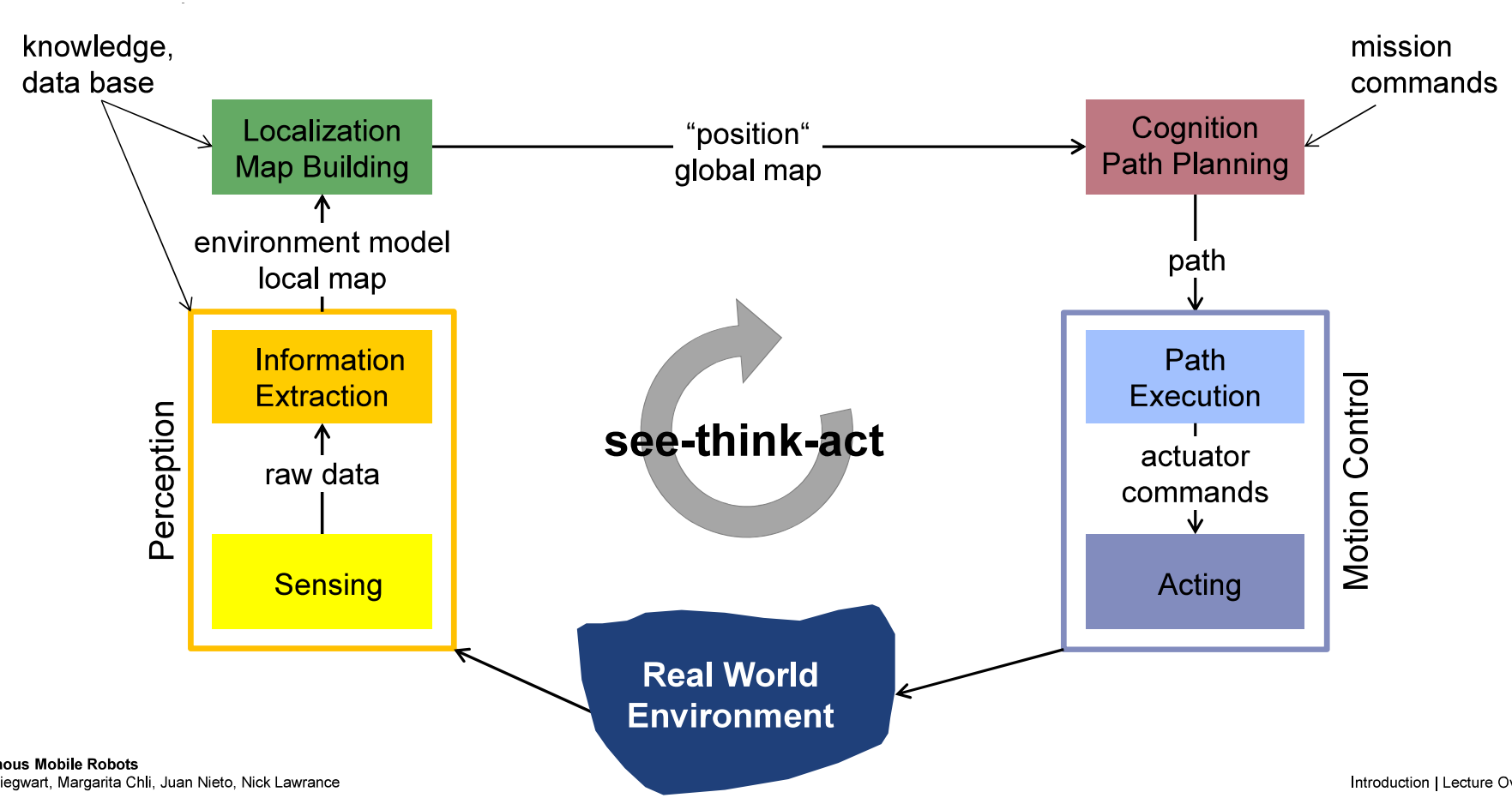
Autonomous mobile robot | the key questions

- The three key questions in Mobile Robotics
  - Where am I ?
  - Where am I going ?
  - How do I get there ?

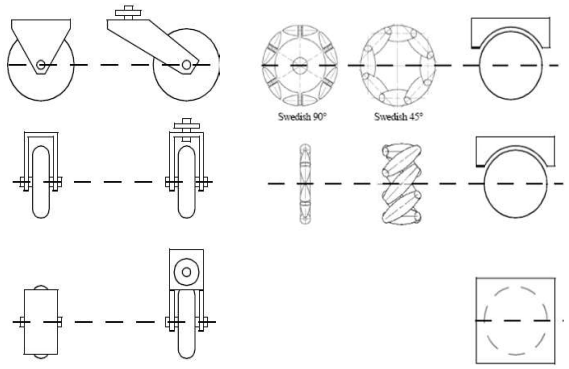
- To answer these questions the robot has to
  - have a model of the environment (given or autonomously built)
  - perceive and analyze the environment
  - find its position/situation within the environment
  - plan and execute the movement

