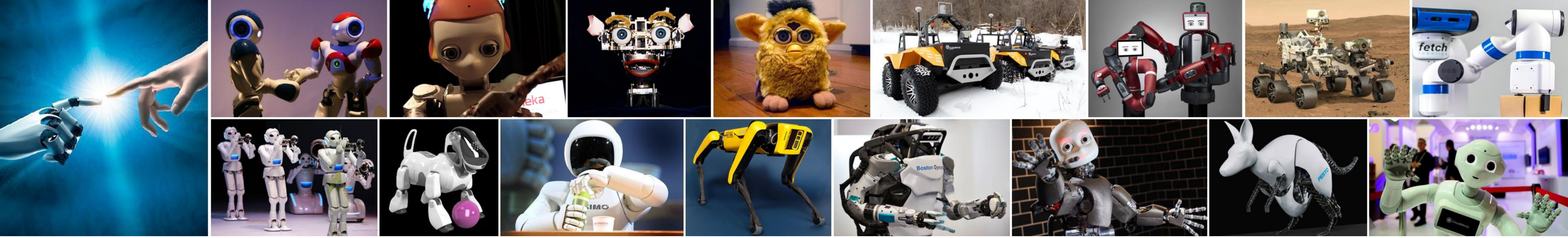
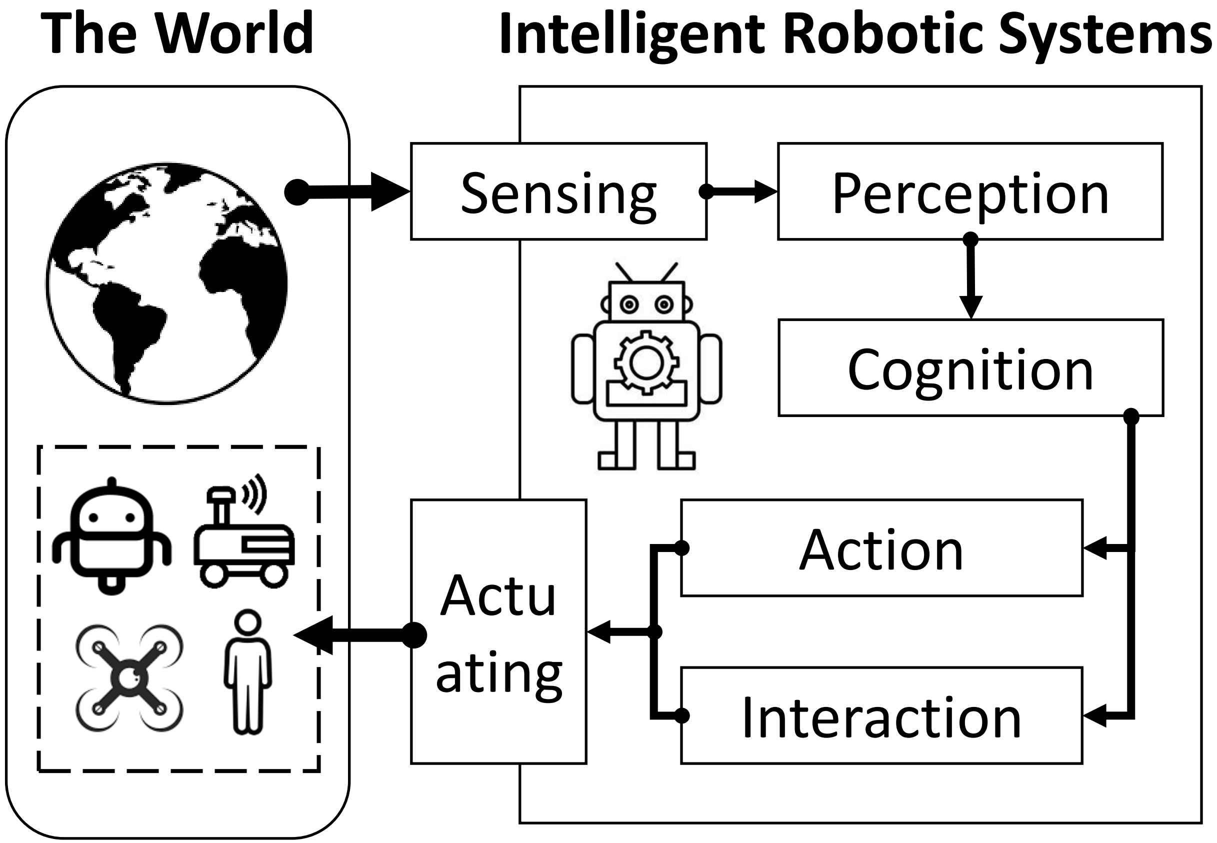


COMPSCI-603: Robotics

Sensing and Actuating

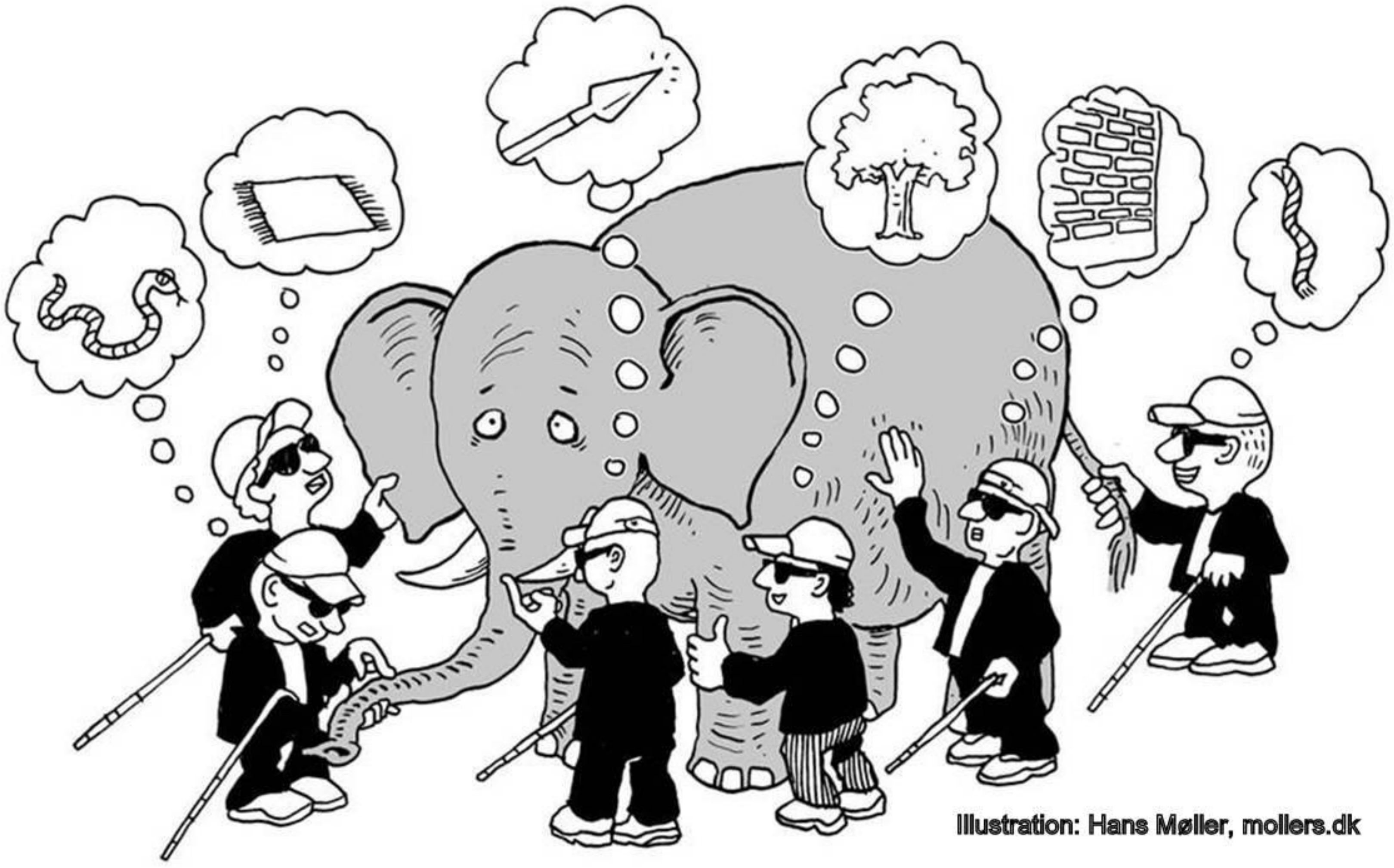
(Brief Overview)

