Sensors and Computing Hardware

Course 1, Module 2, Lesson 1

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FACULTY OF APPLIED SCIENCE & ENGINEERING

In this module ...

- Sensors for perception
- Self-driving computing hardware
- Designing hardware configurations
- Software architecture, decomposition
- Environment representation for self-driving

In this video ...

- Sensors types and characteristics
- Self-driving computing hardware

Sensors

- Sensor: device that measures or detects a property of the environment, or changes to a property
- Categorization:
  - exteroceptive: extero = surroundings
  - proprioceptive: proprio = internal

Sensors for perception

exteroceptive

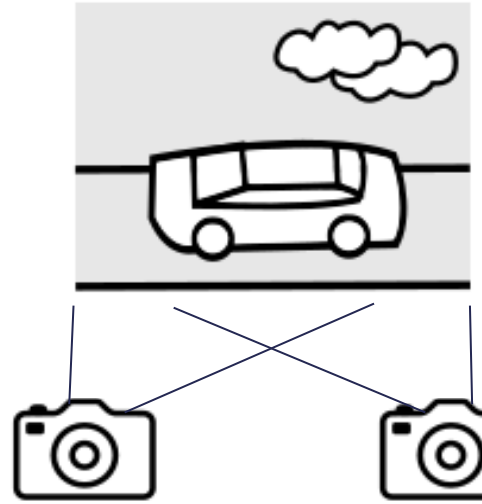
Camera

- Essential for correctly perceiving environment
- Comparison metrics:
  - Resolution
  - Field of view
  - Dynamic range
- Trade-off between resolution and FOV?