Autonomous mobile robot | the see-think-act cycle



Motion Control | kinematics and motion control

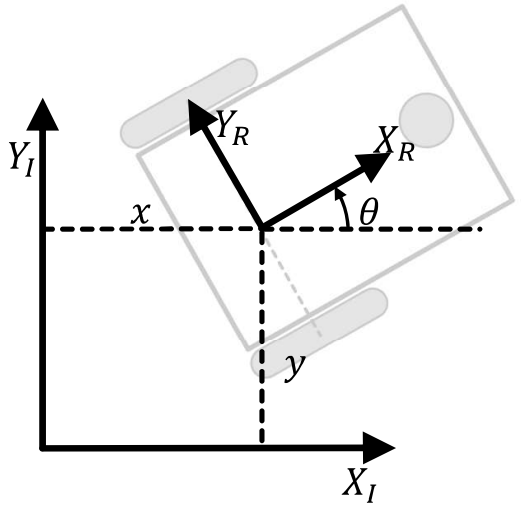
- Wheel types and its constraints
  - Rolling constraint
  - no-sliding constraint (lateral)



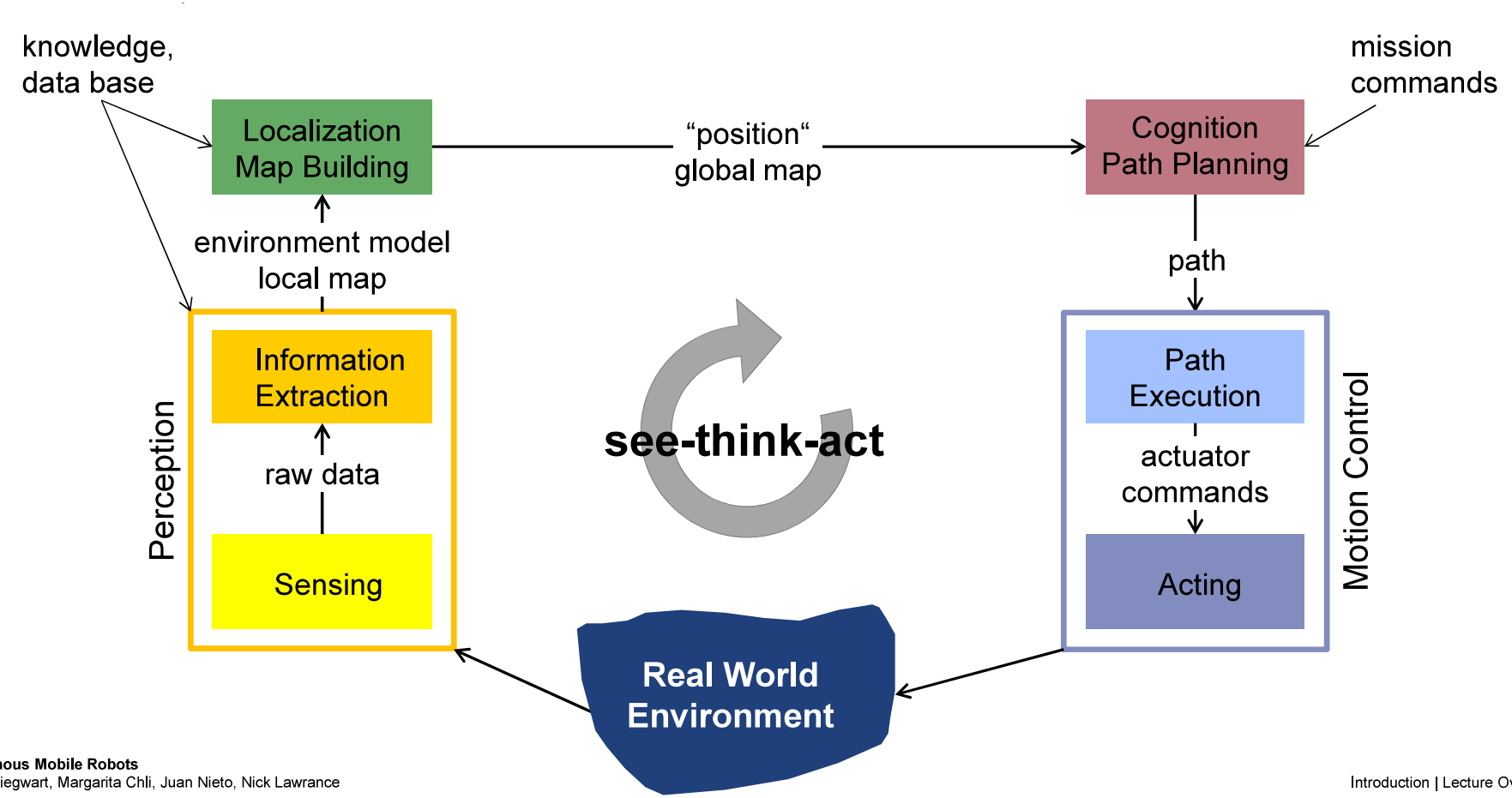
- Motion control

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{bmatrix} = f(\dot{\varphi}_1 \cdots \dot{\varphi}_n, \theta, geometry)$$

$$\begin{bmatrix} \dot{\varphi}_1 \\ \vdots \\ \dot{\varphi}_n \end{bmatrix} = f(\dot{x}, \dot{y}, \dot{\theta}) \quad ?$$

