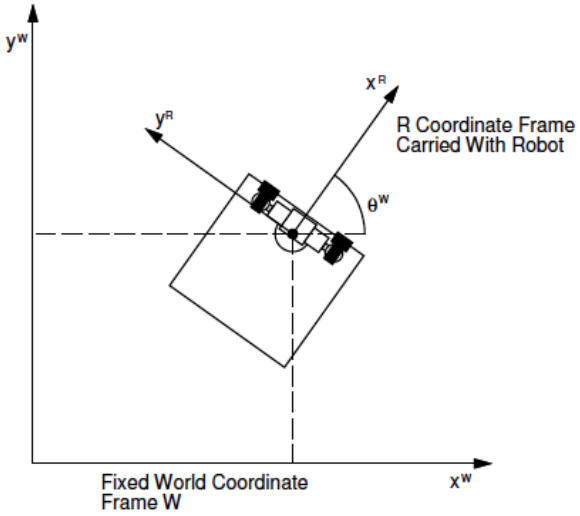
UNIVERSITÀ
DEGLI STUDI
DI PADOVA

MOBILE ROBOT LOCOMOTION

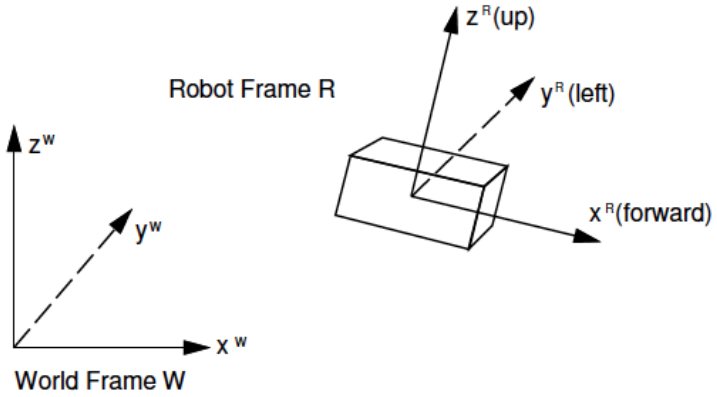
Prof. Emanuele Menegatti

Intelligent Robotics Course

MOTION AND COORDINATE FRAMES



2D



3D

Adapted from A.Davison

DEGREES OF MOTION FREEDOM

Adapted from A.Davison

DEGREES OF MOTION FREEDOM

Adapted from A.Davison

MOST COMMON WHEEL CONFIGURATION

Rack and Pinion

Differential drive

Skid-Steer

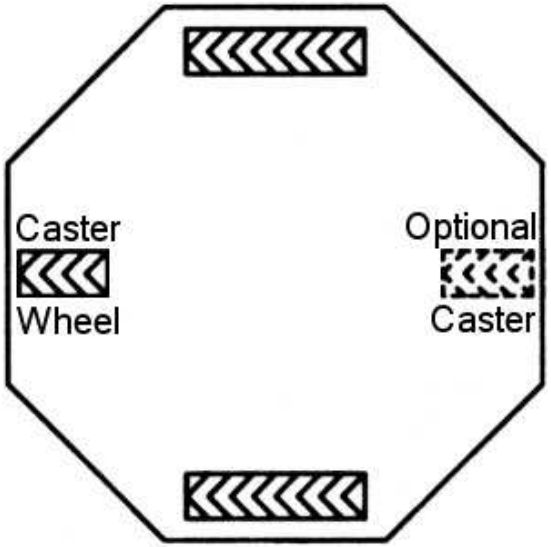
Synchro Drive

- Simple, reliable, robust mechanisms suitable for robots which essentially move in a plane.
- All of these robots are non-holonomic. For instance, a car-like robot can't instantaneously move sideways.
- All types use two motors, but very different kinematics.