Course Overview



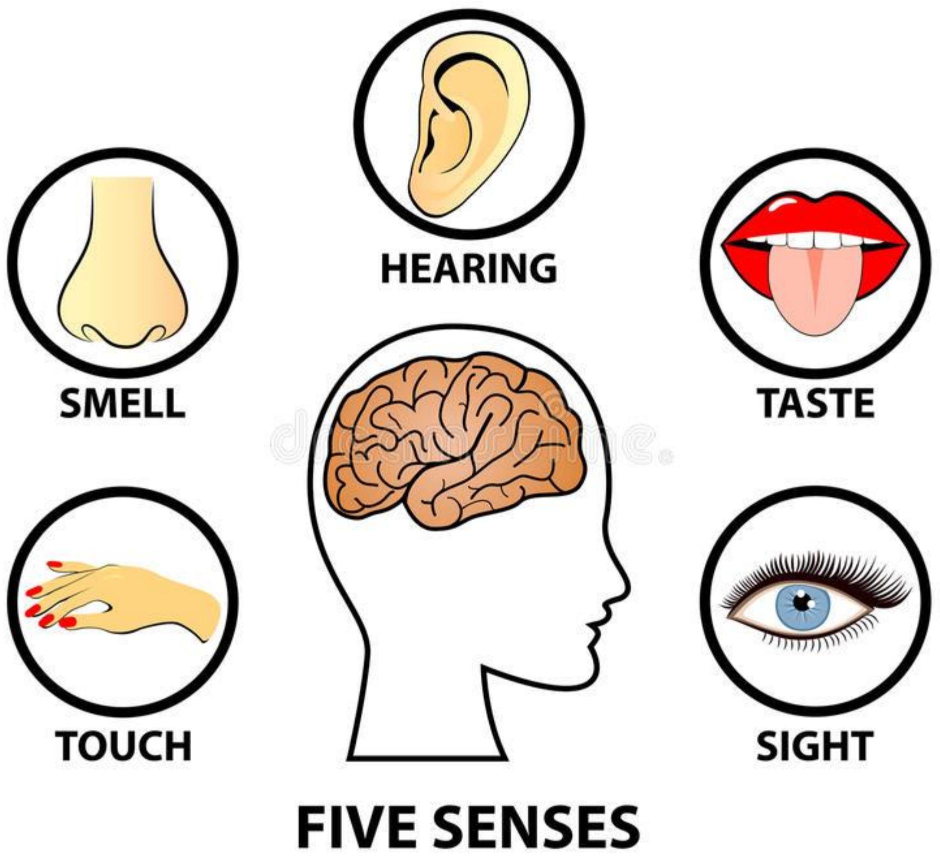
Robot Sensing

- What is the purpose of sensing for robots?



Sensors

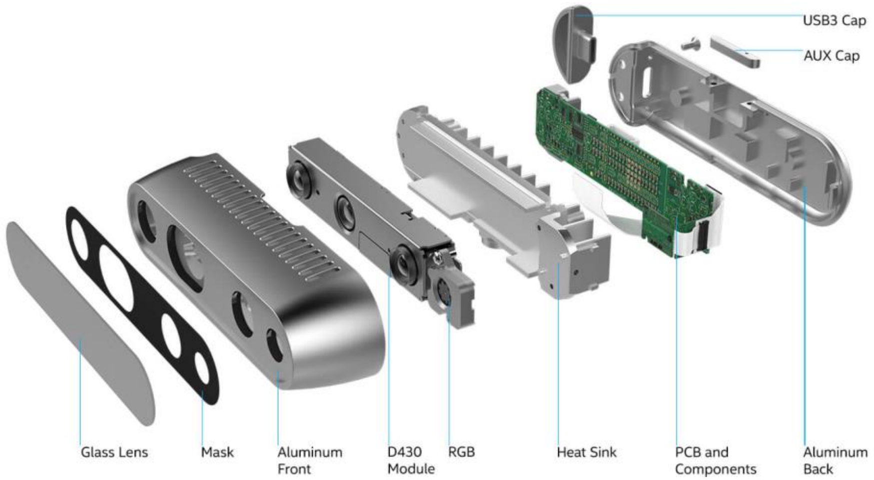
- Sensors are electronic devices that measure physical quantities.
- Sensors are a necessary physical component of the *perception* system of a robot.
- Sensors do not provide state, but measurement or observation
- Examples:
    - Contact: switch
    - Distance: radar
    - Location: GPS



Reference: Roland Siegwart, Illah Reza Nourbakhsh and Davide Scaramuzza. "Introduction to Autonomous Mobile Robots", Chapter 4, MIT Press, 2011.

Sensor Types

- From the perspective of energy emission:
  - Passive: receive energy only.
    - Vision → Camera
    - Hearing → Microphone
  - Active: emit energy and measure its response.
    - Radar, sonar
    - LiDAR
    - Structured light
    - Touch



Sensor Types

- From the perspective of information sources:
  - Proprioceptive sensors: measure values internally to the robot, e.g., for robot state estimation.
    - Battery status
    - Motor rotation
    - CPU temperature
  - Exteroceptive sensors: obtain observations of the external environment, e.g., for situational awareness.
    - Distance
    - Visual images
    - Thermal readings

Common Proprioceptive Sensors

- Odometry sensor (to estimate change in position over time): motor/wheel encoders.
- Inertial sensor (to estimate velocity): gyroscope, accelerometer.
- Heading sensor: compass.
- Tilting angle sensor: inclinometer.

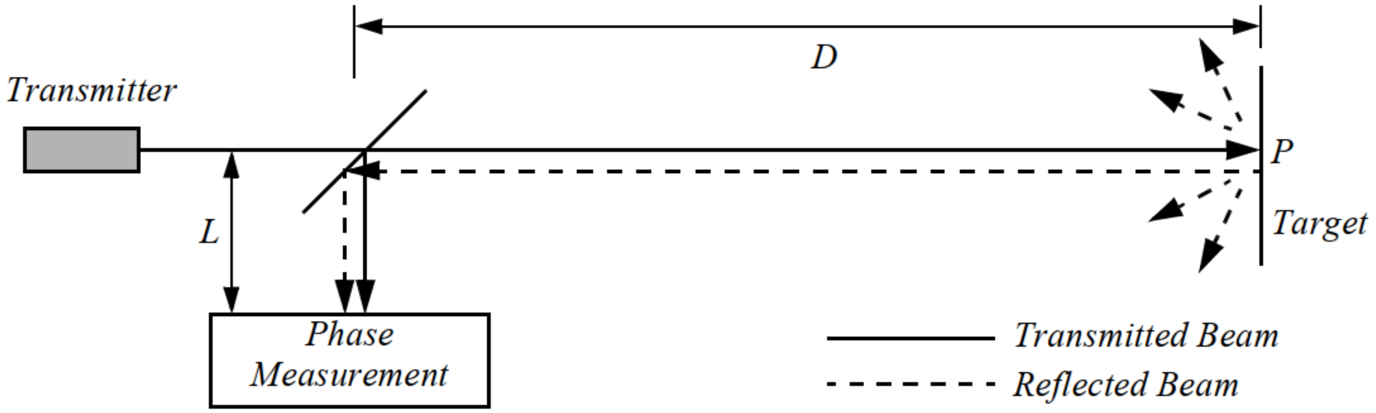
- Inertial measurement unit (IMU): an electronic device that uses a combination of accelerometers, gyroscopes, and sometimes magnetometers to measure orientation in space.