Sensors for perception

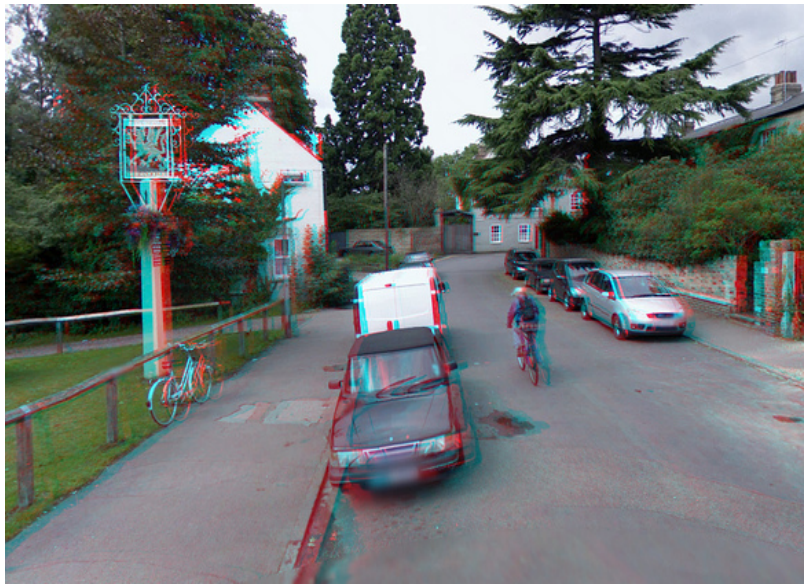
exteroceptive

Stereo



- Enables depth estimation from image data

Left and right images

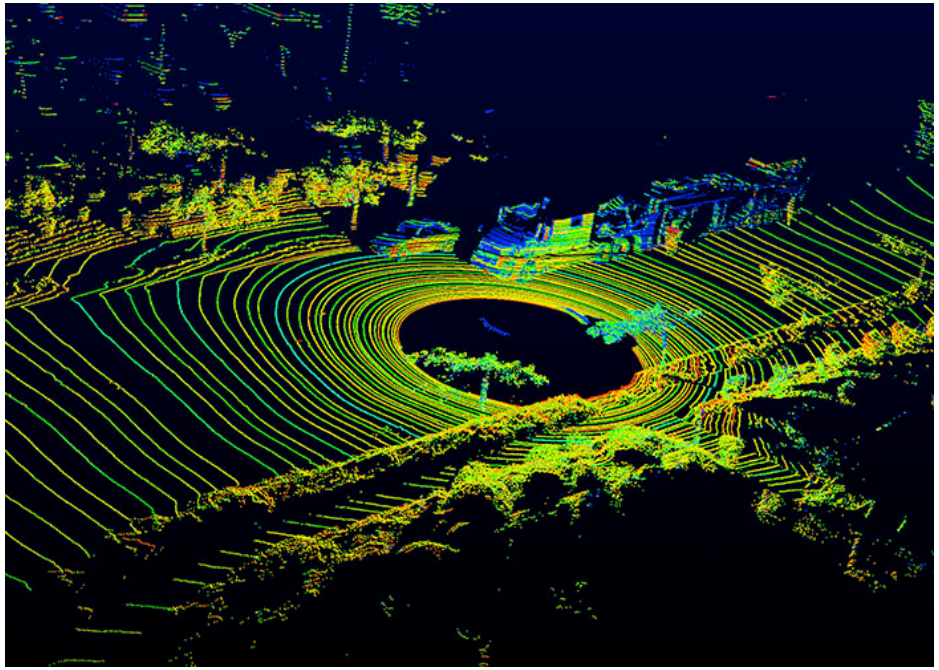


Sensors for perception

exteroceptive

LIDAR

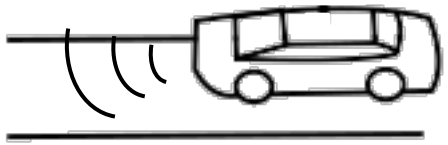
- Detailed 3D scene geometry from LIDAR point cloud
- Comparison metrics:
  - Number of beams
  - Points per second
  - Rotation rate
  - Field of view
- Upcoming: Solid state LIDAR!



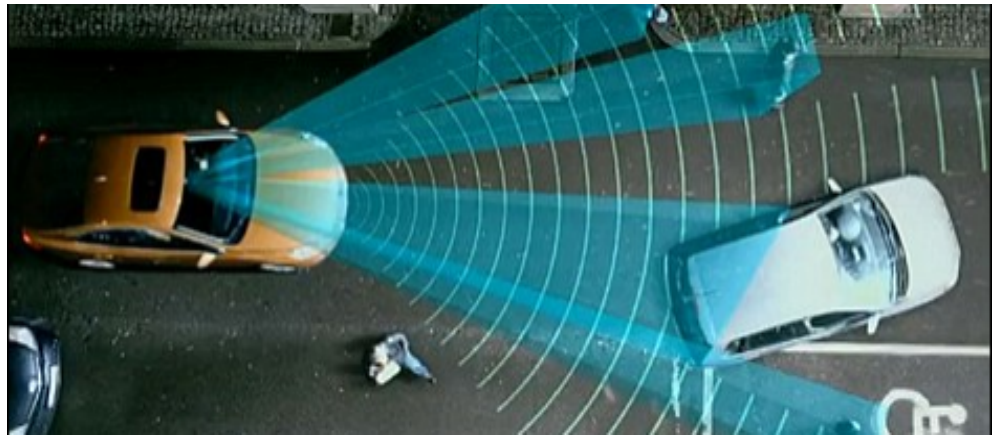
Sensors for perception

exteroceptive

RADAR



- Robust Object Detection and Relative Speed Estimation
- Comparison metrics:
  - range
  - field of view
  - position and speed accuracy
- Configurations:
  - WFOV, short range
  - NFOV, long range

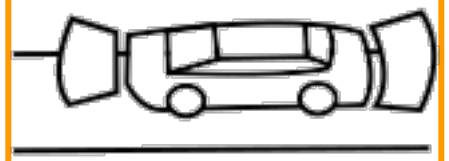


Works in poor visibility like fog and precipitation!

