Introduction to Mobile Robotics

Proximity Sensors

Wolfram Burgard

Sensors of Wheeled Robots

Perception of the environment

Active:

- Ultrasound
- Laser range finder
- Infrared

Time of flight

Phase shift

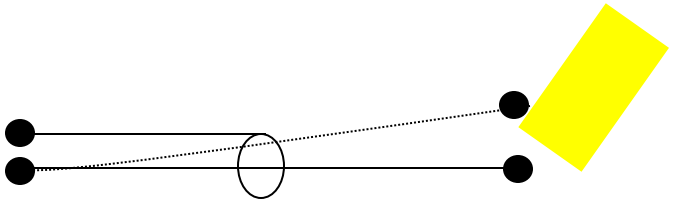
Passive:

- Cameras
- Tactiles

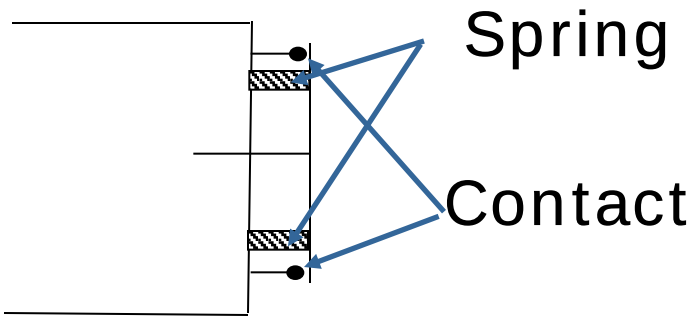
Intensity-based

Tactile Sensors

Measure contact with objects



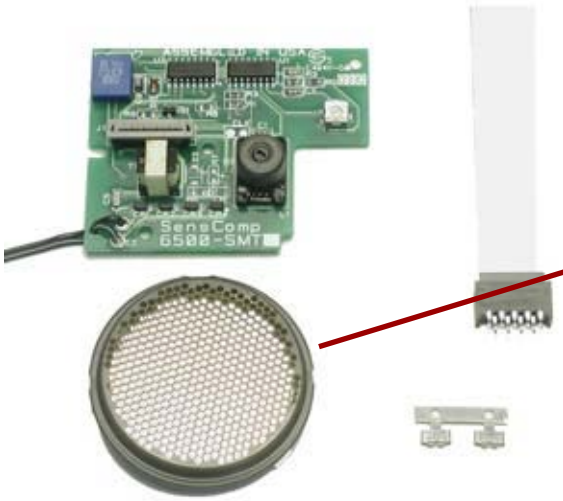
