CS325 Artificial Intelligence
Robotics I – Autonomous Robots (Ch. 25)

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Robots As Killers?

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  2. It must obey orders except when in conflict with law #1.
  3. It must stay alive as long as not in conflict with laws #1 and #2.

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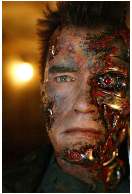
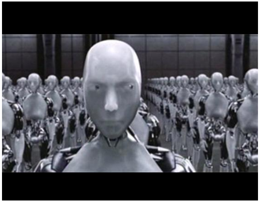
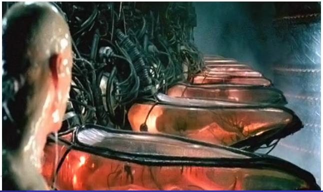
  2. It must obey orders except when in conflict with law #1.
  3. It must stay alive as long as not in conflict with laws #1 and #2.
- Fiction always liked to depict robots taking over







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    - Mundane tasks

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- In reality, first we need to *make* the robots
- Dr. Thrun says we will soon
- They can help with?
  - Disabled people
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  - Risky tasks
  - Mundane tasks
- We'll focus on the the **self-driving car** in two lectures

Entry/Exit Surveys

Exit survey: Computer Vision III – Structure from Motion

- What additional piece of information an SfM algorithm needs when the objects in the scene also moves?
- What parameters an SfM algorithm cannot recover?

Entry survey: Robotics I – Autonomous Robots (0.25 pts)

- What methods that we have previously seen in this class would be involved in robotics?
- Name a useful task that you think would be possible to assign to robots.


2004 DARPA Grand Challenge

Self-Driving Cars and DARPA Challenge

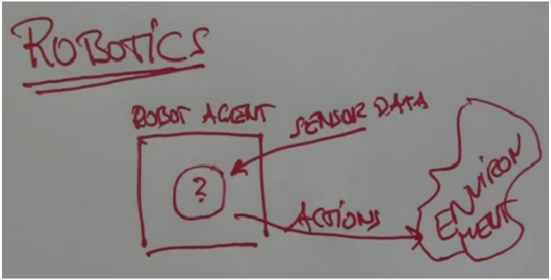
- 1st DARPA challenge was a failure: cars completed at most 5%.
- Undergrads like you made Stanley win!

Urban Challenge

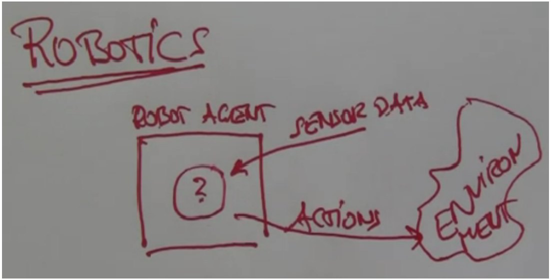
Urban Challenge

- Google car self-drove 100,000 miles already!
- We will focus on machine learning, particle filters, and planning.

Robot as an Agent



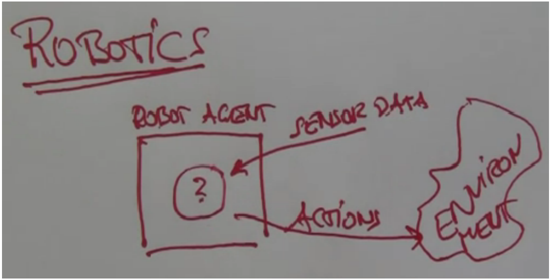
Robot as an Agent



Is it:

1. Part.-observable?
2. Stochastic?
3. Adversarial?
4. Continuous?
5. Single/Multi?

Robot as an Agent



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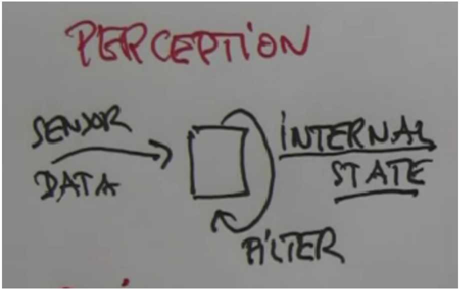
Perception to Estimate Internal State: Kinematic