Sensors for perception

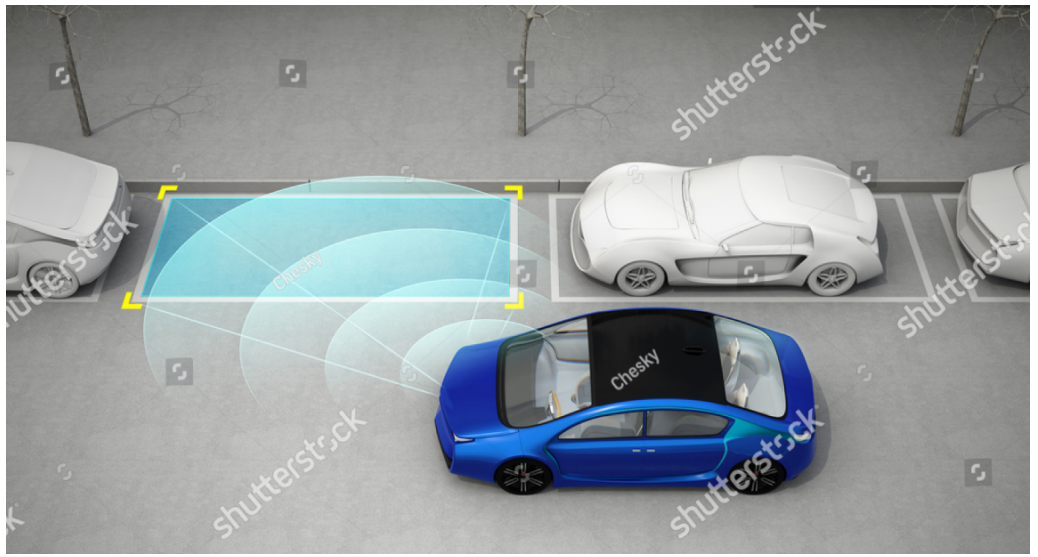
exteroceptive

Ultrasonics



- Short-range all-weather distance measurement
- Ideal for low-cost parking solutions
- Unaffected by lighting, precipitation

- Comparison metrics:
  - Range
  - Field of view
  - Cost



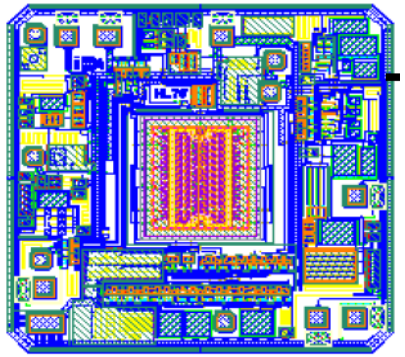
Sensors for perception

proprioceptive

GNSS/IMU

- Global Navigation Satellite Systems and Inertial measurement units

- Direct measure of ego vehicle states
  - position, velocity (GNSS)
    - Varying accuracies: RTK, PPP, DGPS
  - angular rotation rate (IMU)
  - acceleration (IMU)
  - heading (IMU, GPS)



Sensors needed for perception

proprioceptive

Wheel Odometry

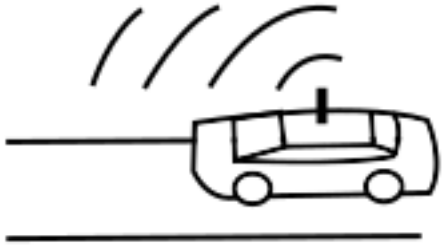
- Tracks wheel velocities and orientation
- Uses these to calculate overall speed and orientation of car
  - speed accuracy
  - position drift