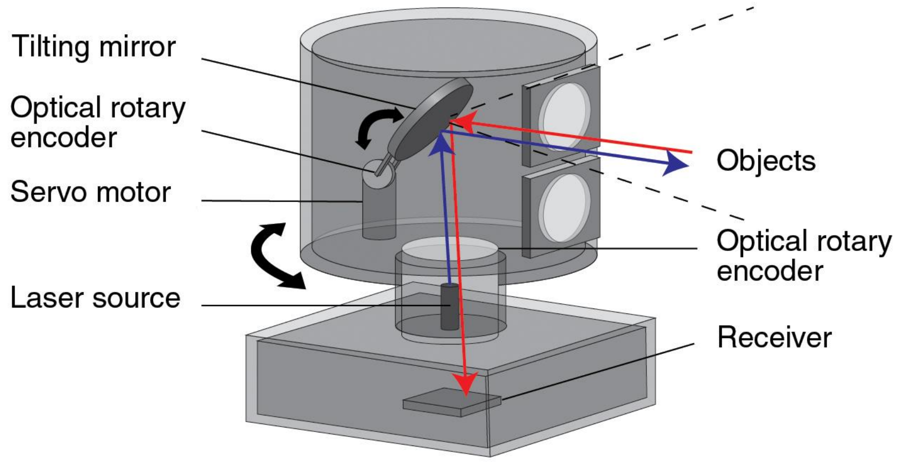
Common Exteroceptive Sensors

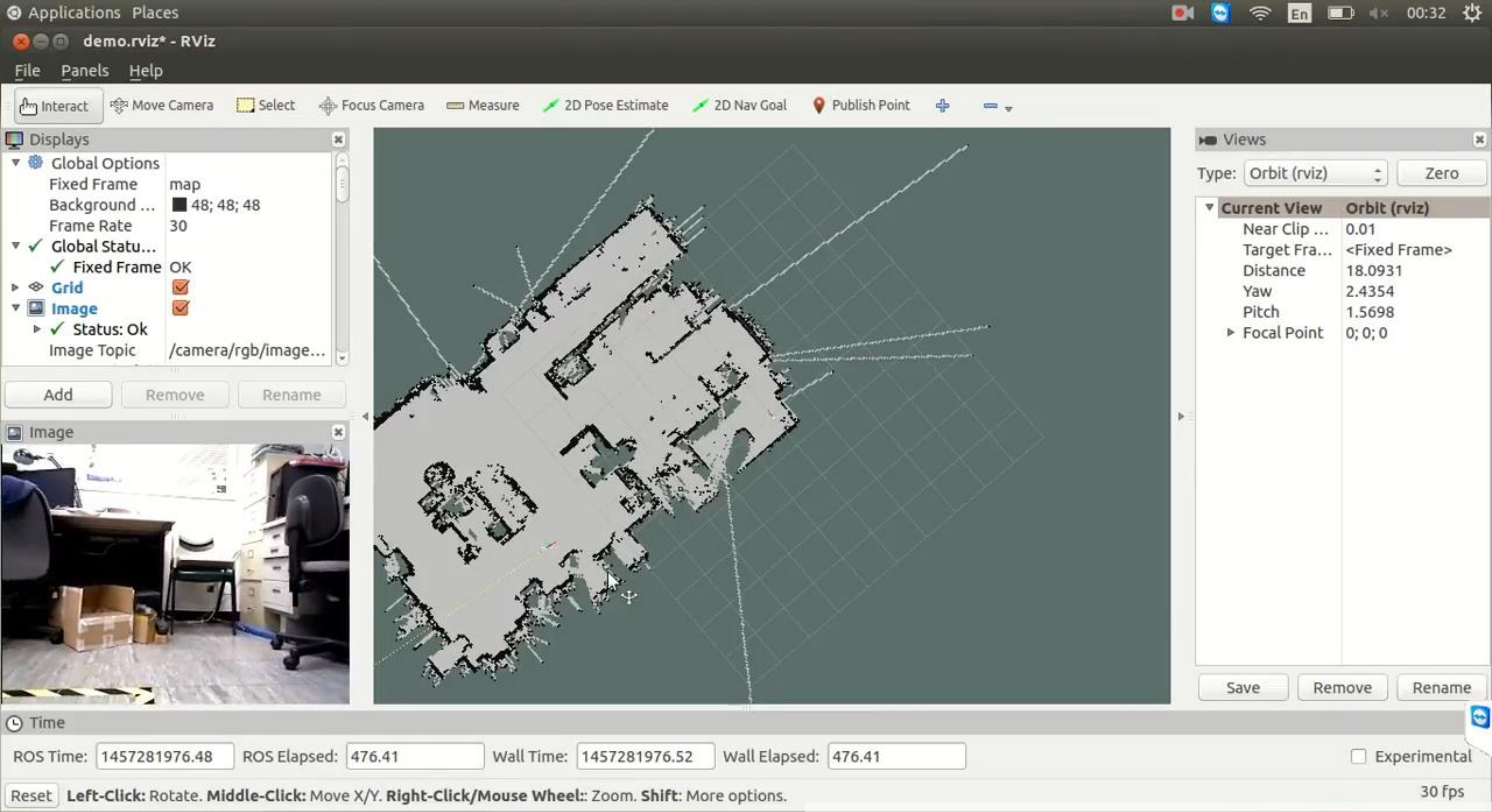
- Laser range sensor
  - Measures large range distance, so called range sensors.
  - Uses propagation speed of electromagnetic waves.
  - Thus, is also called Light Detection And Ranging (LiDAR).