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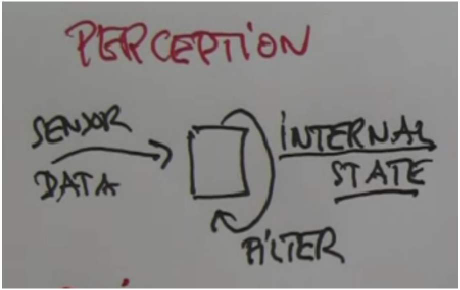
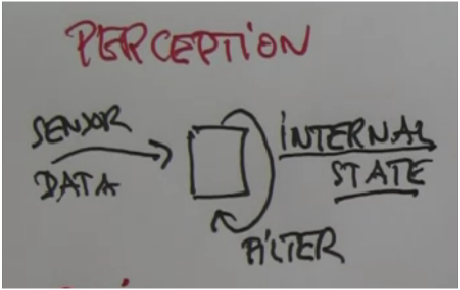


Kinematic state: Where in the world are we??

Perception to Estimate Internal State: Kinematic

Roomba is cleaning a room:



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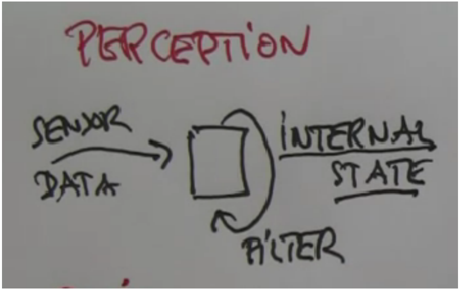

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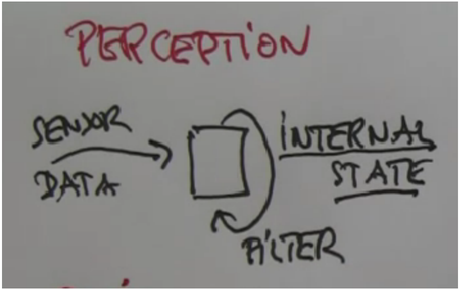

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- x, y

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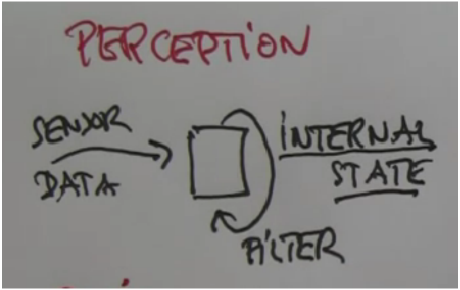


Kinematic state: Where in the world are we??

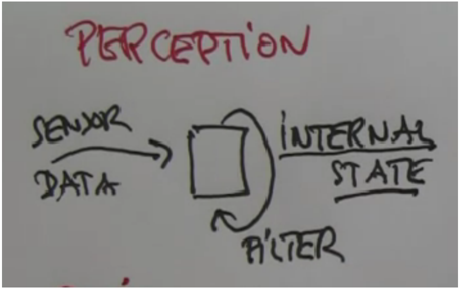
Roomba is cleaning a room:

How many dimensions we need for kinematic state?

- x, y, heading angle

Total: 3

Perception to Estimate Internal State: Kinematic

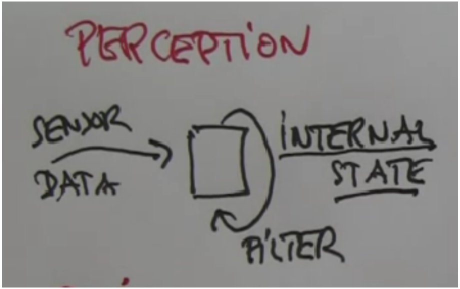


Kinematic state: Where in the world are we??

How about for Junior?

How many dimensions we need for kinematic state?

Perception to Estimate Internal State: Kinematic



Kinematic state: Where in the world are we??

How about for Junior?

How many dimensions we need for kinematic state?

- SAME: x, y, heading angle

Total: 3

Including Movement: Dynamic State

Kinematic state:

Where in the world are we??