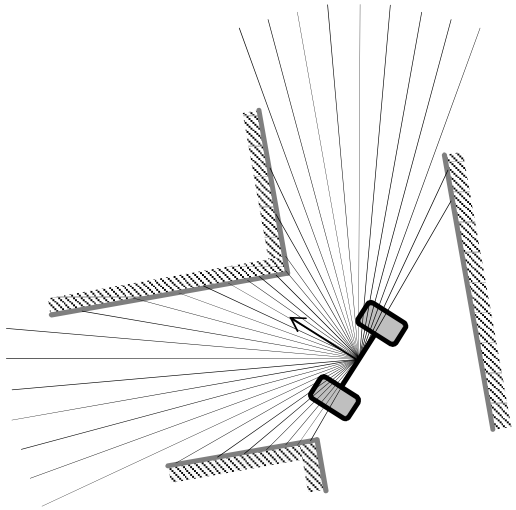


Autonomous mobile robot | the see-think-act cycle

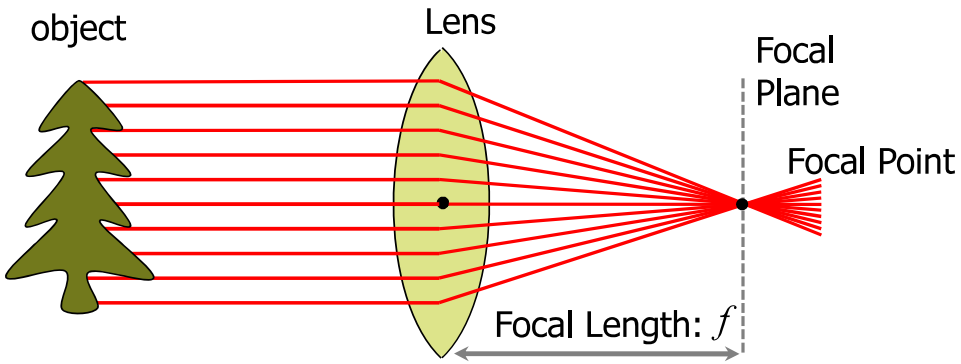


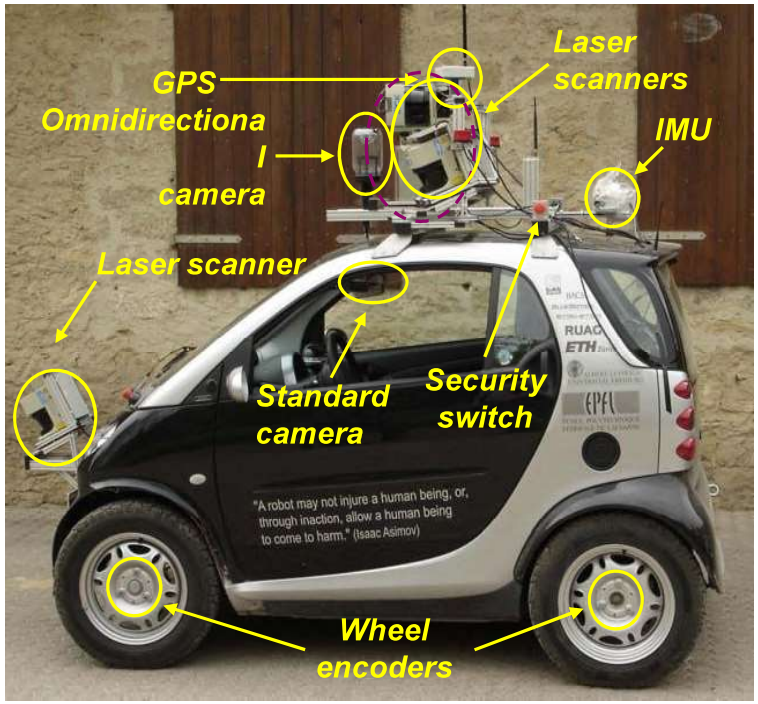
Perception | sensing

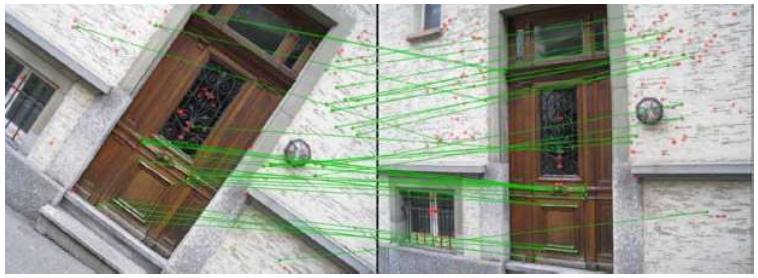
- Laser scanner
  - time of flight



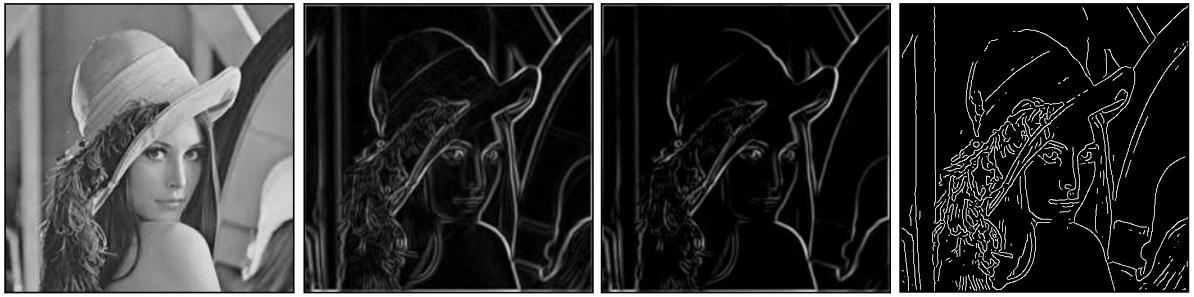
