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

- **Localization Map Building**
  - knowledge, data base
  - environment model, local map
- **Information Extraction**
  - raw data
- **Sensing**
- **Cognition Path Planning**
  - "position" global map
  - path
- **Path Execution**
  - actuator commands
- **Acting**
- **Motion Control**
- **Real World Environment**

Diagram shows the see-think-act cycle with arrows connecting Perception and Motion Control.
Motion Control | kinematics and motion control

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

- Motion control

\[
\begin{bmatrix}
\dot{x} \\
\dot{y} \\
\dot{\theta}
\end{bmatrix} = f(\dot{\phi}_1 \cdots \dot{\phi}_n, \theta, \text{geometry})
\]

\[
\begin{bmatrix}
\dot{\phi}_1 \\
\vdots \\
\dot{\phi}_n
\end{bmatrix} = f(\dot{x}, \dot{y}, \dot{\theta})
\]
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**Perception**
- Knowledge, data base

**Real World Environment**

**see-think-act**

**Localisation Map Building**
- "position" global map

**Mission Commands**
Perception | sensing

- Laser scanner
  - time of flight
- Camera

![Laser scanner diagram](image)

![Autonomous robots diagram](image)
Perception | information extraction

- Filtering / Edge Detection

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

- Keypoint matching
  - BRISK example

Image from [Rosten et al., PAMI 2010]
Autonomous mobile robot | the see-think-act cycle

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  - Sensing
  - Information Extraction
  - Localization Map Building
  - Environment model local map
  - Knowledge, data base

- **Motion Control**
  - Cognition Path Planning
  - Path Execution
  - Acting
  - Mission commands

- **Real World Environment**

- **see-think-act cycle**
  - "position" global map
  - Path
  - Actuator commands

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*Autonomous Mobile Robots*
Roland Siegwart, Margarita Chli, Juan Nieto, Nick Lawrance
**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

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- Sensing

- Cognition Path Planning
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- Motion Control
  - Mission commands
  - Path Execution
    - actuator commands
  - Acting

Real World Environment

Perception
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

- Localization Map Building
  - environment model
  - global map
- Cognition Path Planning
  - path
- Information Extraction
  - raw data
- Sensing
- Path Execution
  - actuator commands
- Acting

Real World Environment

Knowledge, data base

Mission commands
Next generation of Robots
| mobile, smart, connected, adaptive and closer to humans

Industrial Robots

Service Robots

Cyborgs

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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