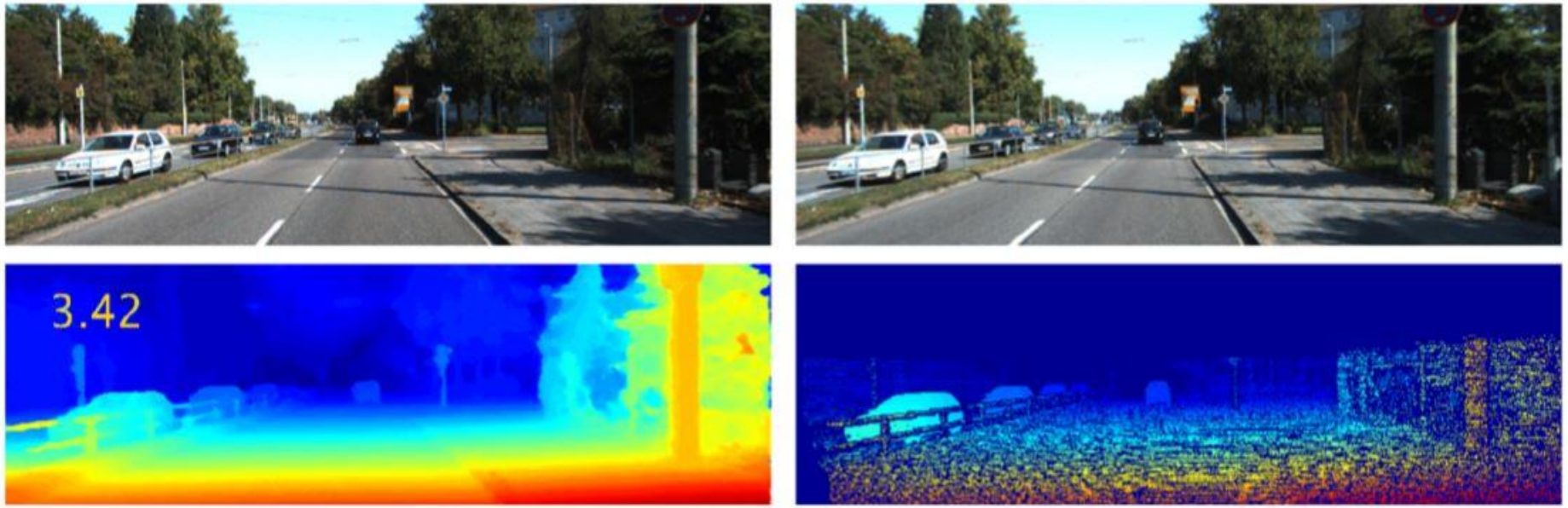


Figure: Disparity map estimation.

Localization & Mapping

- The state-of-the-art SLAM systems are generally classified as filter-based and optimization-based.
- The filter-based SLAM systems are derived from Bayesian filtering.
- The optimization-based SLAM approaches can be divided into two main branches: bundle adjustment (BA) and graph SLAM.
- According to the used sensor(s), SLAM systems can be classified as: Lidar-based, Lidar-IMU-based, visual and visual-IMU ones.

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Applications

- Civil and privately owned self-driving vehicles to optimize daily time management and reduce time spent driving;
- Self-driving trucks for “automated runs” and to reduce human resources;
- Mobility as a Service (MaaS) and car-sharing to minimize upfront costs and the need for parking space.
- Carpooling and taxi or bus services to eliminate driver’s costs paid by the commuters.
- Self-driving vans for leisure.

Q & A

Thank you very much for your attention!

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