- Camera







Perception | information extraction



- Filtering / Edge Detection

- Keypoint Features
  - features that are reasonably invariant to rotation, scaling, viewpoint, illumination
  - FAST, SURF, SIFT, BRISK, …

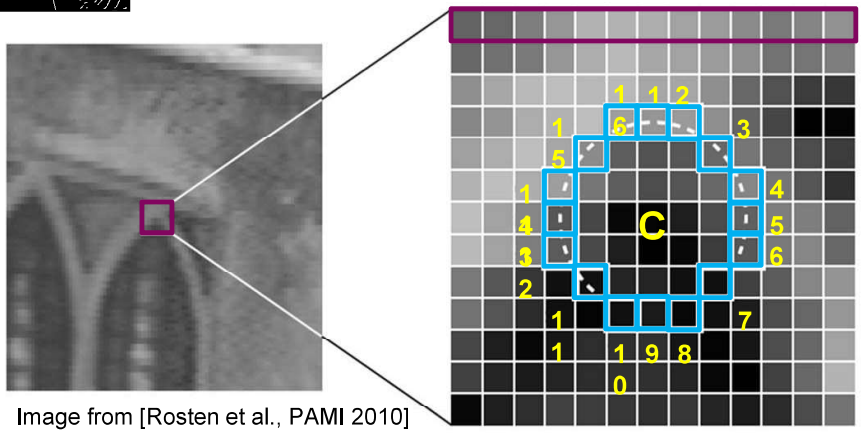
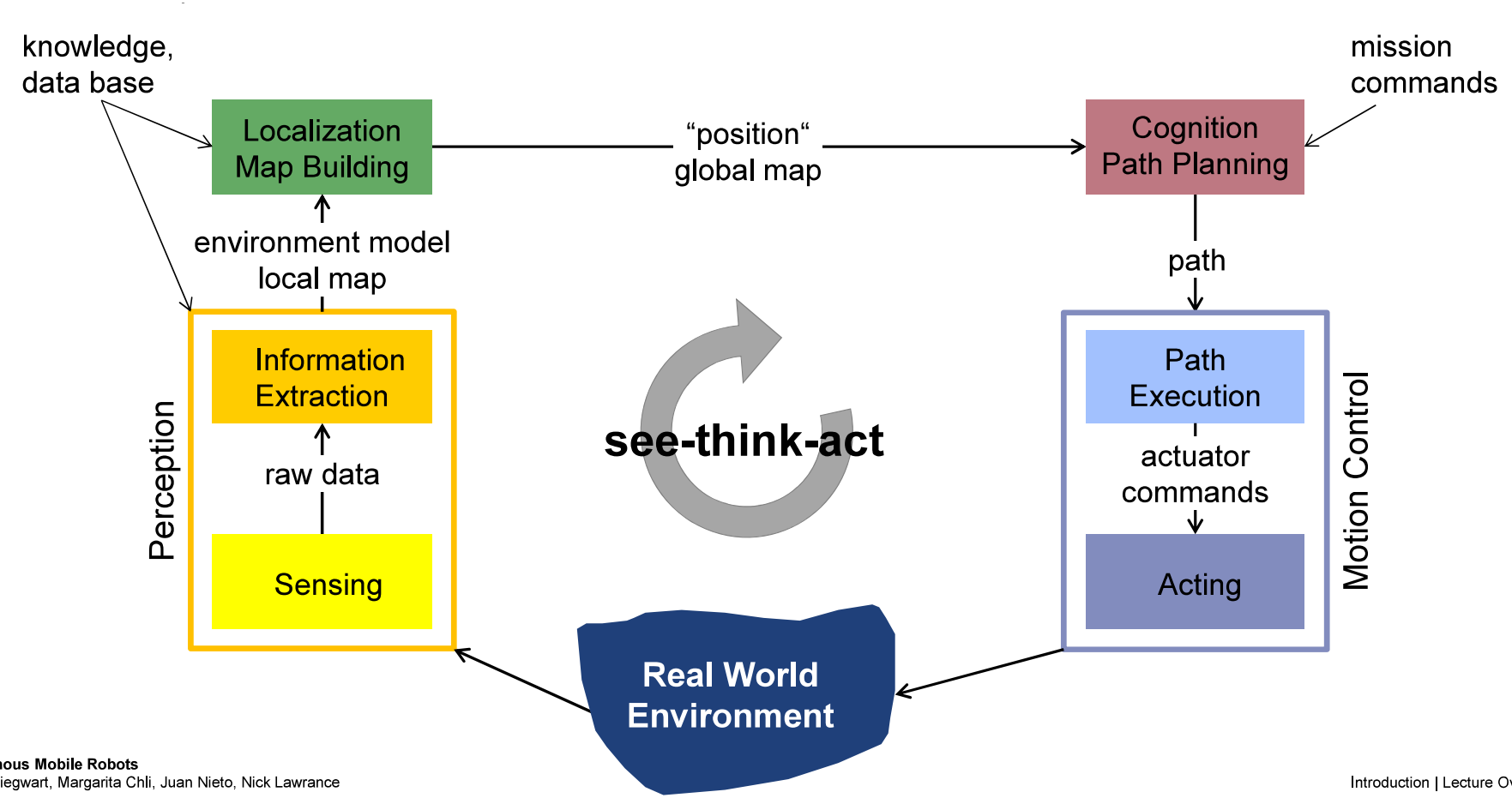


