ROBOTICS
01PEEQW

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Mobile & Service Robotics
Introduction
Definitions

- A mobile robot is a structure capable to move and act (autonomously or remotely operated) in terrestrial, underwater or aerial environments.
- Environments can be assumed to be:
  - totally structured, partially structured or unstructured
  - totally known, partially known or unknown
- Structured environment = one knows the type and the geometric characteristics of the environment:
  - office space: corridors, doors, chairs, tables, etc.
  - obstacles: static or dynamics or both
  - constant or slow-varying in time

Autonomy

- Autonomy is the ability to move independently from a human supervisor.
- It requires:
  - Intelligence, i.e.,
    - CPU, algorithms, database
    - onboard or “in the cloud”
  - Sensors (for perceiving the environment)
  - Actuators (for motion and manipulation, etc.)
  - Energy source:
    - onboard generated
    - or supplied by an “umbilical cord”
**Examples**

- **structured**
- **partially structured**
- **unstructured**

**Fundamental problems in mobile robotics**

- **Locomotion**: how the robot moves in the environment
- **Perception**: how the robot perceives the environment
- **Representation**: how the robot organizes the knowledge about the environment
- **Mapping**: how to build the map of the environment
- **Localization**: where is the robot in the map
- **Path planning/action planning**: what the robot shall do to go from here to there; what are the actions to be performed to complete a specified task
- **Supervision and control**: how are the command to actuators generated to perform simple or complex tasks. How to generate tasks
Locomotion

- Terrestrial robots
  - Wheeled
  - Legged
  - Mixed wheels/legs
  - Biped (humanoids)
  - Others (biomimetics = imitation of natural locomotion)

- Underwater robots
  - Propellers
  - Water jets

- Aerial robots
  - Fixed wings
  - Rotating wings (helicopters and quadcopters)
  - Airships and dirigibles
  - Flapping wings

Terrestrial Robots – wheeled
Terrestrial Robots – legged

Terrestrial Robots – “humanoids”
Underwater Robots

- To move they use
  - Propellers
  - Water jets
  - Fins or entire body motion

Aerial robots (UAV)

- Airship (lighter than air) or aircrafts (heavier than air)
- They use
  - Propellers
  - Rotating wings
  - Flapping wings
Natural Locomotion

- Longitudinal waves
- Transversal waves
- Running
- Jumping
- Step

Biomimetic systems

Nature imitation

- Longitudinal waves
- Transversal waves
Mobile Robots: topics treated

- Wheeled robots
- Kinematics
- Sensors
  - Absolute and relative position (odometry)
  - Speed
  - Proximity and distance
  - Active ranging
  - Vision
- Intelligence
Wheel Types

- Simple non steering wheels
- Simple steering wheels
- Castor wheel
- Omniwheel (omnidirectional wheel) or Swedish wheel
- Spherical omniwheel

- Wheel may be active or passive

Simple non steering wheel

\[ \dot{\phi}(t) = 0 \]

\[ \mathbf{v}(t) = r \omega(t) \]

\[ \mathbf{v}^+(t) = 0 \]
Simple steering wheel

\[ \dot{\phi}(t) \neq 0 \]

\[ \mathbf{v}(t) = r \mathbf{\omega}(t) \quad \mathbf{v}^\perp(t) = 0 \]

graphical scheme

Simple steering wheel

\[ \mathbf{\omega}(t) \]

front view

top view

side view
Castor Wheel

![Castor Wheel Images]

Castor Wheel

![Castor Wheel Diagram]
Omniwheel – Swedish Wheel

Omniwheel – Swedish Wheel

assi a 90°
assi a 45°
Omniwheel can also be used as a support in a differential drive robot
Omnidirectional Spherical Wheel

Wheels Symbols

Swedish 90° Swedish 45°

Swedish 45°
Typical structures

Active fixed wheels + steering wheel

Active fixed wheels + castor passive wheel

Differential wheels + passive spherical wheels
**Typical structures**

- Active omnidirectional wheels
- Omnidirectional active wheels
- Fixed active wheel + passive omnidirectional wheel

- Steering

(a) Skid Steering (no steering wheels)
(b) Two-wheel Steering
(c) All-wheel Steering
(d) Two-wheel Steering (e.g. Rocky 7)
(e) Four-wheel Steering
(f) All-wheel Steering (e.g. Fido, Rocky 8)
Steering

Fig. 2. The mobility of a six-wheel rover with two-wheel front steering (e.g. Rocky 7)
**Simple non steering wheel**

![Simple non steering wheel diagram](image)

**Wheels Symbols**

- Simple passive non steering wheel
- Simple passive steering wheel
- Simple active non steering wheel
- Simple active steering wheel
- Passive castor wheel
- Active castor wheel
- Ominidirectional wheel
- Passive spherical wheel
- Active spherical wheel