Robot Classification

according to the Robotics Institute of America

- **Variable-Sequence Robot**: A device that performs the successive stages of a task according to a predetermined method easy to modify.

- **Playback Robot**: A human operator performs the task manually by leading the Robot.

- **Numerical Control Robot**: The operator supplies the movement program rather than teaching it the task manually.

- **Intelligent Robot**: A robot with the means to understand its environment and the ability to successfully complete a task despite changes to the environment.
Intelligent Robots

Sense/Think/Act

“AI” view

get the computer (robot) to do things that, for now, people are better at
Sense/Think/Act

“AI” view
get the computer (robot) to do things that, for now, people are better at

“Reactive” view
“elephants don’t play chess”
Chess is easy - moving around is hard
What Can Robots Be Used For?

Manufacturing

3Ds: Dirty, Dull, Dangerous

Space
Satellites, probes, planetary landers, rovers

Military

Agriculture

Construction

Entertainment

Consumer
What Can Robots Be Used For?

- Manufacturing
- 3 Ds: Dirty,
What Can Robots Be Used For?

- Manufacturing
- 3 Ds: Dirty, Dull, Dangerous
- Space
- Satellites, probes, planetary landers, rovers
- Military
- Agriculture
- Construction
- Entertainment
- Consumer
The three key questions in Mobile Robotics

- Where am I?
- Where am I going?
- How do I get there?
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

- **Real World Environment**

- **Cognition Path Planning**: "position" global map, path
  - Mission commands

- **Path Execution**: Actuator commands
  - Acting

- **Motion Control**

- **Perception**: Sense, think, act cycle
  - See, think, act cycle
Wheel types and its constraints
- Rolling constraint
- no-sliding constraint (lateral)
Autonomous mobile robot | the see-think-act cycle

- Localization
  - Map Building
    - Environment model
      - Local map
    - Knowledge database
      - Raw data
        - Sensing
          - Information Extraction
            - Cognition Path Planning
              - "Position" global map
                - Path
                  - Mission commands
                    - Motion control
                      - Acting
                        - Path Execution
                          - Actuator commands
Perception | sensing

Laser scanner
- time of flight

Cameras

![Diagram of camera and focal point](image)

![Image of robotic car with sensors](image)
Perception | information extraction

Input Image → Mediated Perception (e.g. Mobileye, Google) → Behavior Reflex (e.g. ALVINN, LeCun et al.) → Direct Perception (ours) → Driving Control
Autonomous mobile robot | the see-think-act cycle

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

The see-think-act cycle: Sensing, Information Extraction, Perception, Localization Map Building, Cognition Path Planning, Motion Control.
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?
Global path planning
- Graph search
Cognition | Where am I going? How do I get there?

- Local path planning
  - Local collision avoidance
Autonomous mobile robot | the see-think-act cycle

- **Localization Map Building**
  - 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**

- **Perception**

- **Knowledge, database**

- **Mission commands**
Motion Control

Rezero | Wheeled locomotion with single point contact

- Up to 17° tilt angle
- Up to 3.5 m/s

http://www.rezero.ethz.ch/

heel design adopted from Kumagai & Ochiai, Tohoku Gakuin University, Japan
Motion Control: Vision only UAV navigation

Swarm of small helicopters

- Vision only navigation (one camera, GPS denied)
- Fully autonomous with on-board computing
- Feature based visual SLAM
Motion Control: Autonomous Driving in traffic
Motion Control: Humanoid Robot

- Honda’s ASIMO - Advanced Step in Innovative MObility
- One of the more advanced humanoid robots
- Compact, lightweight
- Sophisticated walk technology
- Human-friendly design
Beyond Mobility | PR2 robot from Willow Garage

Fold towels

Courtesy of Willow Garage

Clean-up
Lego EV3 Robots

- Lego EV3 robot contains a programmable EV3 **controller** (brick), user interface with an LCD screen, Lego building blocks, motors and various sensors such as light, ultrasonic, color, touch, gyro.
Lego EV3 Robots

- Lego EV3 robot contains a programmable EV3 controller (brick), user interface with an LCD screen, Lego building blocks, motors and various sensors such as light, ultrasonic, color, touch, gyro.
- The brick contains 4 outputs (motors) 4 inputs (sensors), USB, Bluetooth, or Wi-Fi connection, LCD screen, 16 MB flash memory, 64 MB RAM, SD Card Port, EV3 Brick Button lights, sound.