Image from [Rosten et al., PAMI 2010]

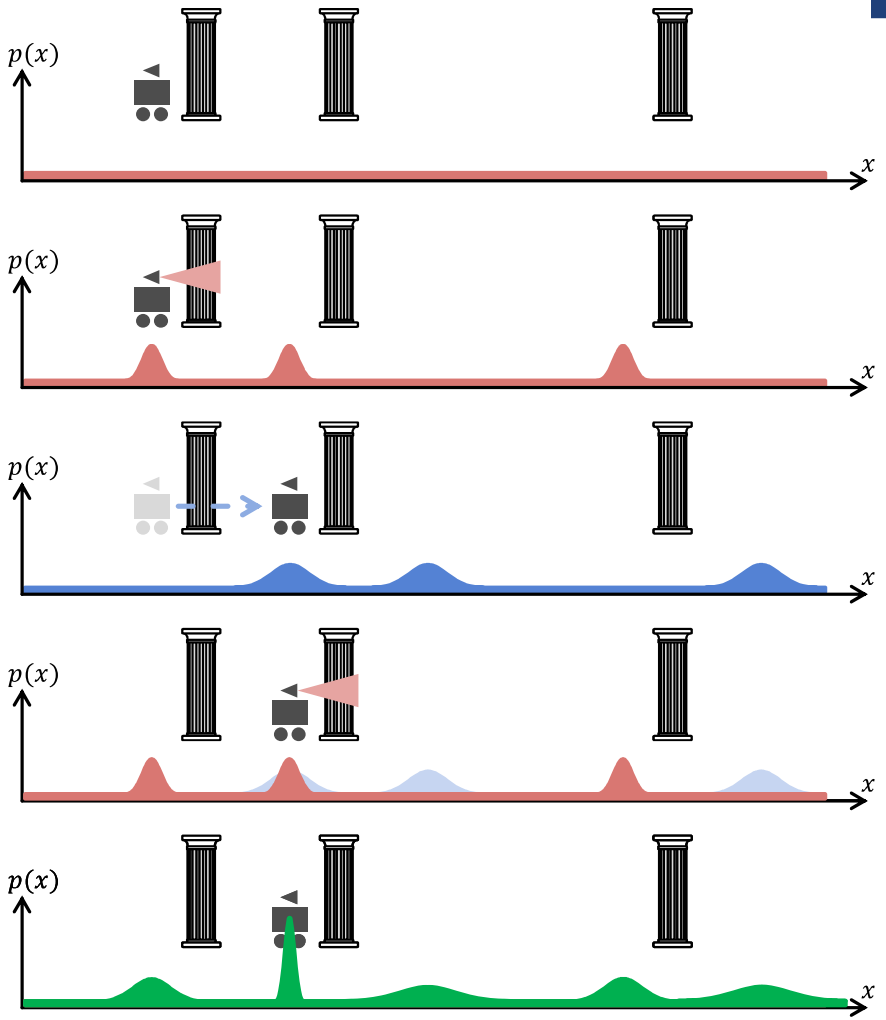
- Keypoint matching
  - BRISK example

Autonomous mobile robot | the see-think-act cycle

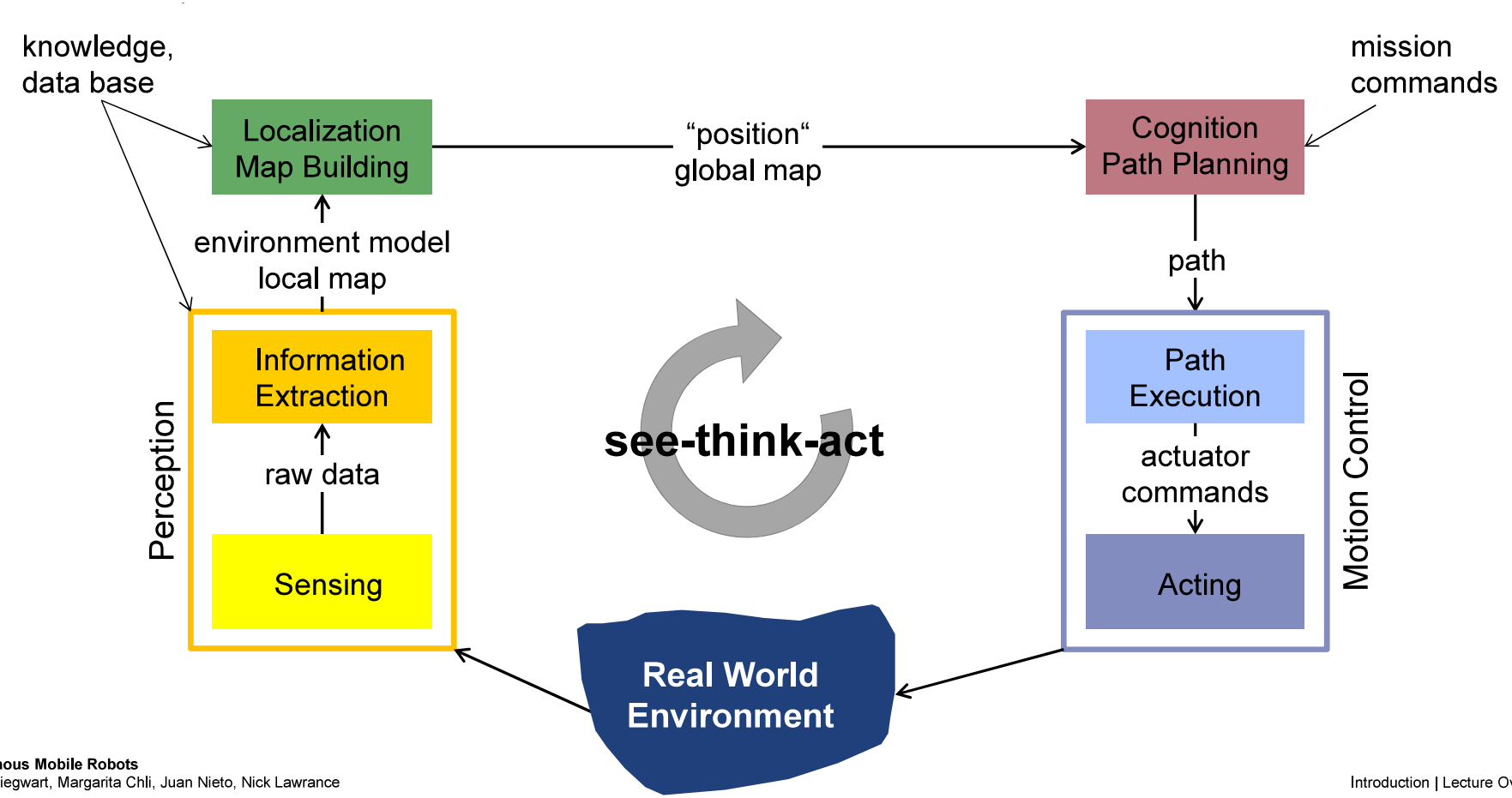


Localization | where am I?

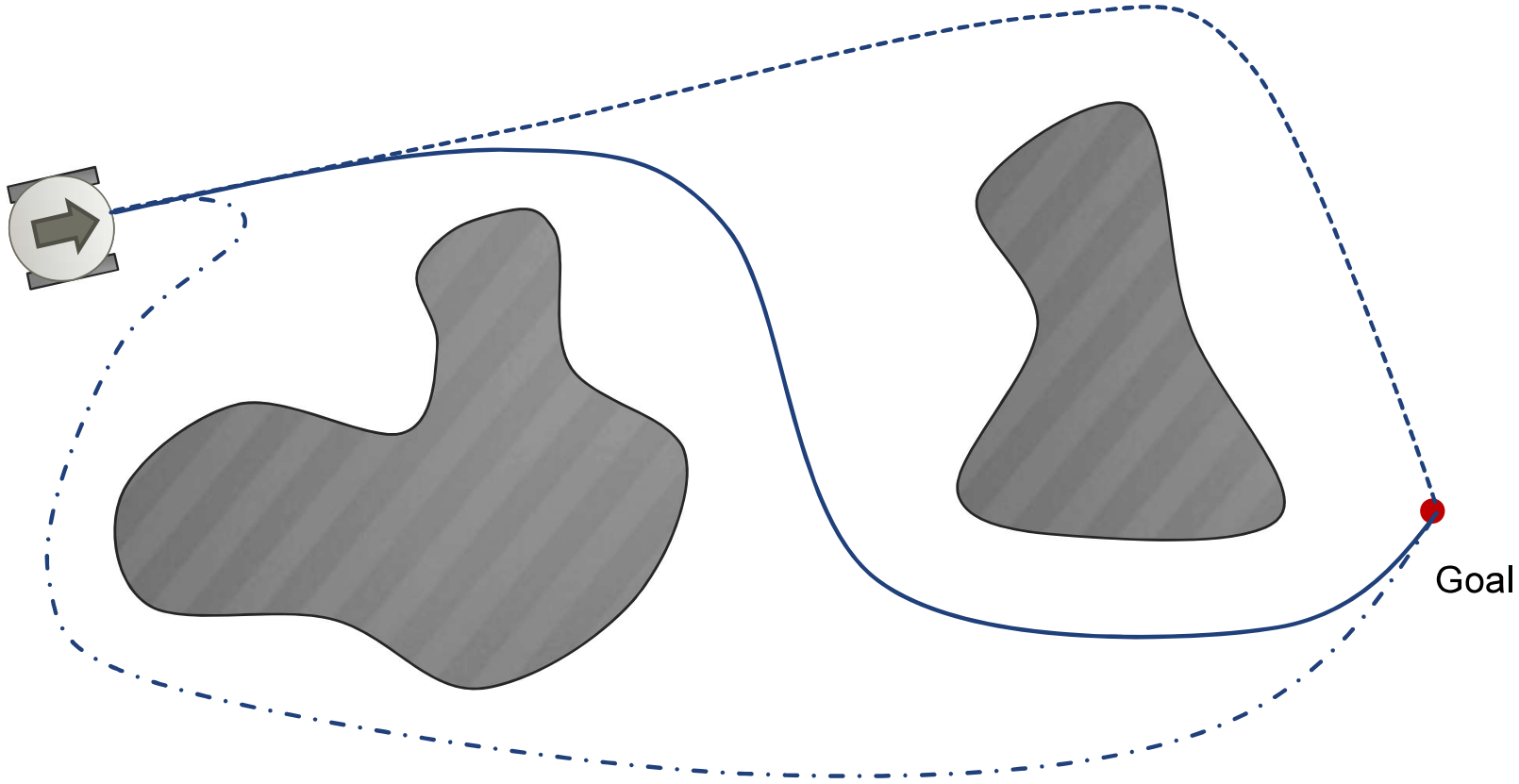
- SEE: The robot queries its sensors → finds itself next to a pillar
- ACT: Robot moves one meter forward
  - motion estimated by wheel encoders
  - accumulation of uncertainty
- SEE: The robot queries its sensors again → finds itself next to a pillar
- Belief update (information fusion)