RPLiDAR

Distance = (Speed of Light x Time of Flight) / 2



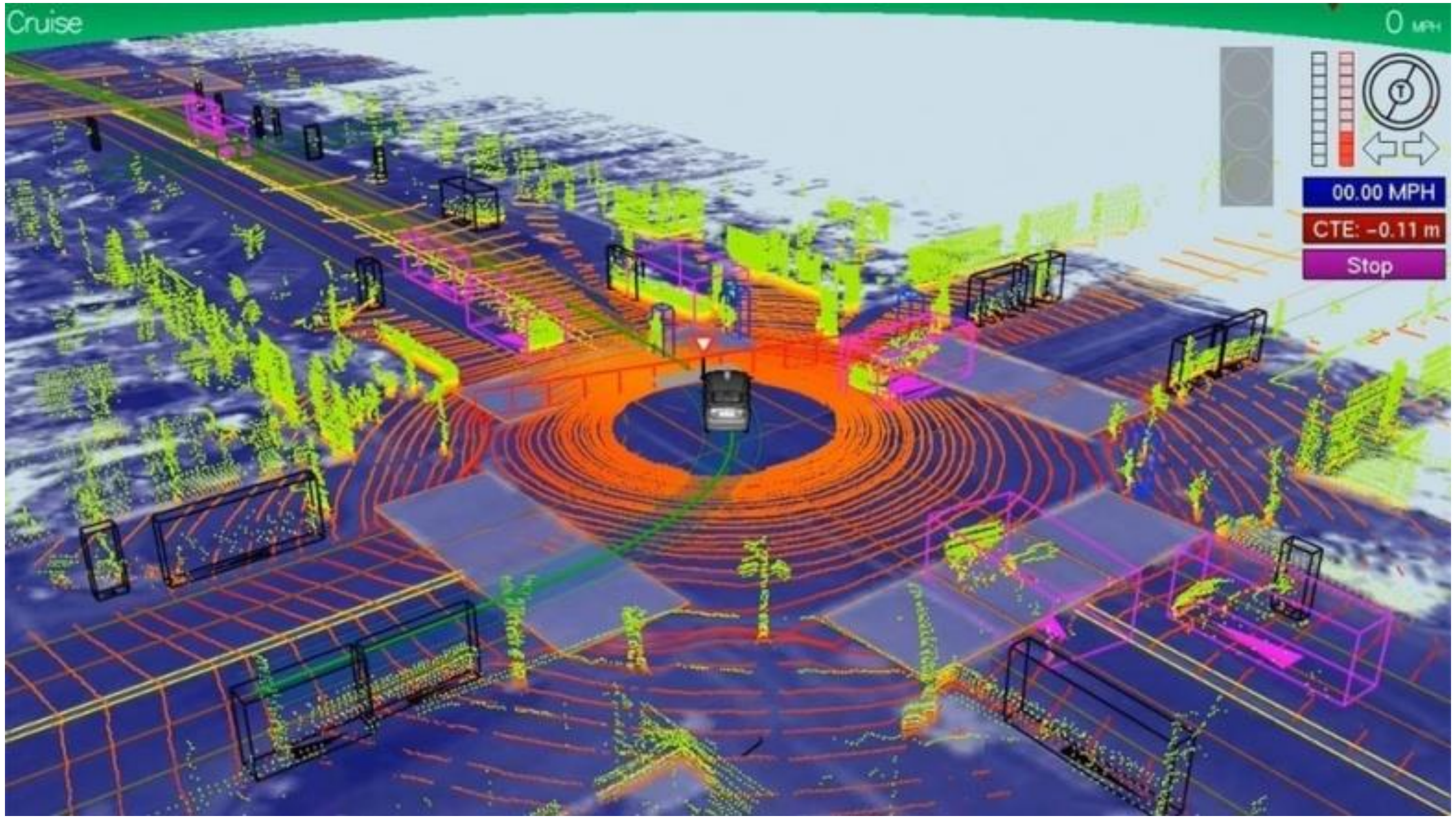


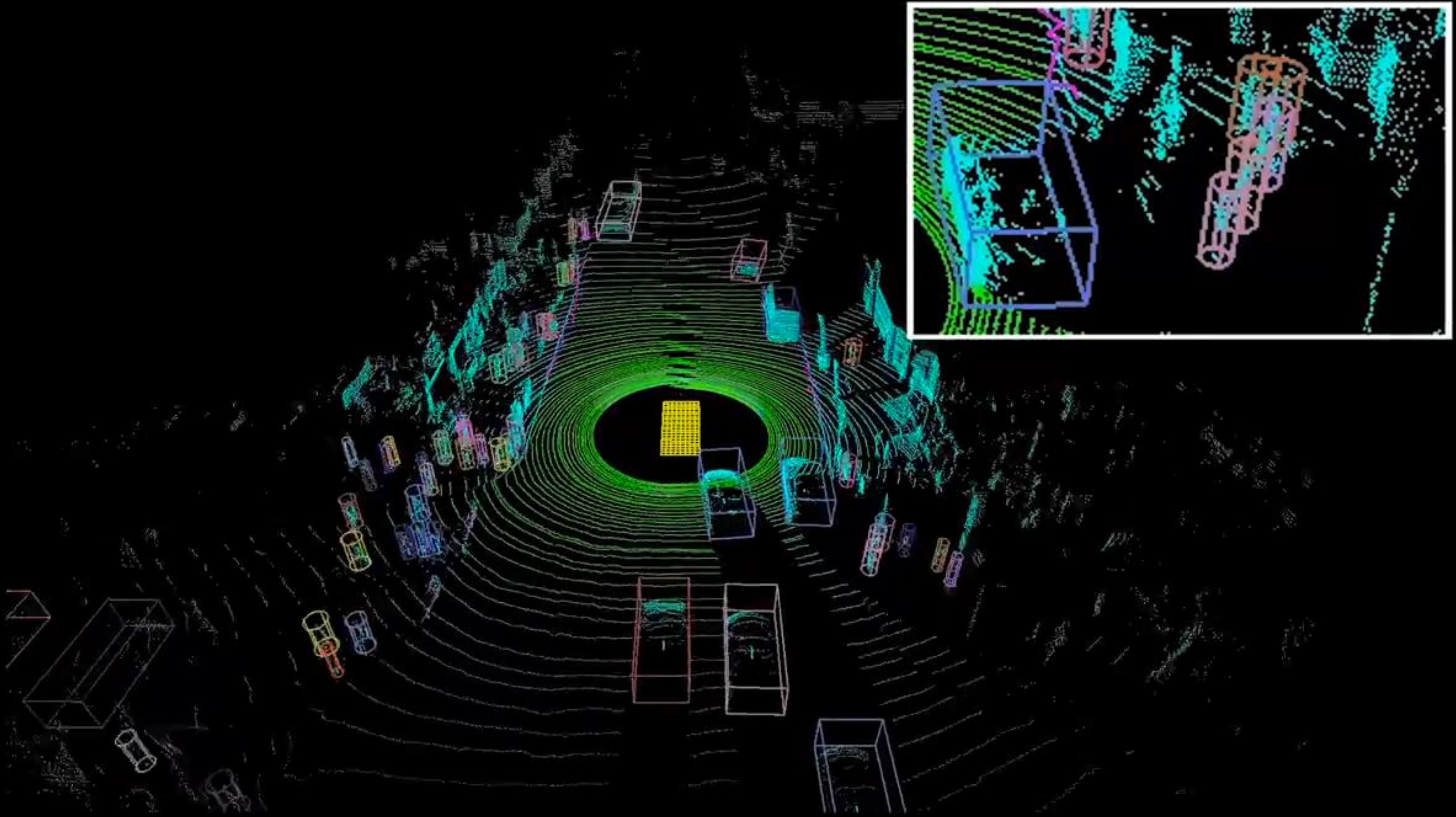


2D SLAM using PRLiDAR: https://www.youtube.com/watch?v=iVndhBqpp-0

Common Exteroceptive Sensors

- 3D LiDAR: use multiple laser beams to expend the vertical field of view.

