

# Introduction to Mobile Robotics

## **Proximity Sensors**

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# Sensors of Wheeled Robots

## Perception of the environment

### Active:

- Ultrasound
- Laser range finder
- Infrared

Time of flight

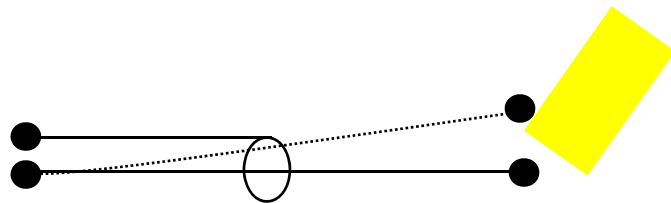
### Passive:

- Cameras
- Tactiles

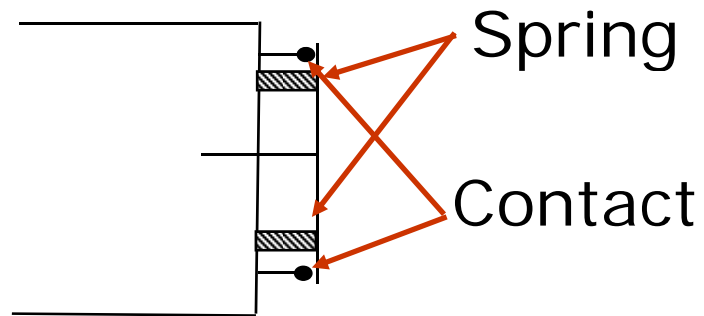
Intensity-based

# Tactile Sensors

Measure contact with objects



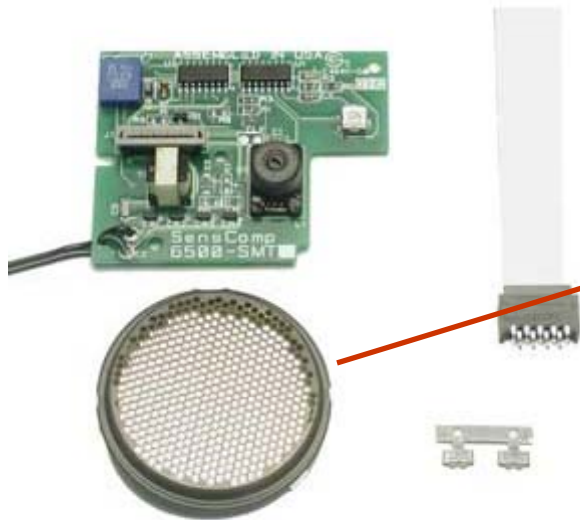
Touch sensor



Bumper sensor

# Ultrasound Sensors

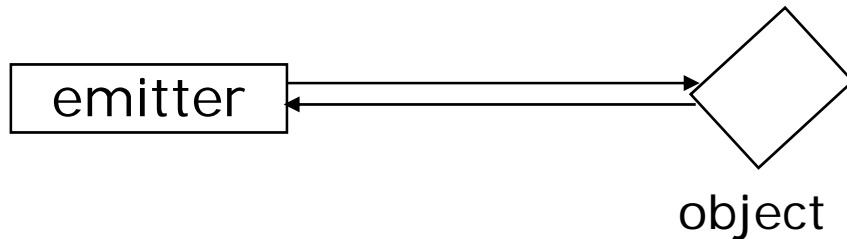
- Emit an ultrasound signal
- Wait until they receive the echo
- Time of flight sensor



