Introduction to Mobile Robotics

Proximity Sensors

Wolfram Burgard, Michael Krawez

UTN

Sensors of Wheeled Robots

Perception of the environment

Active:

- Ultrasound
- Laser range finder
- Infrared

Time of flight

Phase shift

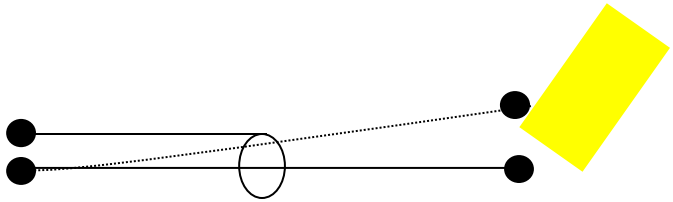
Passive:

- Cameras
- Tactiles

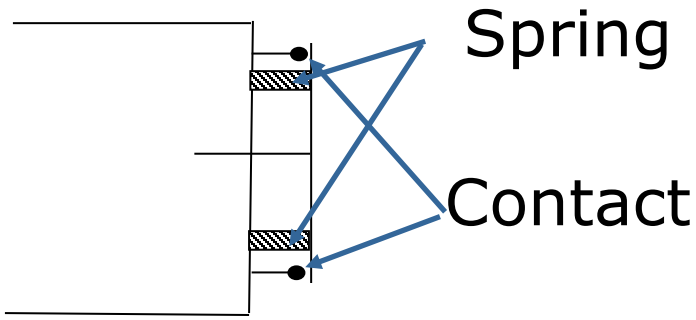
Intensity-based

Tactile Sensors

Measure contact with objects



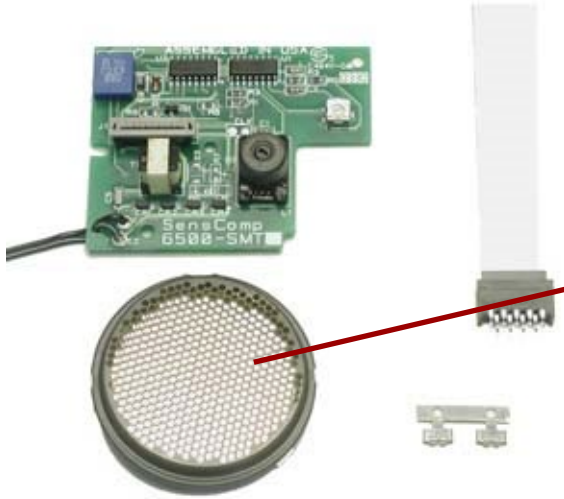
Touch sensor



Bumper sensor

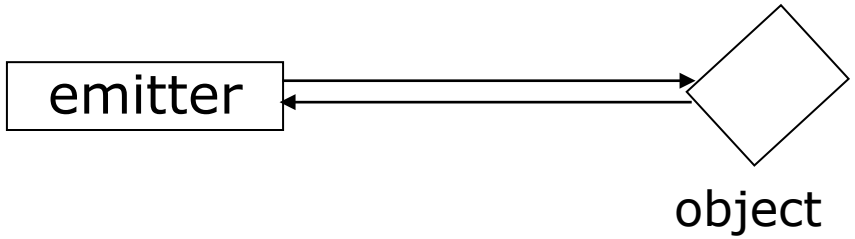
Ultrasound Sensors

- Emit an ultrasound signal
- Wait until they receive the echo
- Time of flight sensor