Touch sensor



Bumper sensor

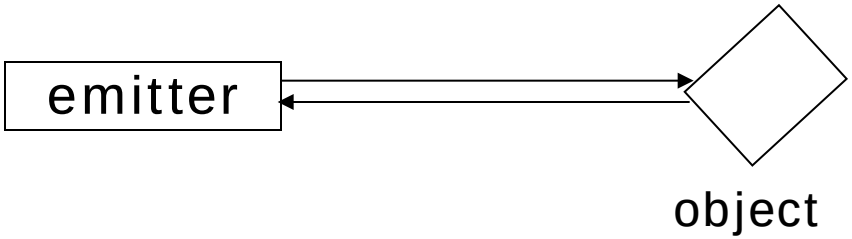
Ultrasound Sensors

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



Polaroyd 6500

Time of Flight Sensors



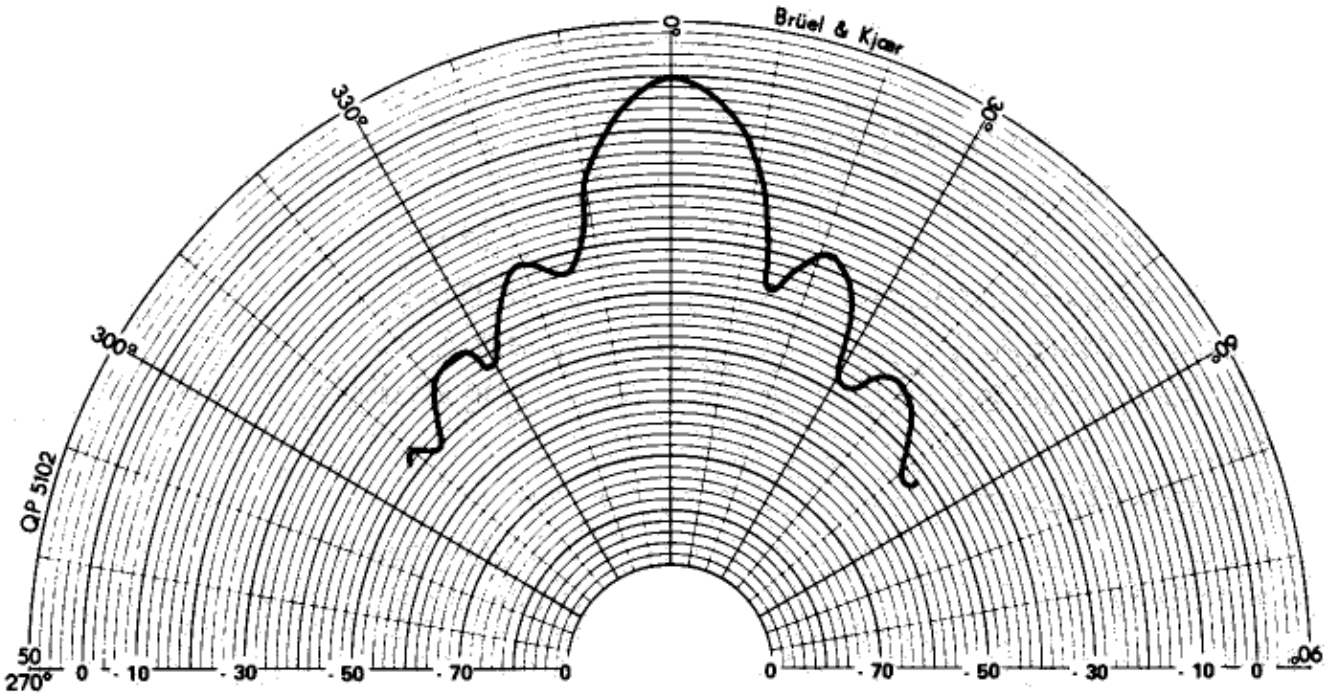
$$d = v \times t / 2$$

v: speed of the signal

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

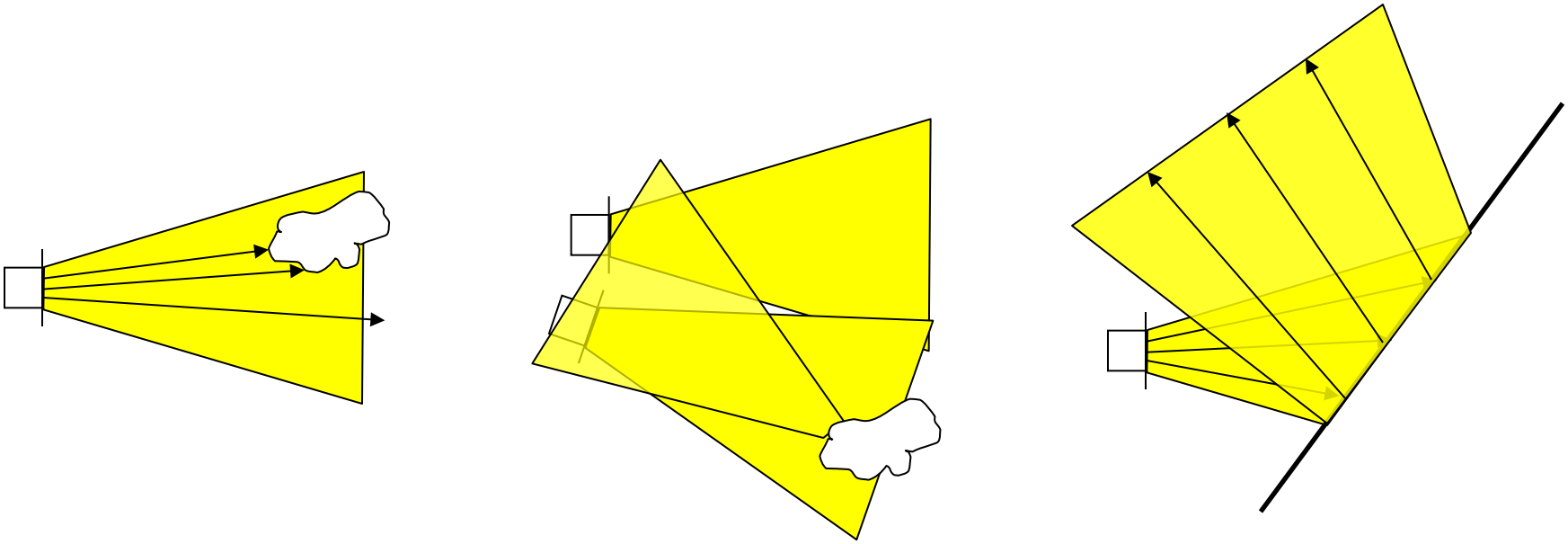
Properties of Ultrasounds

- Signal profile [Polaroid]