Polaroid 6500



# Time of Flight sensors



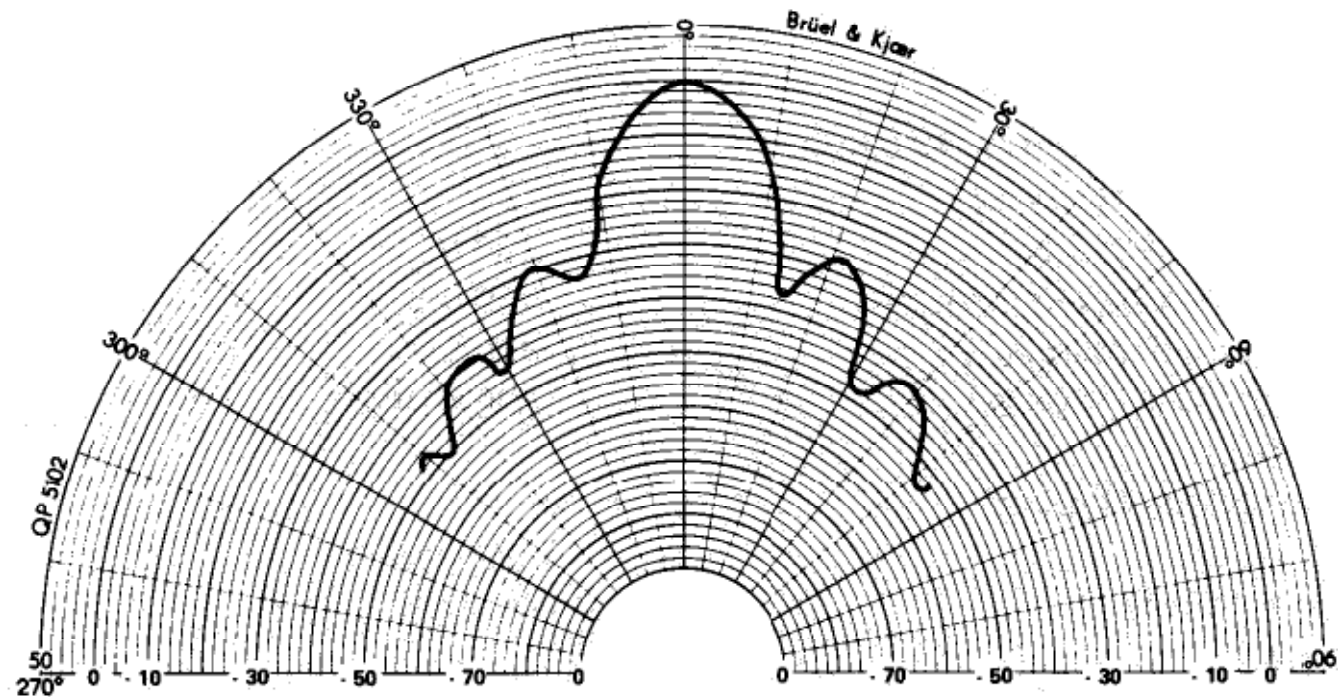
$$d = v \times t / 2$$

$v$ : speed of the signal

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

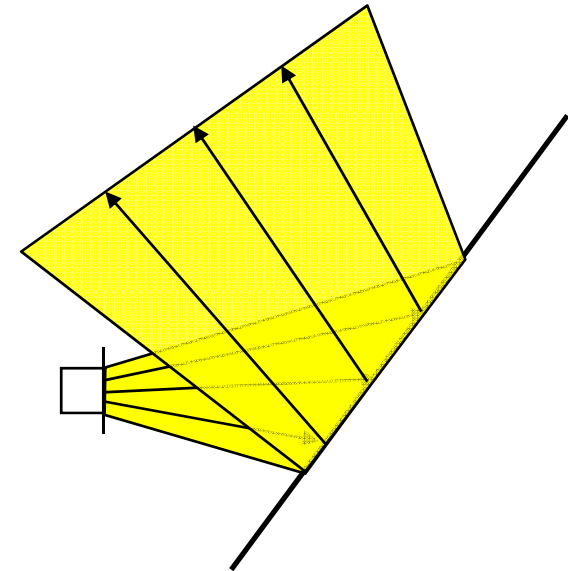
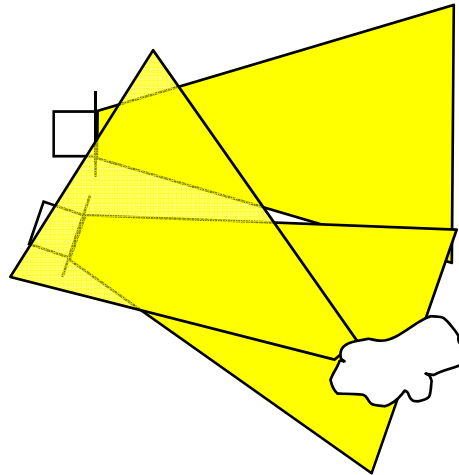
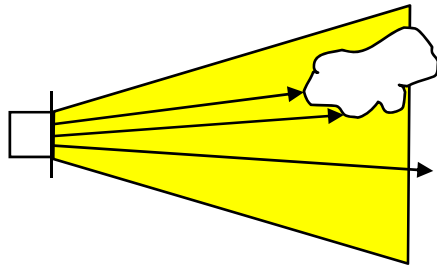
# Properties of Ultrasounds

- Signal profile [Polaroid]