Polaroyd 6500

Time of Flight Sensors



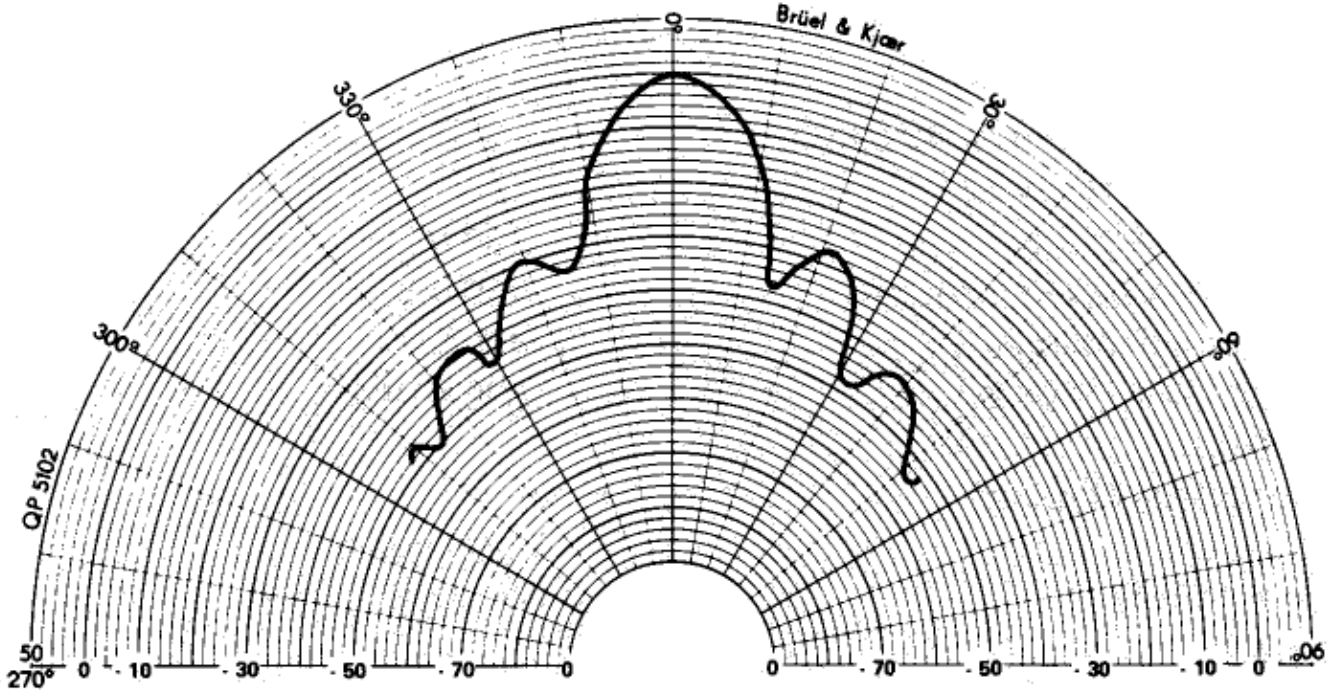
$$d = v \times t / 2$$

v: speed of the signal

t: time elapsed between broadcast of signal and reception of the echo.

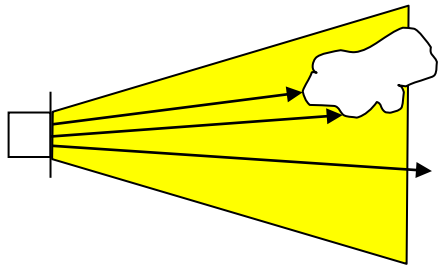
Properties of Ultrasounds

- Signal profile [Polaroid]

