Robotica – Robot Industriali e di Servizio
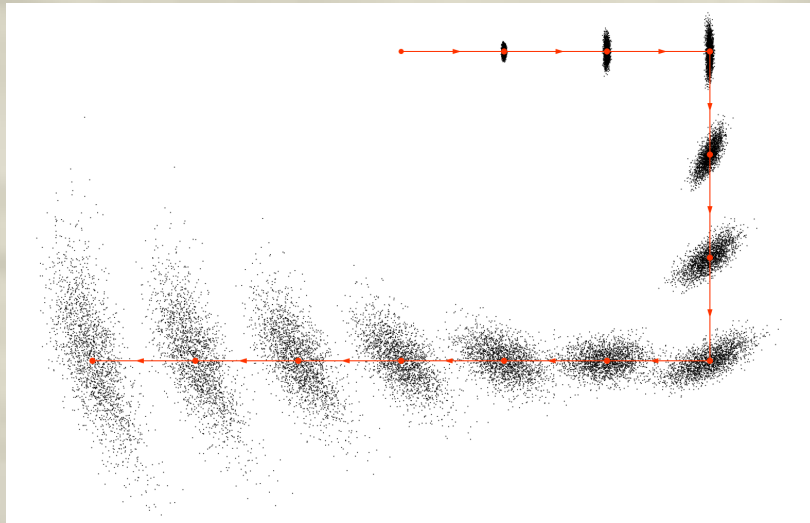
Lezione 24:
La localizzazione markoviana

7 maggio 2014
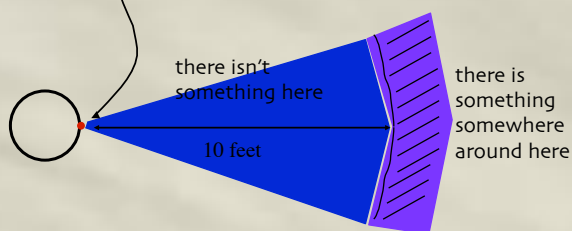
Come si muove un robot senza sensori:

Review: Use Sonar to Create Map

⇒ What should we conclude if this sonar reads 10 feet?

there isn't
something here

there is
something
somewhere
around here

10 feet

Local Map
■ unoccupied
☐ no information
■ occupied

What is it a map of?

⇒ Several answers to this question have been tried:

SPURIOUS
WALL

WALL

robot

WALL

SHELVES

CABINET

BOX

DESK

DESK

DESK
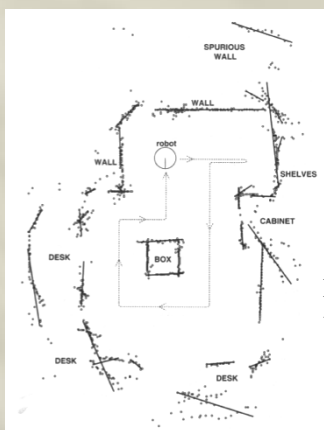
What information **should** this map contain,
given that it is created with sonar ?

Each cell is either occupied or unoccupied -- this
was the approach taken by the Stanford Cart.

What is it a map of ?

Several answers to this question have been tried:

pre '83   It's a map of occupied cells. o_{xy} cell (x,y) is occupied $\overline{o}_{xy}$ cell (x,y) is unoccupied

'83 - '88   It's a map of probabilities: $p(\,o\mid S_{1..i}\,)$ The certainty that a cell is **occupied**, given the sensor readings S_1, S_2, ..., S_i

$p(\,\overline{o}\mid S_{1..i}\,)$ The certainty that a cell is **unoccupied**, given the sensor readings S_1, S_2, ..., S_i

⭐ It's a map of *odds*.   The odds of an event are expressed *relative to the complement* of that event.

evidence = $\log_2$(odds)   probabilities

The odds that a cell is **occupied**, given the sensor readings S_1, S_2, ..., S_i $odds(\,o\mid S_{1..i}\,) \ = \ \dfrac{p(\,o\mid S_{1..i}\,)}{p(\,\overline{o}\mid S_{1..i}\,)}$

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Localization: Relative

⇒ If you know your speed and direction, you can calculate where you are relative to where you were (integrate).

⇒ Speed and direction might, themselves, be absolute (compass, speedometer), or integrated (gyroscope, Accelerometer)

⇒ Relative measurements are usually more accurate in the short term -- but suffer from accumulated error in the long term

⇒ Most robotics work seems to focus on this.