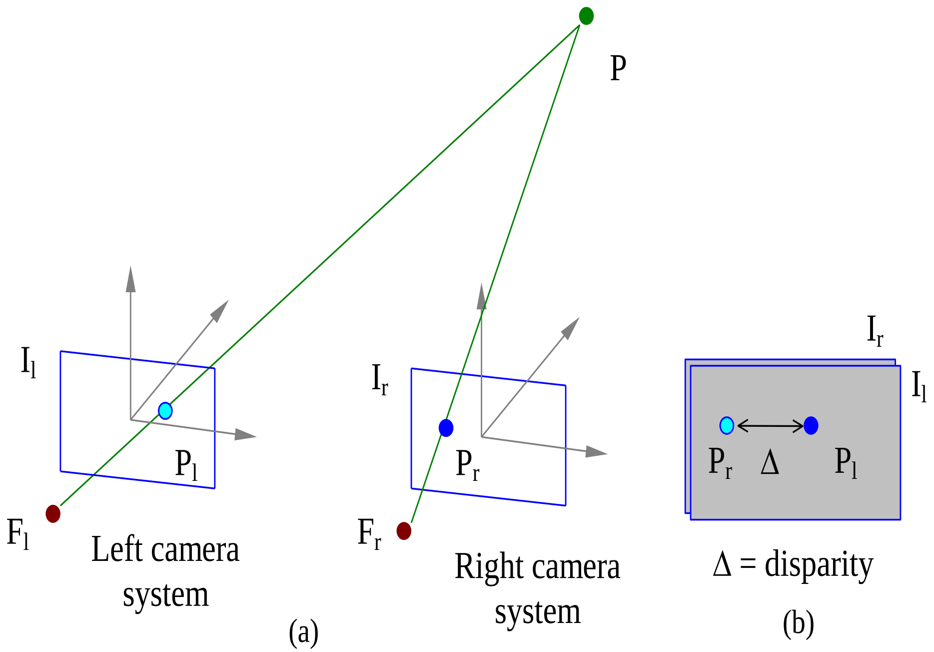


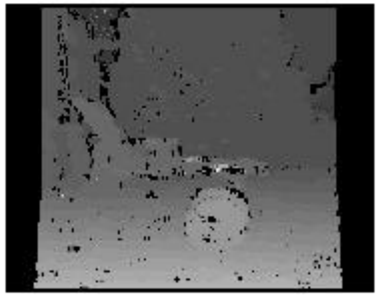


NVIDIA DRIVE Labs: https://www.youtube.com/watch?v=T7w-ZCVVUgM

Common Exteroceptive Sensors

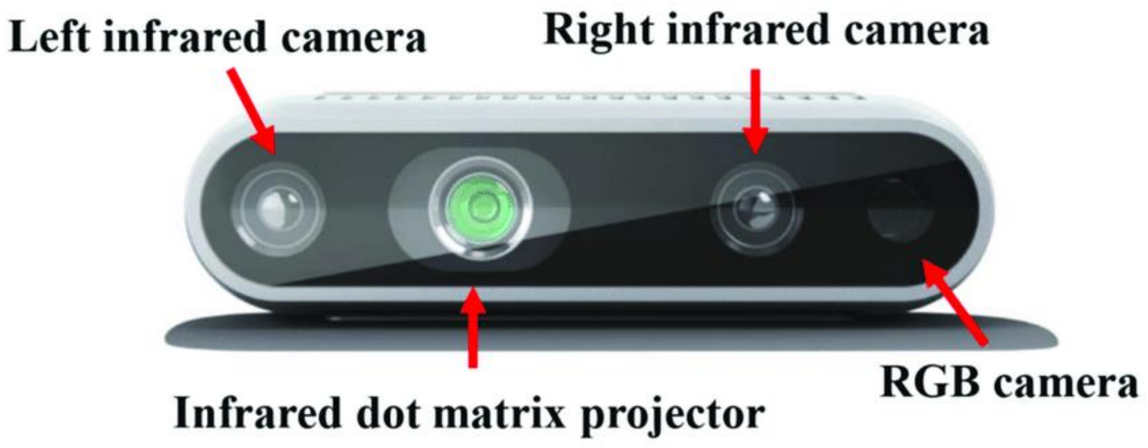
- Stereo camera: two (or more) cameras looking at the same scene from different perspectives provide a mean for determining three-dimensional shape and position.



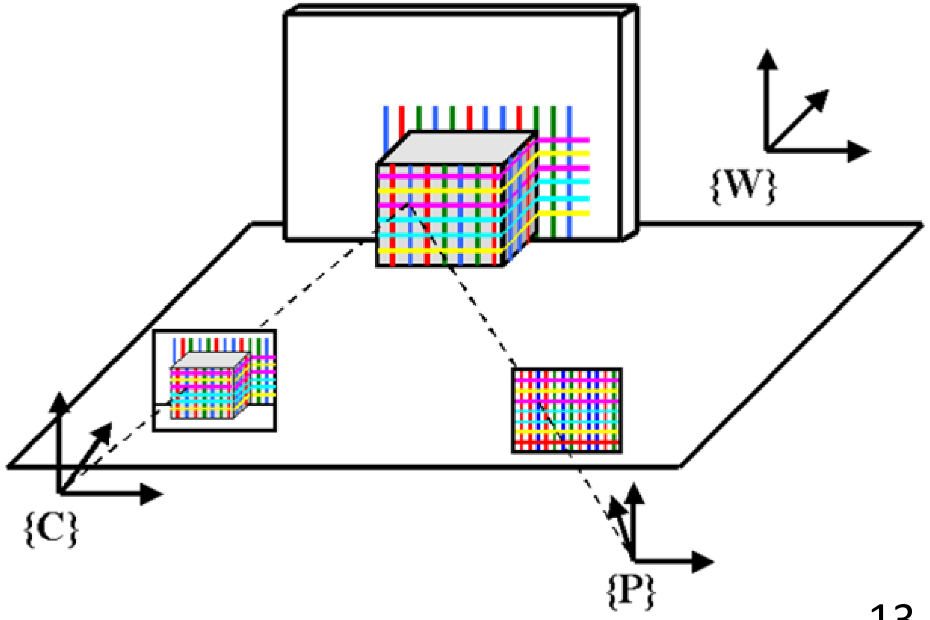


Common Exteroceptive Sensors

- Structured light sensor (color-depth sensors):
  - Projects a known pattern onto the scene.
  - Measures the similarity of sensed and projected patterns to find correspondence.
  - Uses triangulation to estimate distance.

