→ Locomotion

Maps physical actions into movement, defining how a robot moves in the environment.

Three solutions:

- tracked locomotion
- legged locomotion
- wheeled locomotion

↳ Tracked locomotion

Great traction power, good for very tough terrain. Change of direction is done by sliding the tracks, which makes it difficult to use odometry. Large ammount of power to turn.

↳ Legged locomotion

Locomotion with legs, complex, power consumption and lack stability.

↳ Wheeled locomotion

Most suitable for common apps.

Configuration and type of wheel depend on app.

Main constraint is flat terrain

Big wheels → + torque (better for large obstacles)

- wheel types:
  - standard
  - steered standard
  - offcentered orientable wheel (castor)
  - swedish (omnidirectional)

Static stability:

- **two wheels:** minimum for stability, center of mass should be bellow the axle that links the wheels.

  2 configs: - one steering wheel in the front and traction wheel in the back.

  - two differential drive with center of mass bellow axle.

- **three wheels:** stable, center must be inside the triangle formed by ground contact of wheels.

  various configs, from differential, independent traction wheels, free wheels, motorized swedish, ...

- **four wheels:** stable, requires suspension system to compensate for irregularities in the environment.

  multiple different configurations.

→ **Kinematics:** modeling the motion without considering the forces that cause the object to move.

→ Differential drive

Common configs: 2 active independent wheels or 1/2 passive castor wheels.

Robot follows trajectory defined by speed of each wheel. Trajectory is sensitive to differences in the relative velocity of the wheels.

For small displacements:

$$x' = x + d_{center} \times \cos\theta$$
$$y' = y + d_{center} \times \cos\theta$$
$$\theta' = \theta + \phi$$

distance travelled

$$d_{center} = \frac{d_{right} + d_{left}}{2}$$

$$\phi = \frac{d_{right} - d_{left}}{L} = \frac{d_{left}}{r}$$

→ Tricycle drive

Two rear wheels and one (steering) front wheel, which can be passive or the driving wheels).

Main problems: traction.

Kinematic model:

$$v_x(t) = v_s(t) \cdot \cos\alpha(t)$$

$v_s(t)$ ↙ linear velocity of steering wheel

$\alpha(t)$ ↘ steering angle

$$v_y(t) = 0$$

$$\omega(t) = \frac{v_s(t)}{l} \times \sin\alpha(t)$$

$\omega(t)$ ↙ angular velocity

l ↘ distance between back and front wheels

→ Ackermann steering

Method of choice for outdoor vehicles.

Inside turning wheel is turned more than the outside turning wheel.

A differential gear must be used in the traction axel.

→ Synchro drive

3+ wheels.

The robot can move in any direction and can always reorient its wheels to move along a new trajectory without changing its foot print.

Orientation of the chassis is not controllable

→ Omnidirectional drive

Uses swedish wheels, each having independent motor.
Allows to move in any direction and complex movements.
Excellent maneuvenability