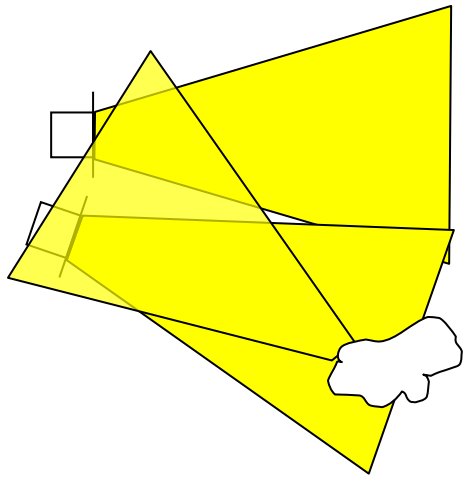


Sources of Error

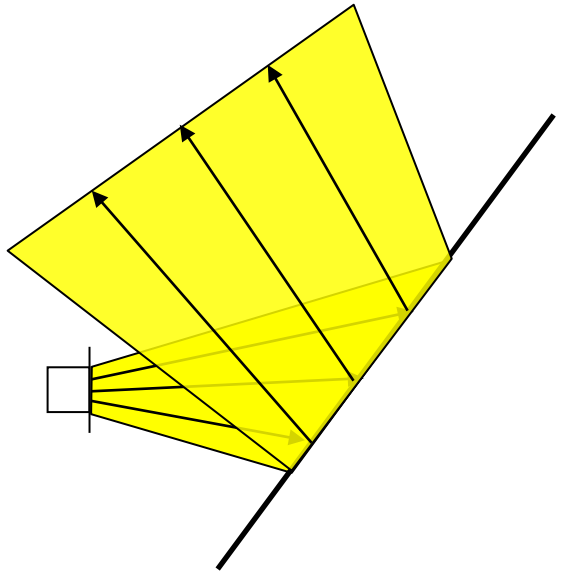
Opening angle



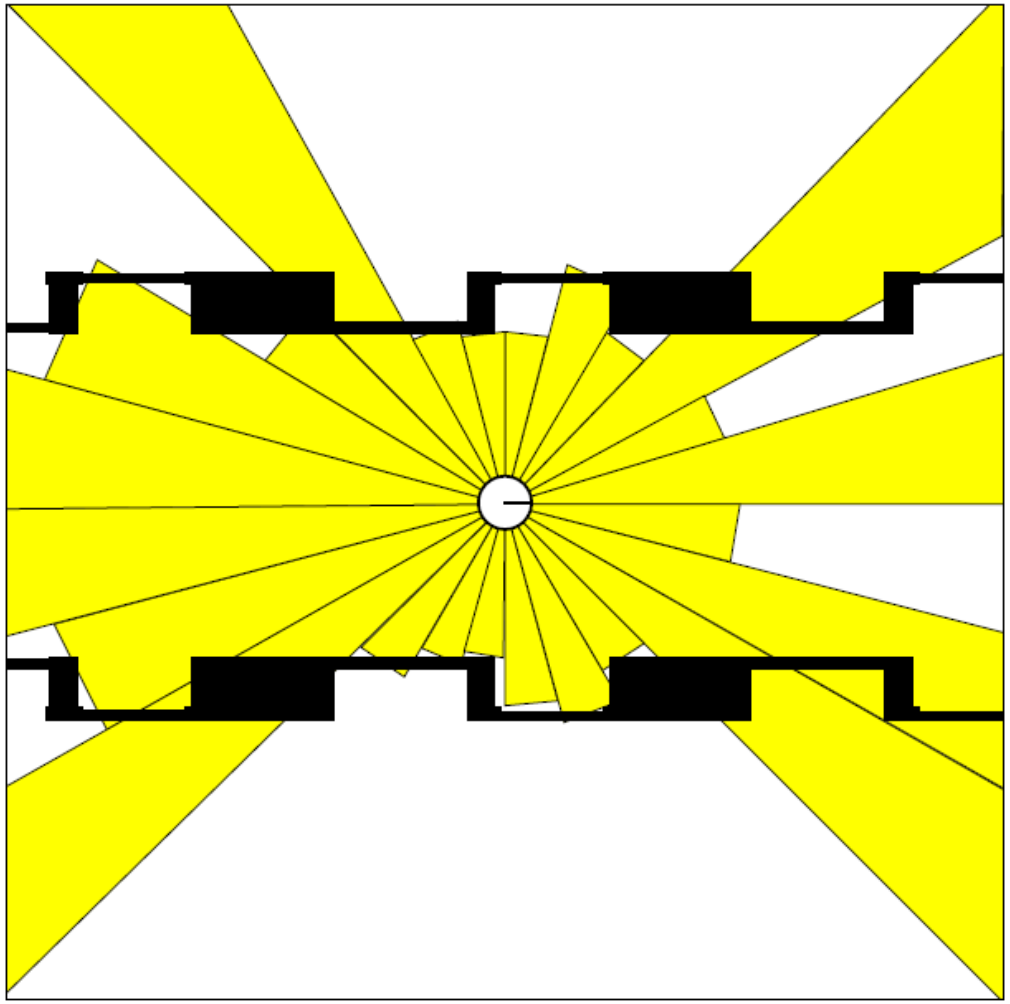
Crosstalk



Specular reflection



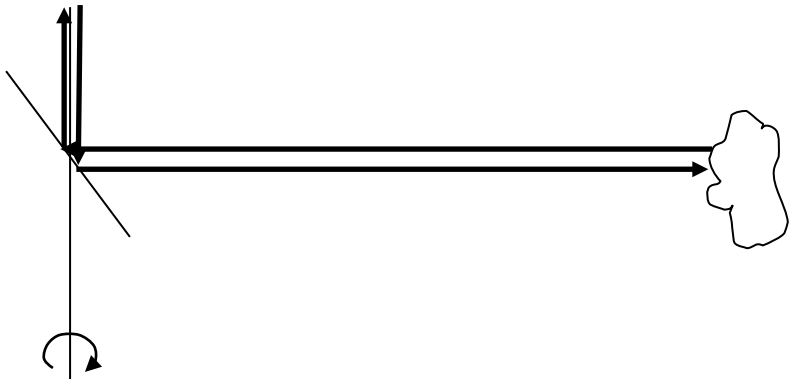
Typical Ultrasound Scan



Parallel Operation

- Given a 15 degrees opening angle, 24 sensors are needed to cover the whole 360 degrees area around the robot.
- Let the maximum range we are interested in be 10m.
- The time of flight then is 2*10/330 s=0.06 s
- A complete scan requires 1.45 s
- To allow frequent updates (necessary for high speed) the sensors have to be fired in parallel.
- This increases the risk of crosstalk