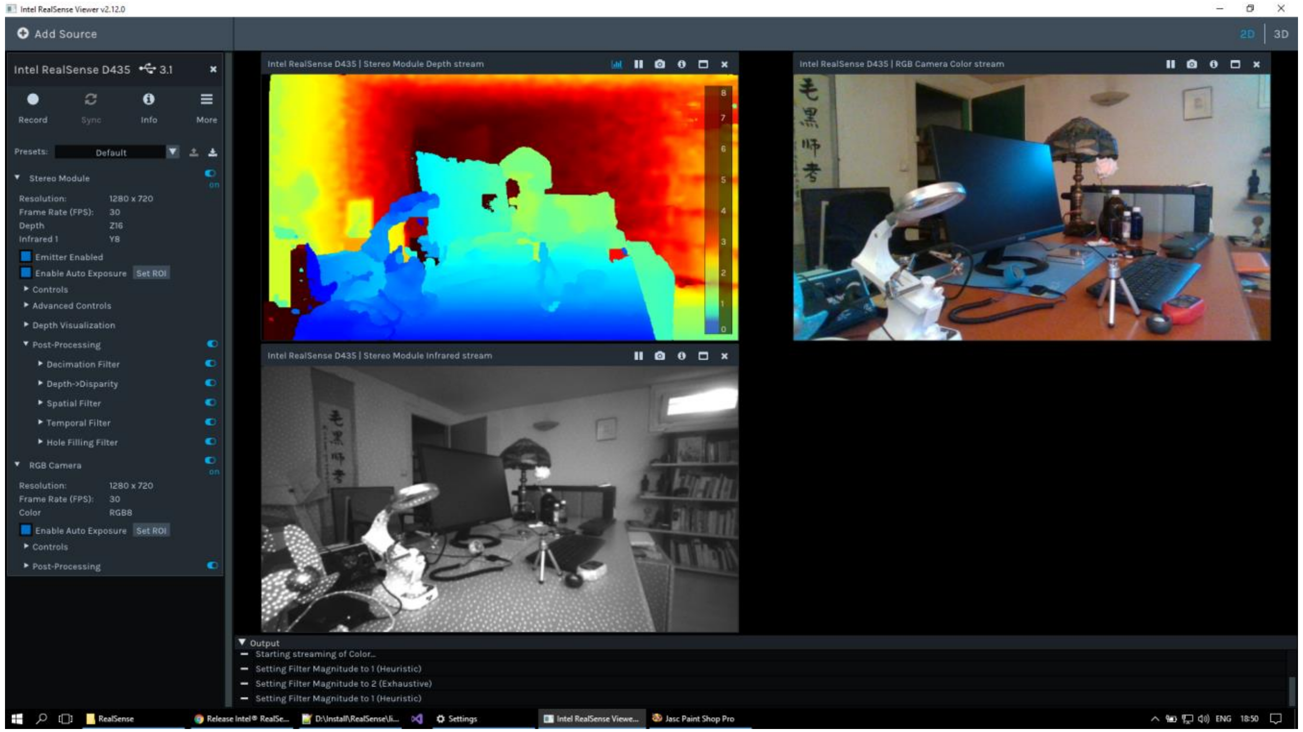


Intel RealSense D435

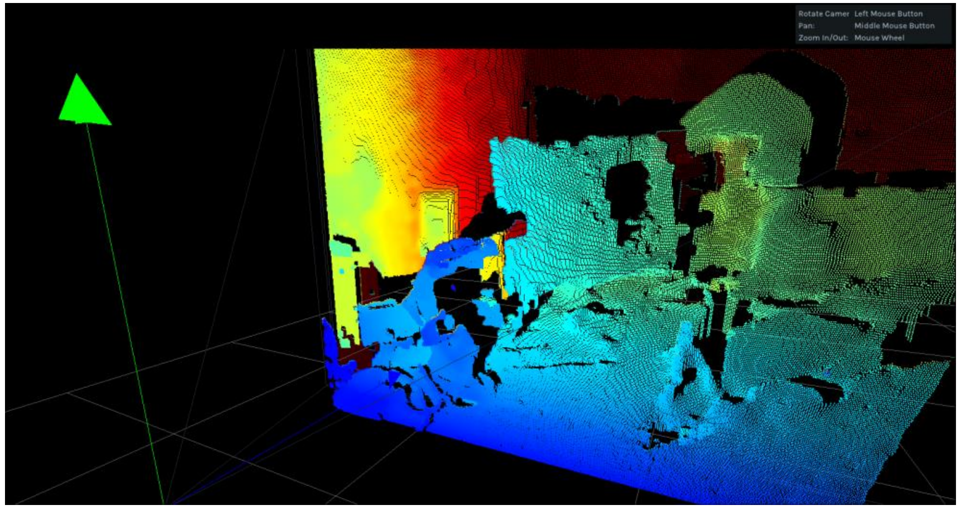


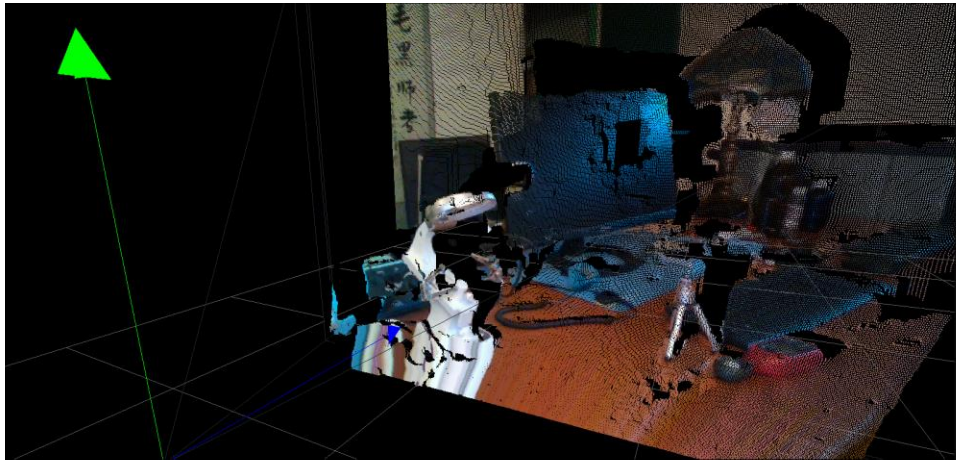
Common Exteroceptive Sensors

- Structured light sensor:
  - https://github.com/IntelRealSense/librealsense/releases

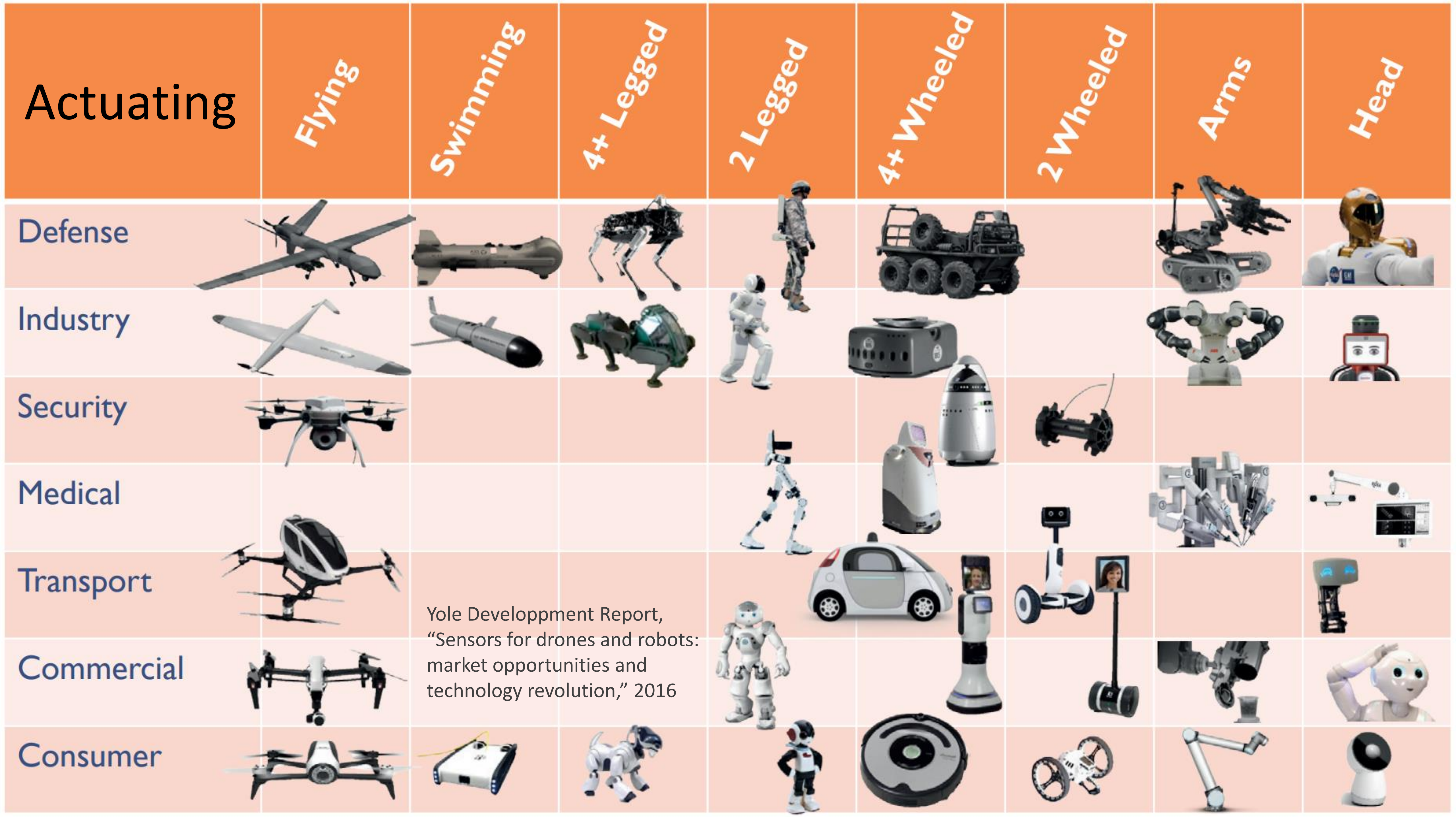


Reference: “Intel RealSense D435 review” by Maurice's Musings.