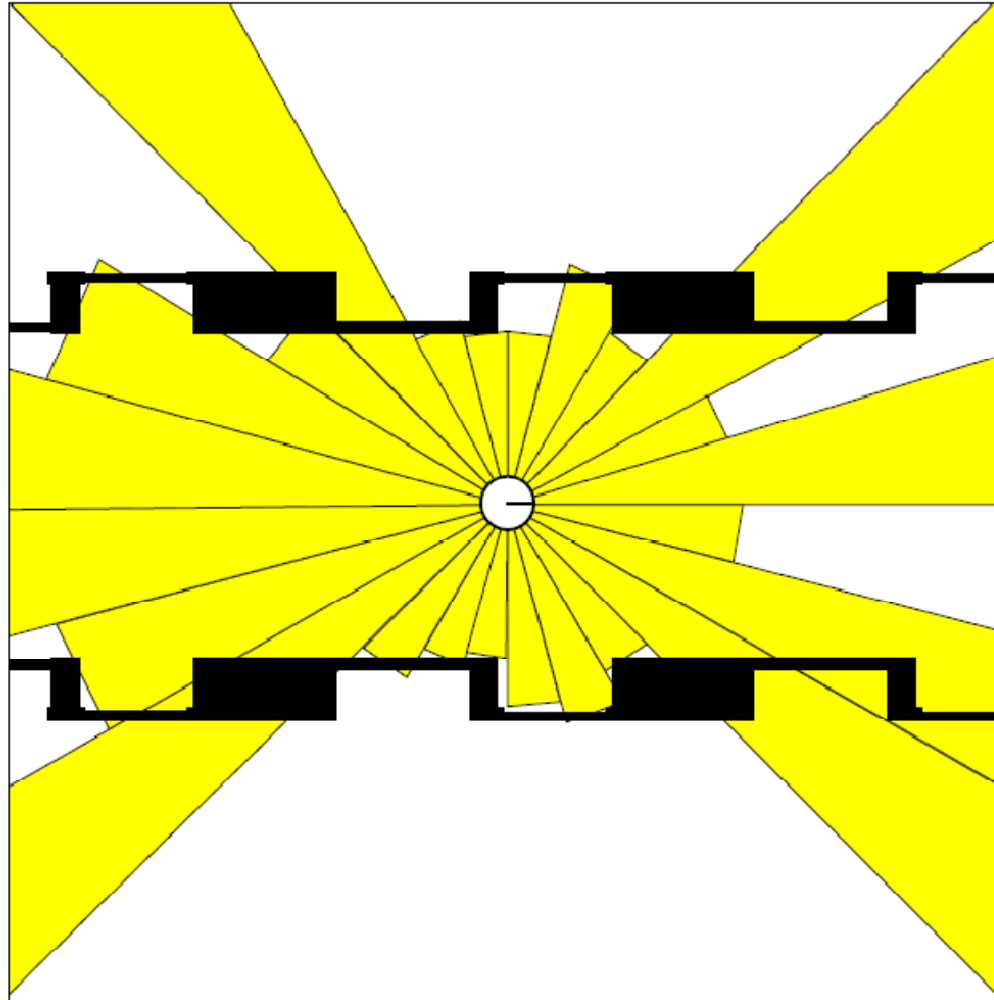


# Sources of Error

- Opening angle
- Crosstalk
- Specular reflection



# Typical Ultrasound Scan

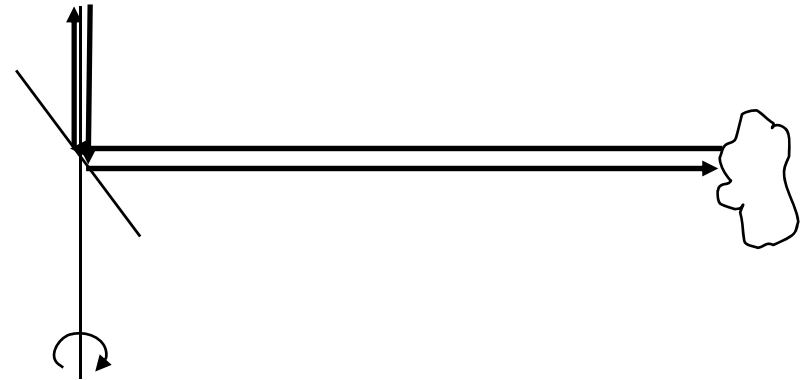




# Parallel Operation

- Given the 15 degrees opening angle, 24 sensors are needed to cover the whole 360 degrees area around the robot.
- Given the maximum range of a measurement is 10m.
- The time of flight then is  $2 \cdot 10 / 330 = 0.66\text{sec}$
- A complete scan requires 1.45 secs
- 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
- Approved security for collision detection

# Robots Equipped with Laser Scanners



Zora:



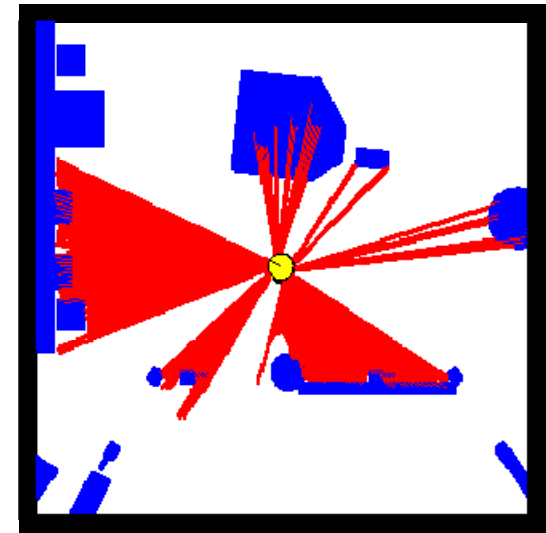
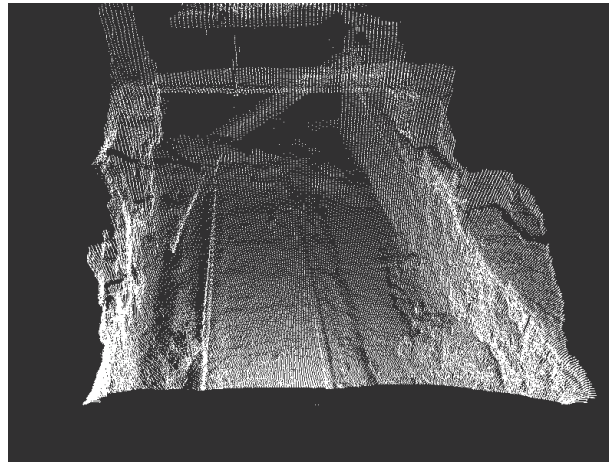
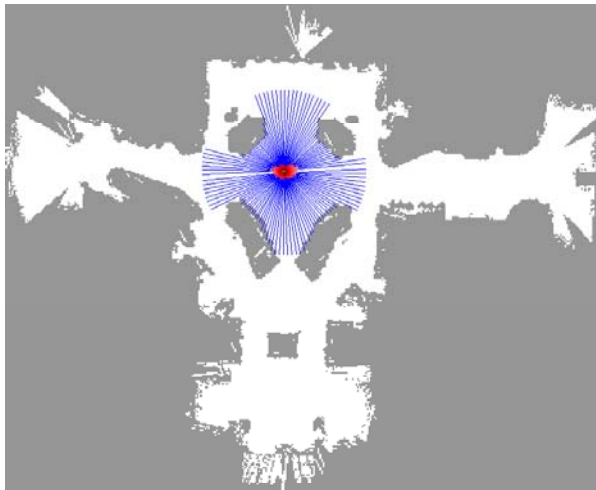
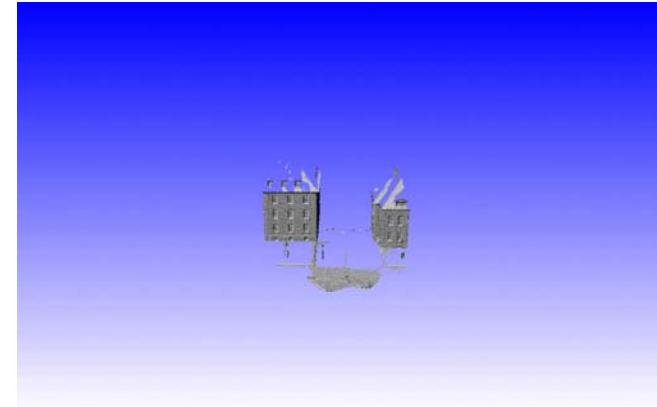
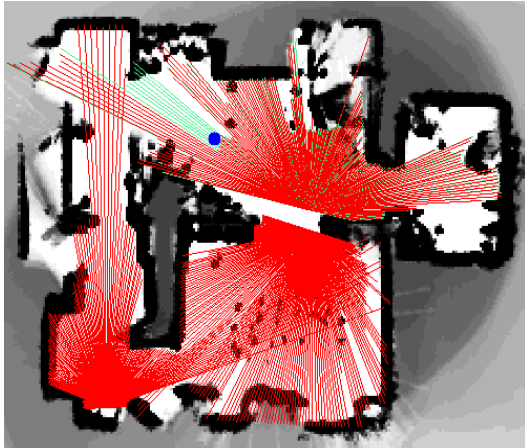
Groundhog:



Herbert:



# Typical Scans



# The DARPA Grand Challenge