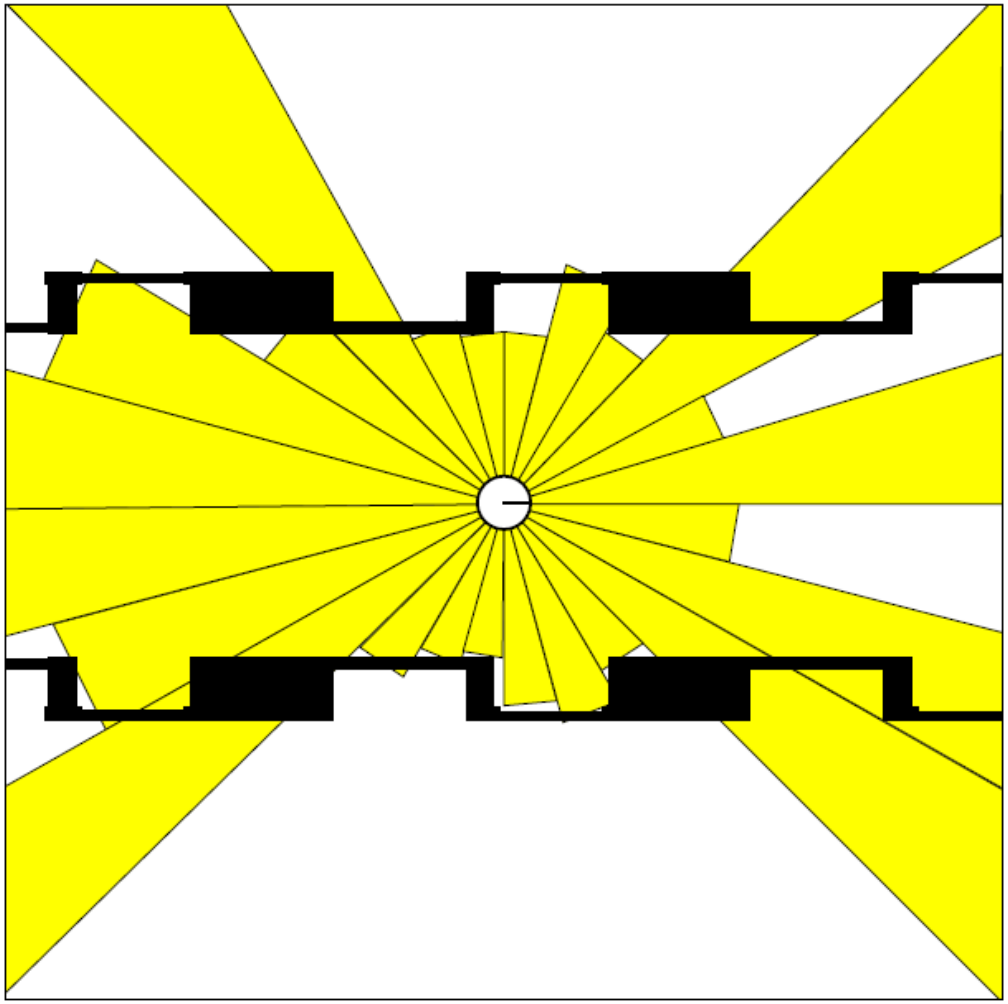


Sources of Error

- Opening angle
- Crosstalk
- Specular reflection



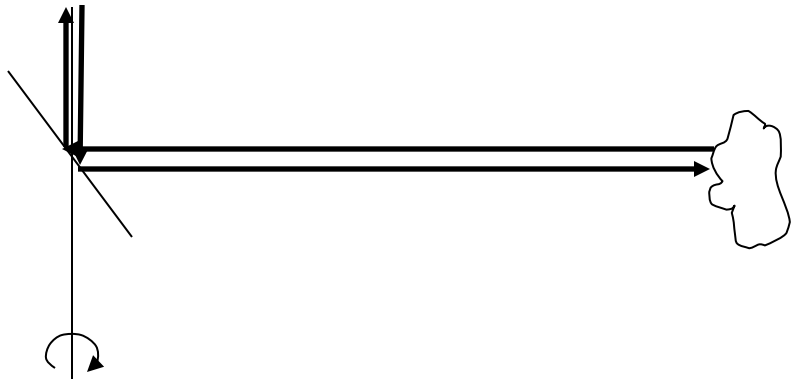
Typical Ultrasound Scan



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*10m divided by the speed of sound (330m/sec) which leads to 0.06sec
- A complete scan thus requires 24*0.06=1.45sec
- 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