Laser Range Scanner

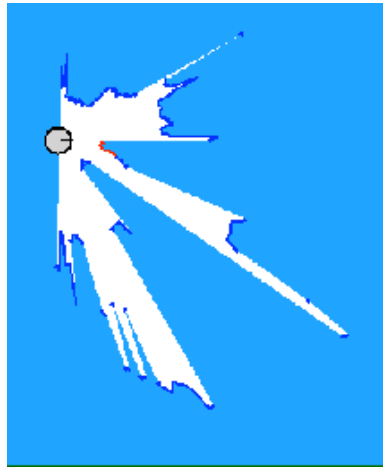


Properties

- High precision
- Wide field of view
- Some laser scanners are security approved for emergency stops (collision detection)

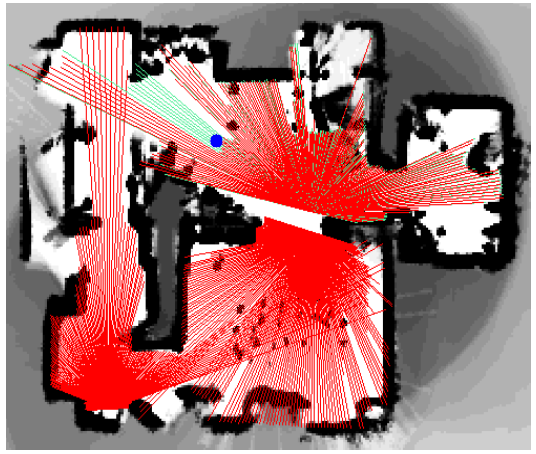
Computing the End Points

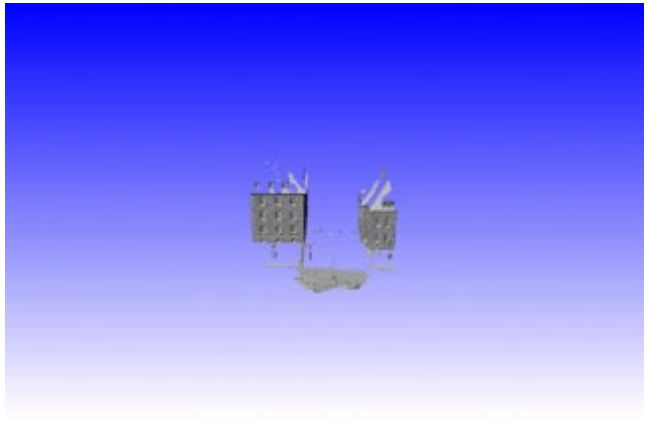
- Laser data comes as an array or range readings, e.g. [1; 1.2; 1.5; 0.1; 81.9; …]
- Assume a field of view of 180 deg
- First beams starts at -½ of the fov
- Maximum range: ~80 m (SICK LMS)