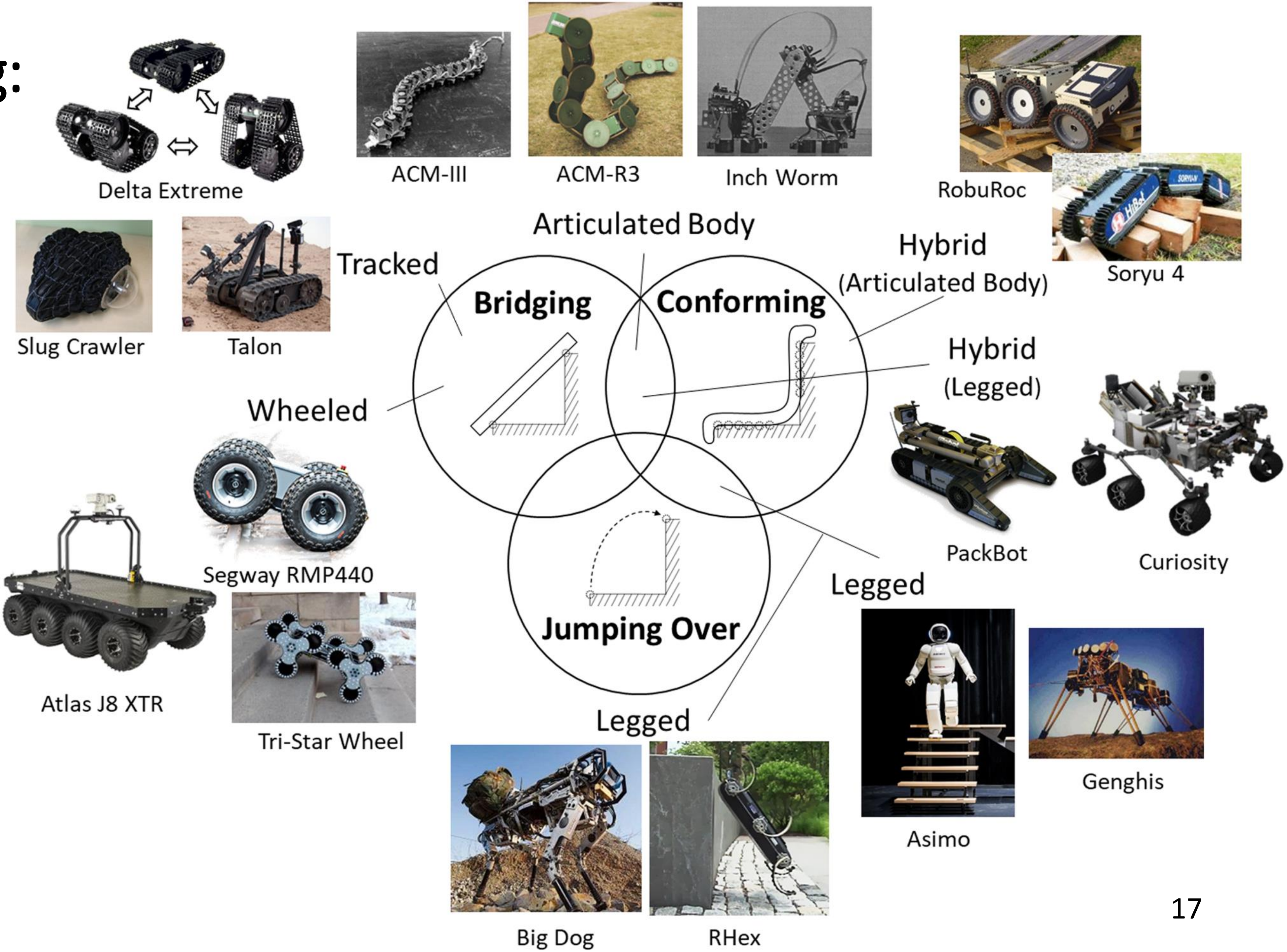
http://www.youtube.com/watch?v=9Y4RQVpp-BY



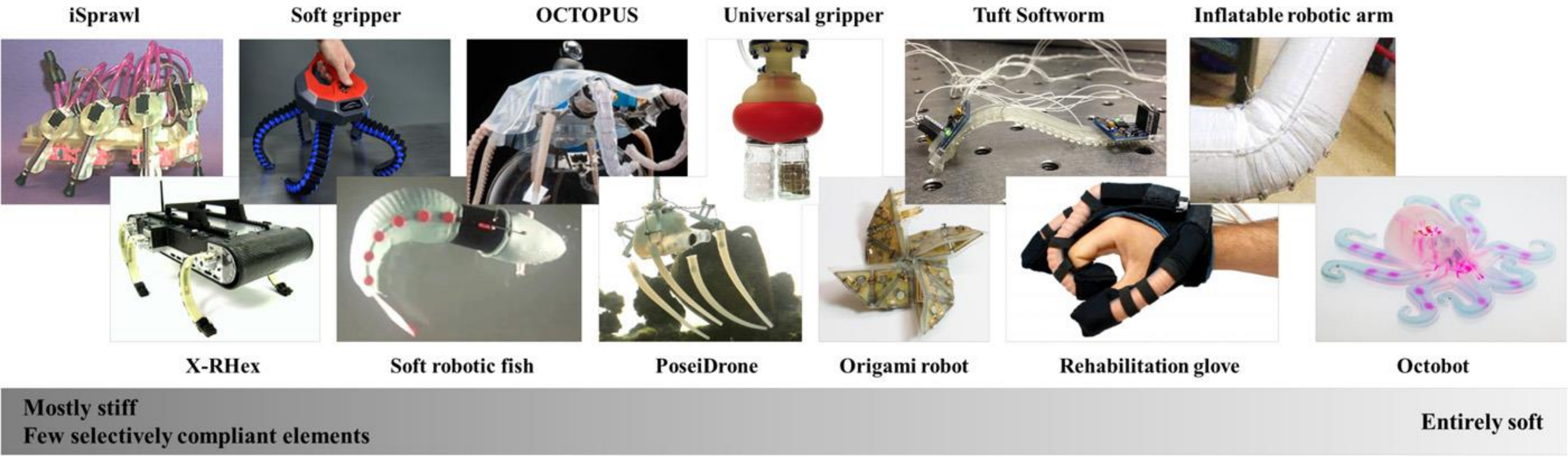
Yole Developpment Report, “Sensors for drones and robots: market opportunities and technology revolution,” 2016

Actuating: Mobile Robots

Chun Fan Goh, Akshay Hinduja, Divish Ajmani, Robin Song, Lei Zhang, and Kenji Shimada. "Designing a mobility solution for fully autonomous welding of double-hull blocks." Journal of Mechanisms and Robotics 11, no. 4. 2019.