Including Movement: Dynamic State

Kinematic state:

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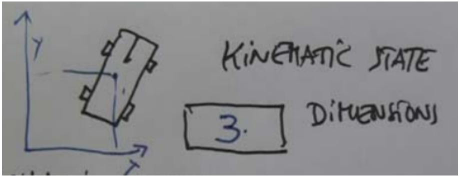
Junior:



Including Movement: Dynamic State

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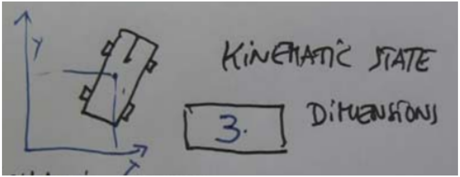


Including Movement: Dynamic State

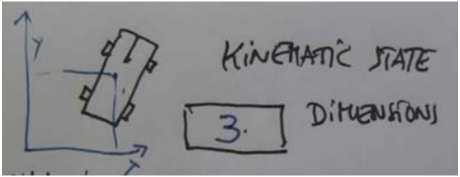
Kinematic state:

Where in the world are we??

Dynamic state:

Where are you going??

Junior:



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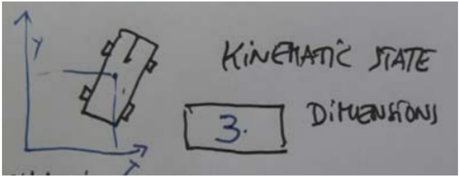


Dynamic state:

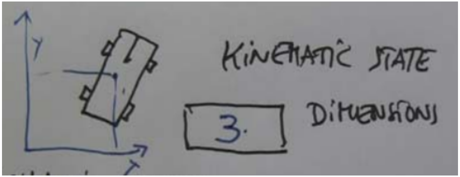
Where are you going??
(also includes the kinematic state).

Including Movement: Dynamic State

Kinematic state:

Where in the world are we??

Junior:



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How many dimensions in dynamic state of Junior?

Including Movement: Dynamic State

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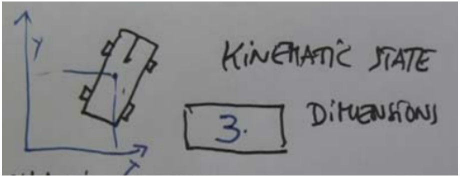

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How many dimensions in dynamic state of Junior?

- 3 from kinematic
- forward velocity, v
- **yaw rate**: turning angle

Kinematic state:

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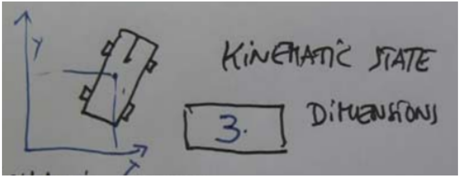

Dynamic state:

Where are you going??
(also includes the kinematic state).

How many dimensions in dynamic state of Junior?

- 3 from kinematic
- forward velocity, v
- **yaw rate**: turning angle

Total: 5

More Dimensions: Flying

More Dimensions: Flying

More quadcopter videos:

- Aggressive Maneuvers I: State estimation
- Aggressive Maneuvers II: Hoops!
- Aggressive Maneuvers III: Trajectory planning
- Fails!

Kinematic & Dynamic State of Copters?

Quadcopters:

Dimensions in **kinematic** state?

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Total: 6

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Dimensions in **dynamic** state?

- 6 from kinematic
- 3 for each dimensional velocity

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Dimensions in **dynamic** state?

- 6 from kinematic
- 3 for each dimensional velocity
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Total: 12

Kinematic & Dynamic State of Copters?

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Total: 6

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- 3 for each dimensional velocity
- 3 for each angular velocity

Total: 12

Unlike a car, this can go in all directions!