Sensors needed for perception: Summary

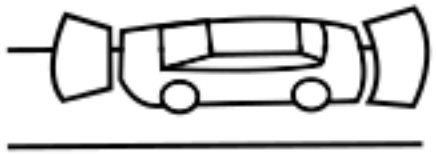
Camera

LIDAR

RADAR



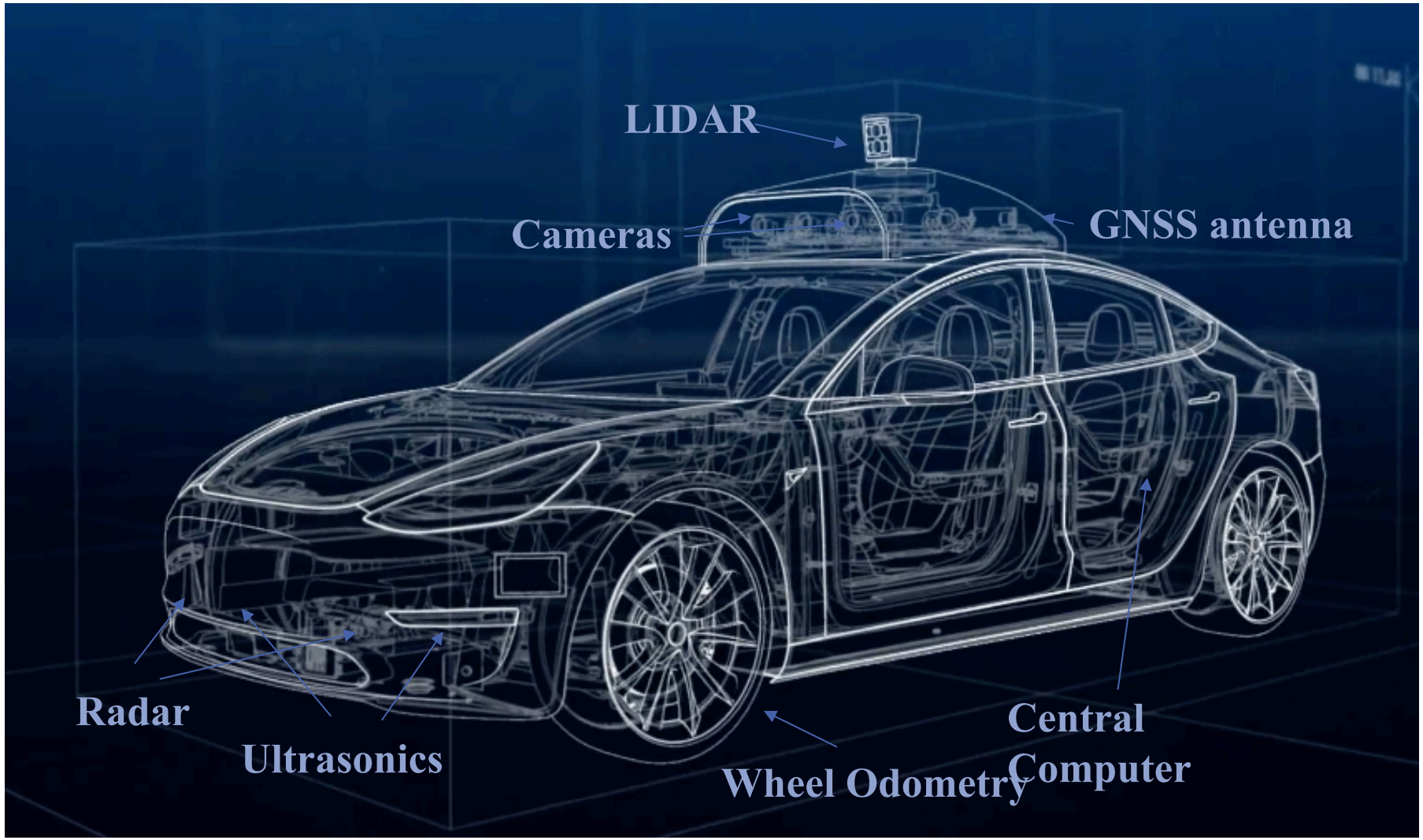
Ultrasonics



GNSS/IMU

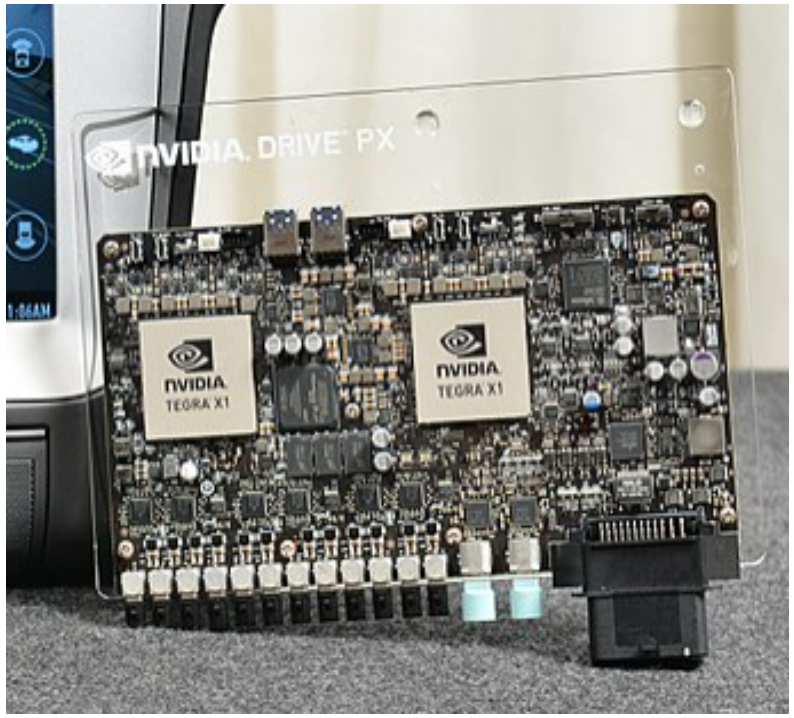
Wheel Odometry

Sensors needed for perception



Computing Hardware

- Need a “self-driving brain”
  - Takes in all sensor data
  - Computes actions
  - Already existing advanced systems that do self driving car processing (e.g. Drive PX/AGX, Intel & Mobileye EyeQ)



Computing Hardware

- Need a “self-driving brain”
- Image processing, Object detection, Mapping
  - GPUs - Graphic Processing Unit
  - FPGAs - Field Programmable Gate Array
  - ASICs - Application Specific Integrated Chip

Computing Hardware

- Need a “self-driving brain”
- Image processing, Object detection, Mapping
  - GPUs, FPGAs, ASICs
- Synchronization Hardware
  - To synchronize different modules and provide a common clock

Summary

- Sensors - exteroceptive and proprioceptive
  - camera, LIDAR, RADAR, ultrasonics, GNSS, IMU, wheel odometry
- Self-driving computing hardware