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Localization Methods

⇒ Markov Localization:
- Represent the robot's belief by a probability distribution over possible positions and uses Bayes' rule and convolution to update the belief whenever the robot senses or moves

⇒ Monte-Carlo methods

⇒ Kalman Filtering

⇒ SLAM (simultaneous localization and mapping)
⇒ ....

Markov Localization

⇒ What is Markov Localization ?
- Special case of probabilistic state estimation applied to mobile robot localization
- Initial Hypothesis:
  - Static Environment
    - Markov assumption
    - The robot's location is the only state in the environment which systematically affects sensor readings
- Further Hypothesis
  - Dynamic Environment

Markov assumption (or static world assumption)

If one knows the robot's location ℓ, future measurements are independent of past ones (and vice-versa)

$$P(d_{t+1}, d_{t+2}, \cdots \mid L_T = \ell, d_0, d_1, \cdots, d_t) = P(d_{t+1}, d_{t+2}, \cdots \mid L_T = \ell)$$

- The robot's location is the only state in the environment
- Knowing the robot state is all one needs to know about the past to predict future data.

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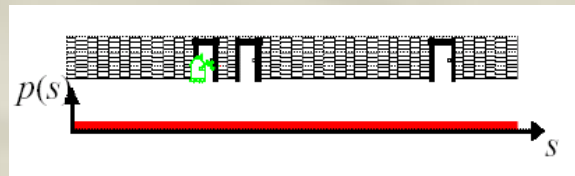
Markov Localization

- Instead of maintaining a single hypothesis as to where the robot is, Markov localization maintains a probability distribution over the space of all such hypothesis

- Uses a fine-grained and metric discretization of the state space

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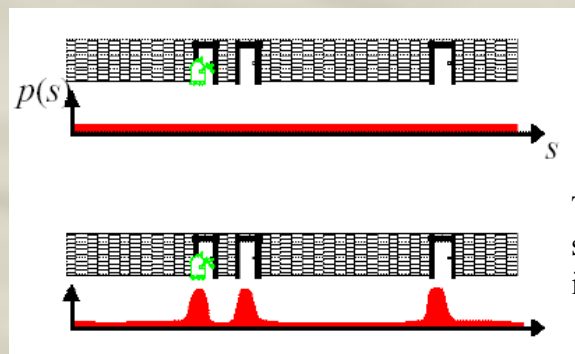# *Example*

➩ Assume the robot position is one- dimensional

The robot is placed somewhere in the environment but it is not told its location

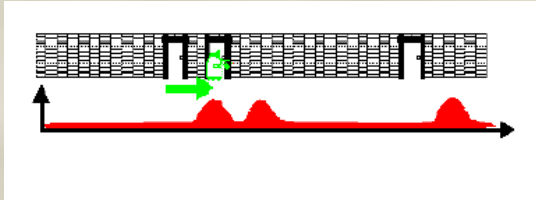# *Example*

➩ Assume the robot position is one- dimensional

The robot is placed somewhere in the environment but it is not told its location

The robot queries its sensors and finds out it is next to a door

Example

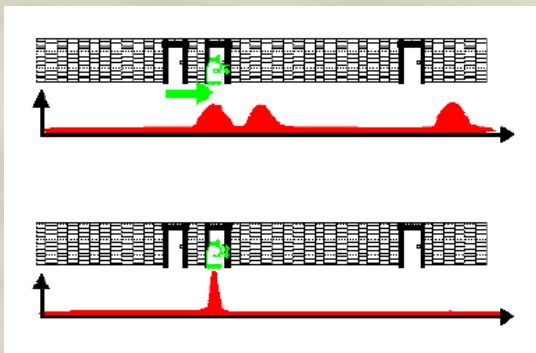The robot moves one meter forward. To account for inherent noise in robot motion the new belief is smoother

Example

The robot moves one meter forward. To account for inherent noise in robot motion the new belief is smoother

The robot queries its sensors and again it finds itself next to a door

Una spiegazione migliore:

➥ http://en.wikipedia.org/wiki/Monte_Carlo_localization

Per approfondire:

➥ http://plymouth.tinigrifi.eu/aint509.php
➥ http://www.cs.cmu.edu/afs/cs/project/jair/pub/
volume11/fox99a-html/node2.html
➥ http://moodle.epfl.ch/course/view.php?id=261
➥ http://lis.epfl.ch/resources/podcast/2006/12/raja-chatila-
robot-navigation.html

MobileEyes: interfaccia grafica

tcp/ip

MobileEyes

Interfaccia
(serverDemo)

Mappa

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ARNL fa la localizzazione

tcp/ip

MobileEyes

Interfaccia
(arnlServer)

Mappa

Mappa

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