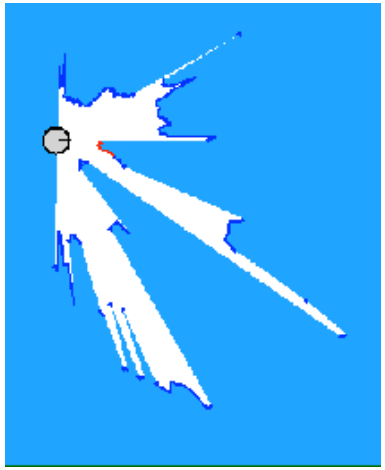


Properties

- 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 an field of view of 180 deg
- First beams starts at -½ of the fov
- Maximum range: ~80 m (SICK LMS)



Computing the End Points

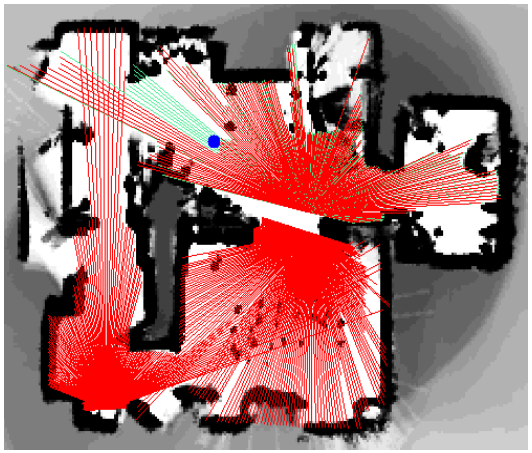
- Laser data comes as an array or range readings, e.g. [1; 1.2; 1.5; 0.1; 91.9; …]
- Assume an field of view of 180 deg
- First beams starts at -½ of the fov

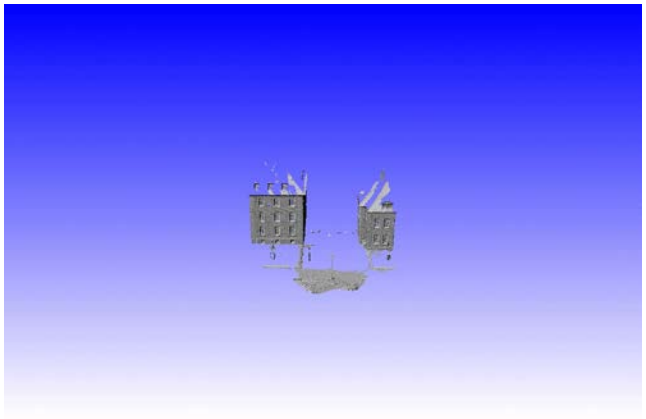
Typical problems to be solved:

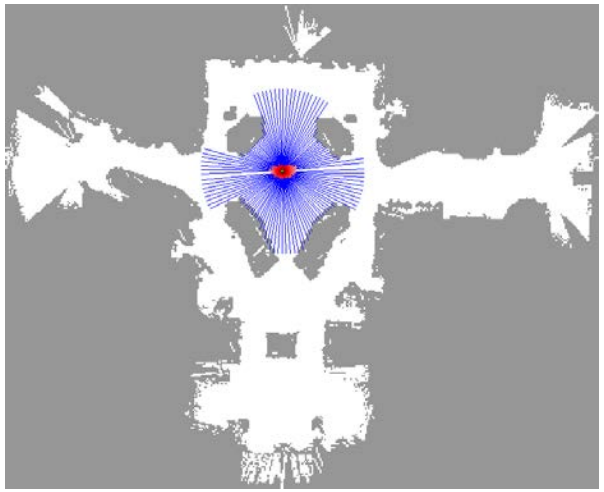
- Where are the end points relative to the sensor location?
- Where are the end points in an external coordinate system?

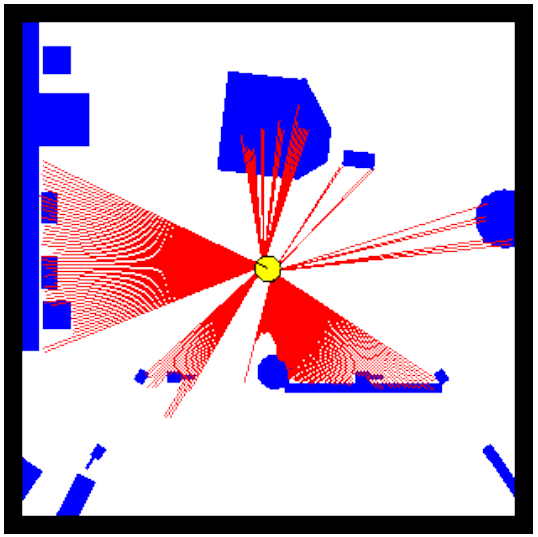
Robots Equipped with Laser Scanners

Typical Scans









Another Range Sensor (Kinect)

Wolfram in 3D