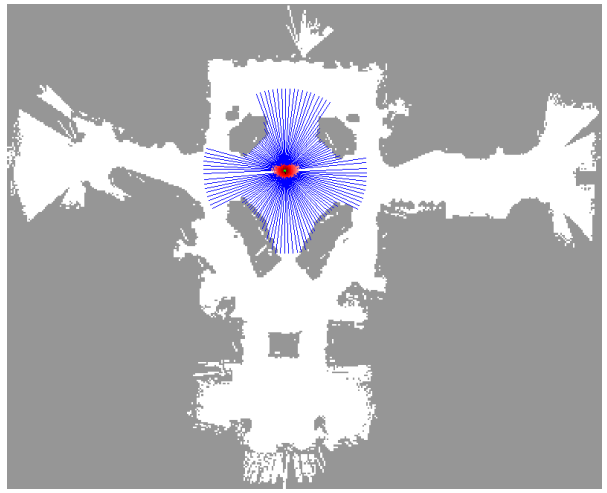


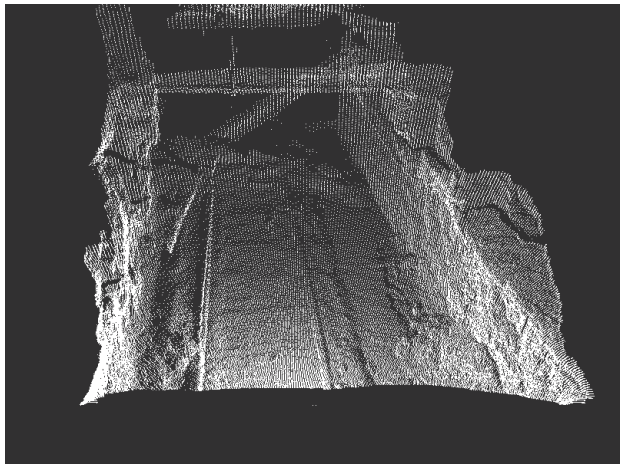
Robots Equipped with Laser Scanners

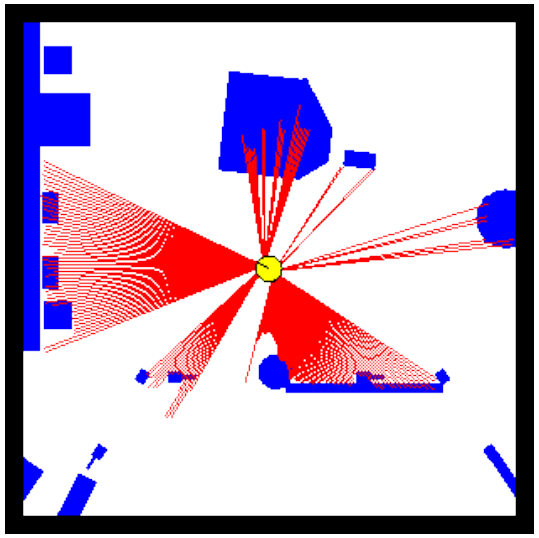
Typical Scans











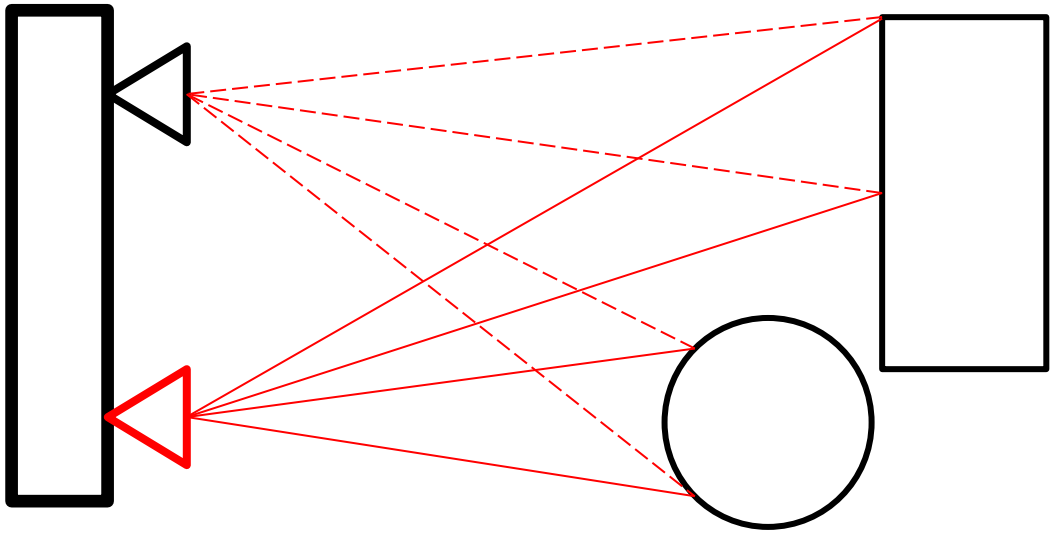
Structured Light Sensors

Microsoft Kinect

Asus Xtion

Structured Light Sensors

- An infrared projector illuminates the scene with a known light pattern
- Scene is captured by an infrared sensor, depth is derived from pattern distortion



Structured Light Pros and Cons

- Pros
  - Cheap
  - Dense range image
  - Relatively precise at a range up to ~5 meters
- Cons
  - Low operational range
  - Sensitive to sunlight
  - Sensitive to dark surfaces
  - Sensitive to reflecting surfaces

Summary

- Different types of range sensors:
  - Sonar
  - LiDAR
  - Structured light
- Accurate and reliable measurements possible…
- …however, many error sources remain