Autonomous mobile robot | the see-think-act cycle

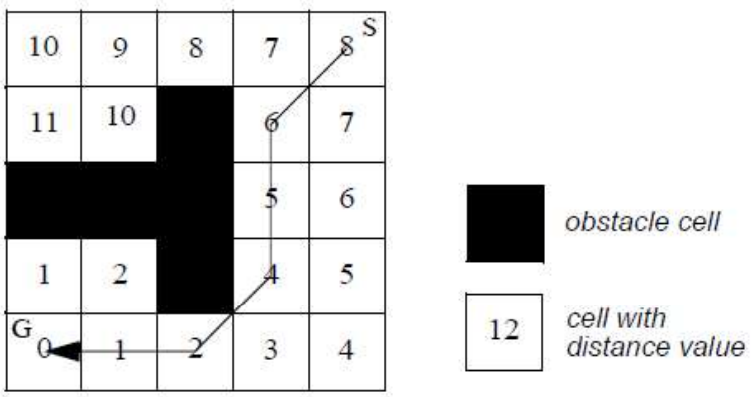


Cognition | Where am I going ? How do I get there ?

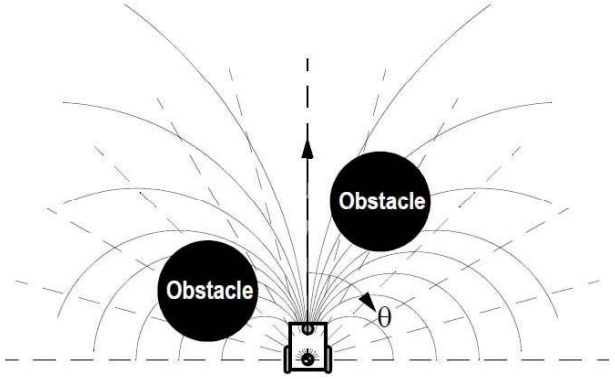


Cognition | Where am I going ? How do I get there ?