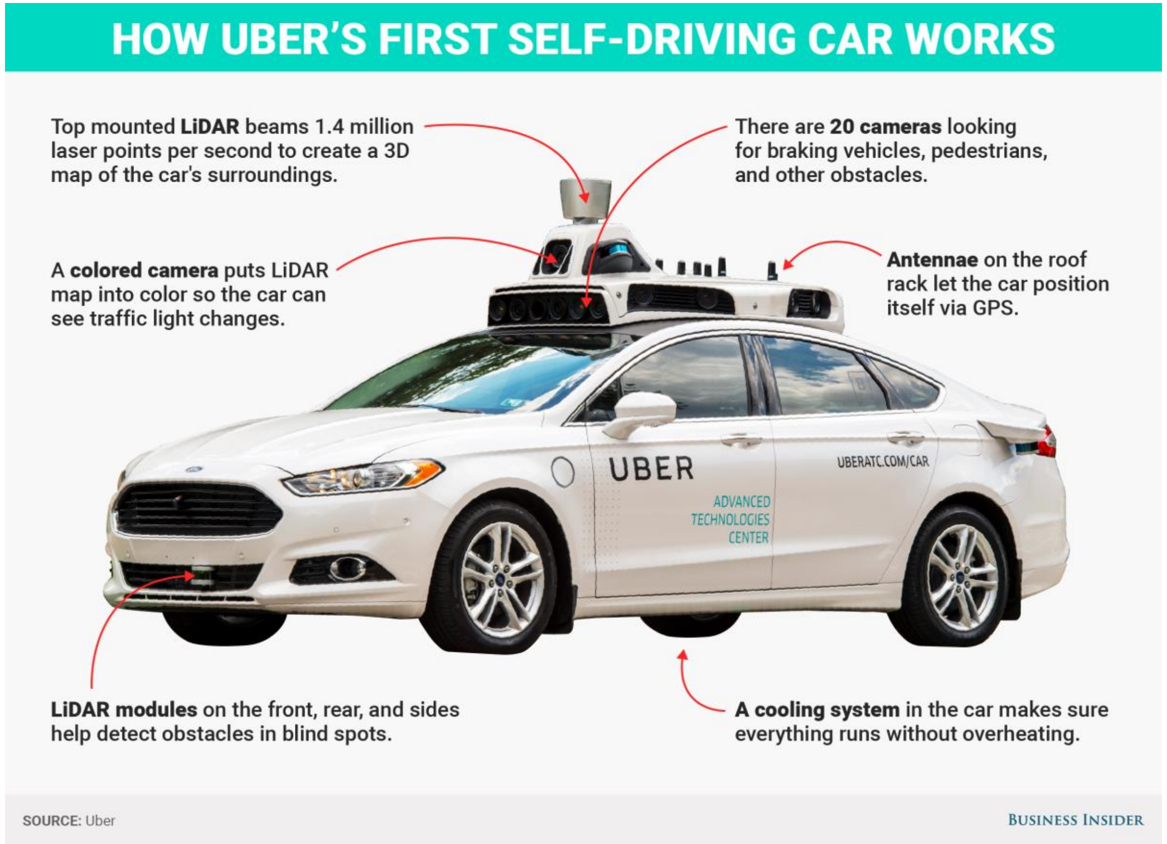
Actuating: Soft Robots

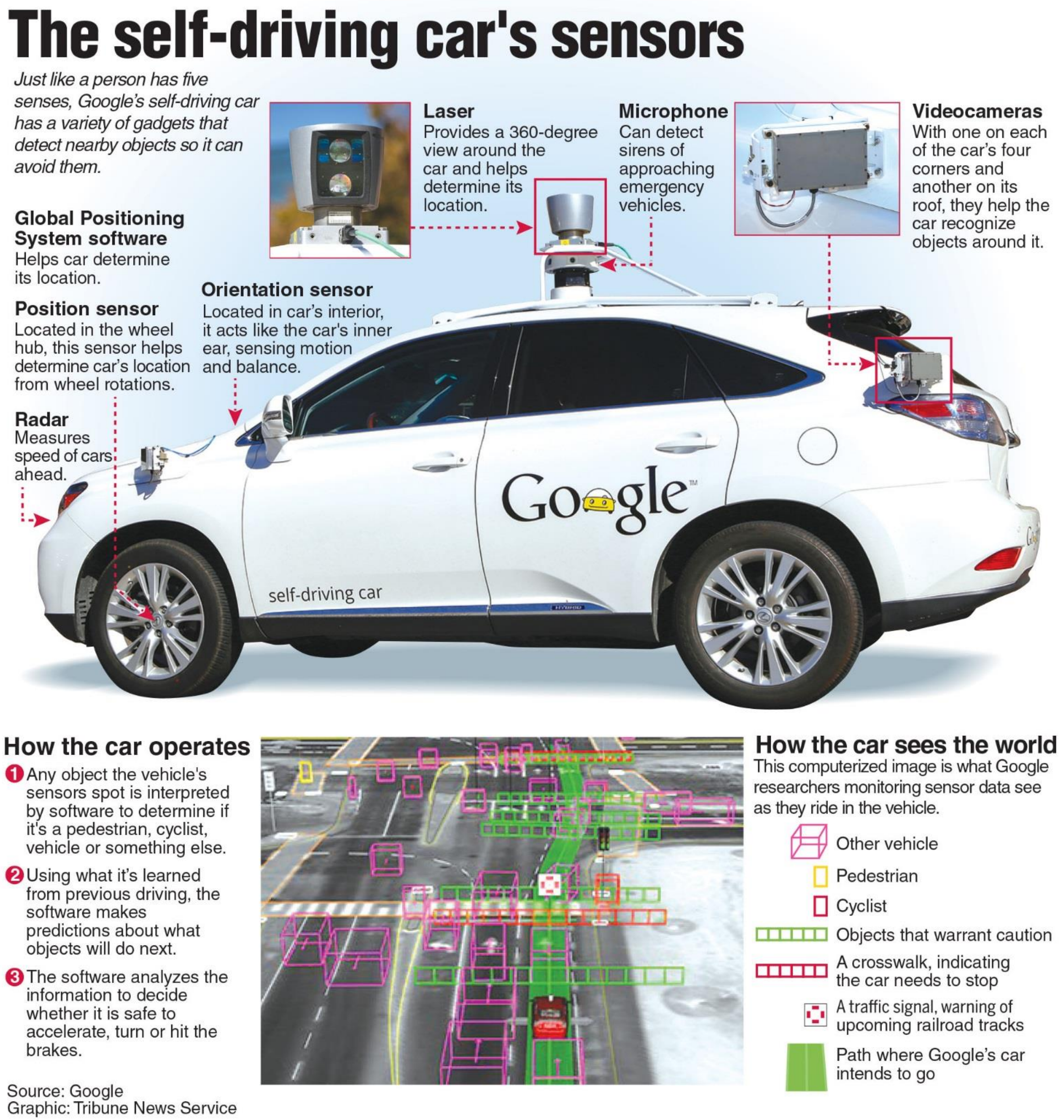


Cecilia Laschi, Barbara Mazzolai, and Matteo Cianchetti. "Soft robotics: Technologies and systems pushing the boundaries of robot abilities." Science robotics 1, no. 1. 2016.

Real-World Robots

- Autonomous driving





Real-World Robots

- Mars Rover