Honda's Asimo: a humanoid bipedal robot

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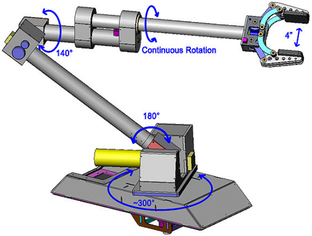
Robotic arm:



Kinematic & Dynamic State of Jointed Robots

Honda's Asimo: a humanoid bipedal robot

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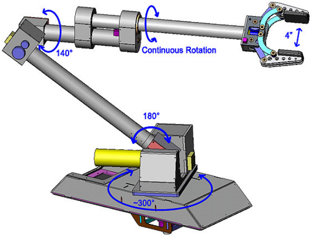

Kinematic dimensions:

Kinematic & Dynamic State of Jointed Robots

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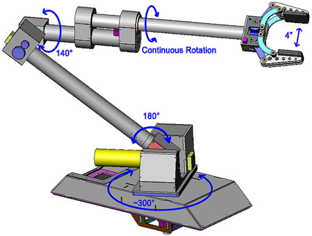

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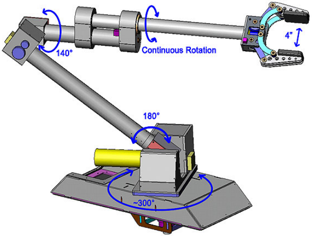

Kinematic dimensions: 6?

- base angles (2)
- joint angles (2)
- arm rotation (1), grab (1)

Kinematic & Dynamic State of Jointed Robots

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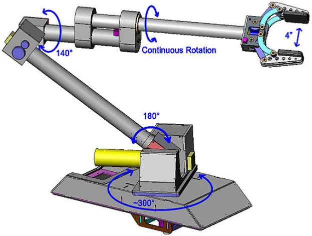

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Dynamic dimensions?

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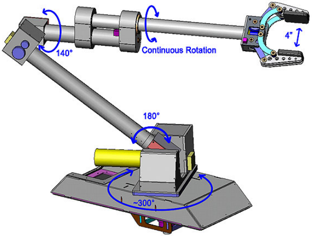

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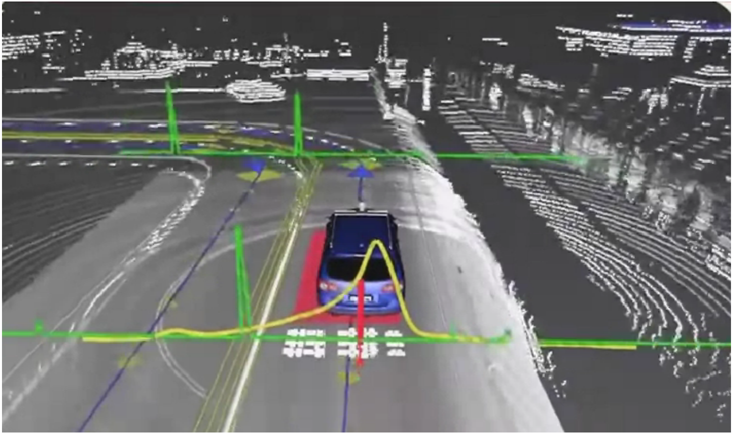
Dynamic dimensions? 2×6

Localization



Monte Carlo Localization: Particle Filter

Roomba:

Kinematic state variables:

- x, y: location
- θ: heading angle

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Each particle:

$$\begin{pmatrix} x \\ y \\ \theta \end{pmatrix}$$

Remember: estimation and prediction?

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State estimation after Δt:

$$x' = x +$$

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State estimation after Δt:

$$x' = x + \Delta t \, v \cos\theta$$

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1st approx., but works well.

Localization Question

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State estimation after Δt:

$$
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\end{aligned}
$$

Initial state:

- $x = 24,\ y = 18,\ \theta = 0$
- $v = 5/\mathrm{sec},\ w = \frac{\pi}{8\,\mathrm{sec}}$

Localization Question

Roomba:

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- x, y: location
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Estimate after $\Delta t = 1$ sec?

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- $x = 24,\ y = 18,\ \theta = 0$
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Estimate after $\Delta t = 1$ sec?

$$\begin{aligned} x' &= 24 + 1 \times 5 \times 1 = \mathbf{29} \\ y' &= 18 + 1 \times 5 \times 0 = \mathbf{18} \\ \theta' &= 0 + 1 \times \frac{\pi}{8} = \boldsymbol{\frac{\pi}{8}} \end{aligned}$$