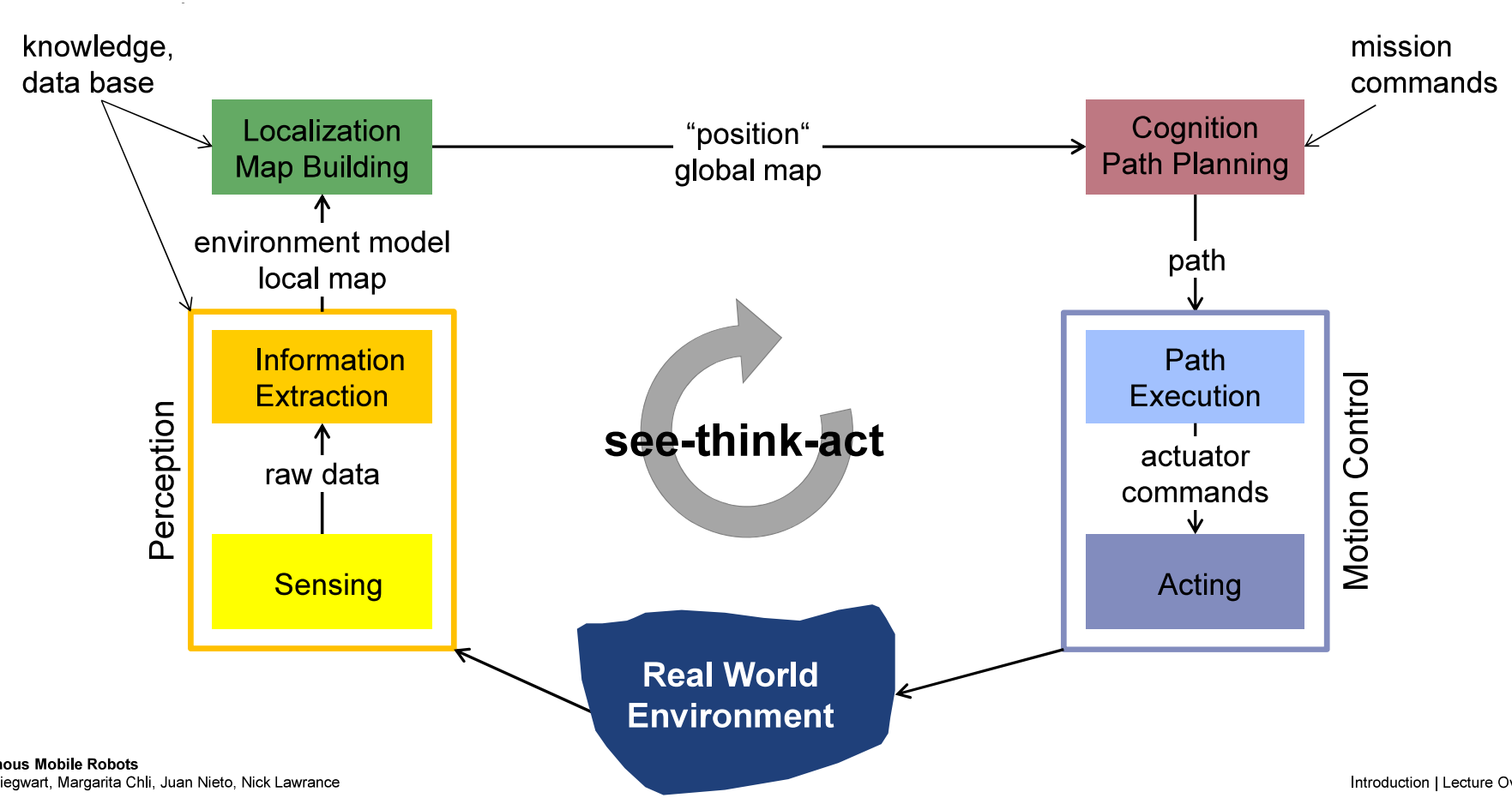
- Global path planning
  - Graph search



- Local path planning
  - Local collision avoidance

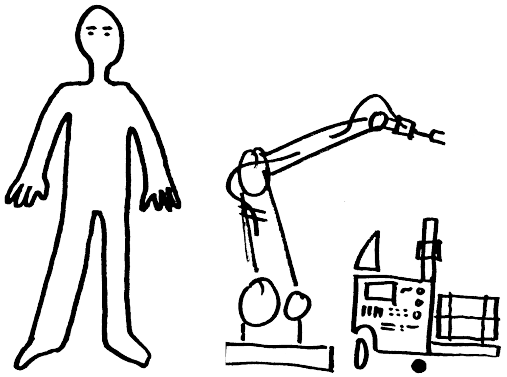


Autonomous mobile robot | the see-think-act cycle

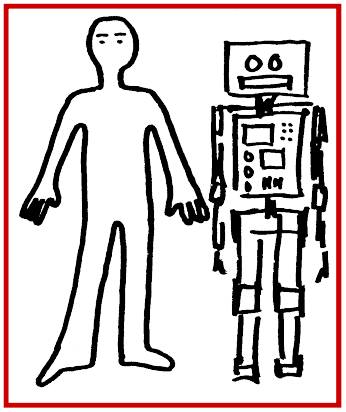


Next generation of Robots

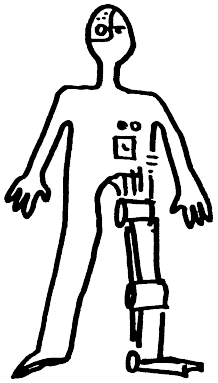
| mobile, smart, connected, adaptive and closer to humans



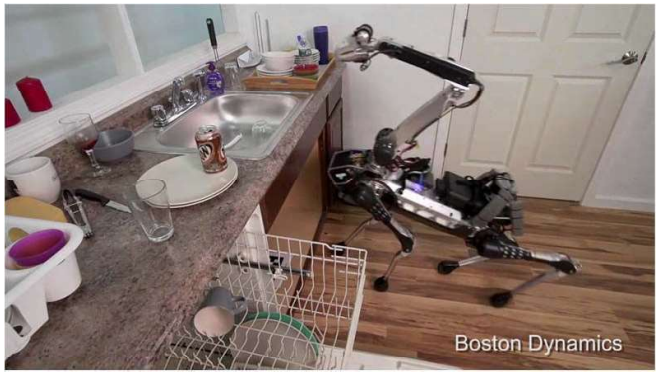
Industrial Robots



Service Robots



Cyborgs



Robotics | challenges and technology drivers

- The challenges
  - ***Seeing***, ***feeling*** and ***understanding*** the world
  - Dealing with ***uncertain*** and ***partially available*** information
  - ***Act*** appropriately onto the environment
- Technology drivers
  | *technology evolutions enable robotics revolutions*
  - Laser time-of-flight sensors
  - Cameras and IMUs combined with required calculation power
  - Torque controlled motors, “soft” actuation
  - New materials

Willow Garage