Adapted from A.Davison

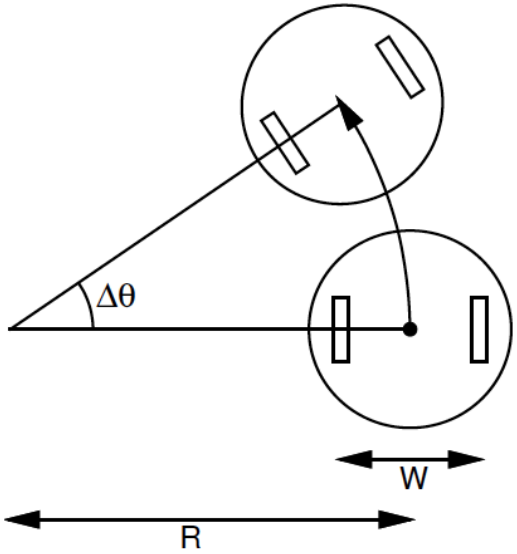
A simple example of robot's kinematic

DIFFERENTIAL DRIVE PLATFORM



Adapted from A.Davison

CIRCULAR PATH OF A DIFFERENTIAL DRIVE ROBOT

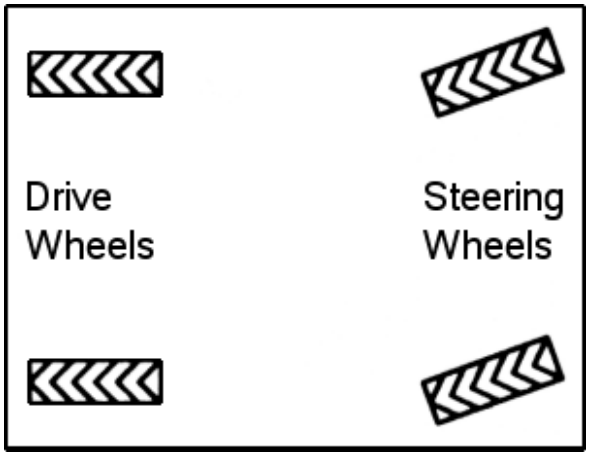


Adapted from A.Davison

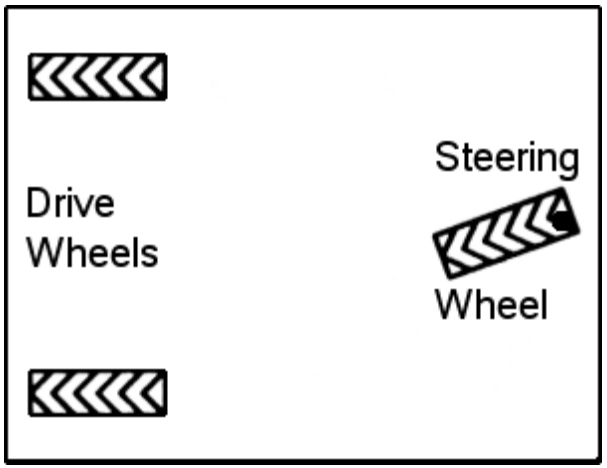
CIRCULAR PATH OF A DIFFERENTIAL DRIVE ROBOT

Adapted from A.Davison

CAR / TRICYCLE / RACK AND PINION DRIVE



CAR

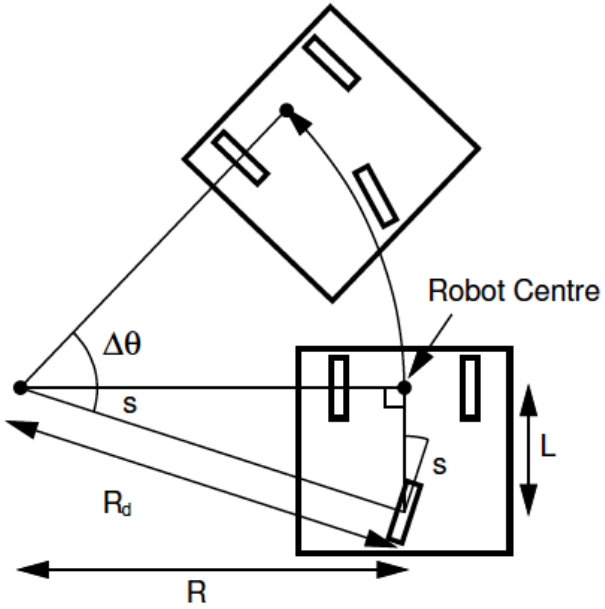


TRICYCLE

- Two motors: one to drive, one to steer.
- Cannot normally turn on the spot.
- With a fixed speed and steering angle, it will follow a circular path.
- With four wheels, need rear differential and variable ('Ackerman') linkage for steering wheels.

Adapted from A.Davison

CIRCULAR PATH OF A CAR-LIKE TRICYCLE ROBOT

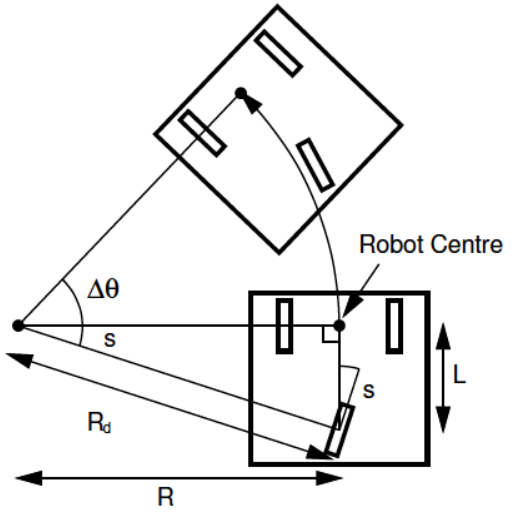


$$R = \frac{L}{\tan s} \ .$$

$$R_d = \frac{L}{\sin s} \ .$$

Adapted from A.Davison

CIRCULAR PATH OF A CAR-LIKE TRICYCLE ROBOT



In time Δt the distance along its circular arc moved by the drive wheel is $v\Delta t$, so the angle $\Delta\theta$ through which the robot rotates is:

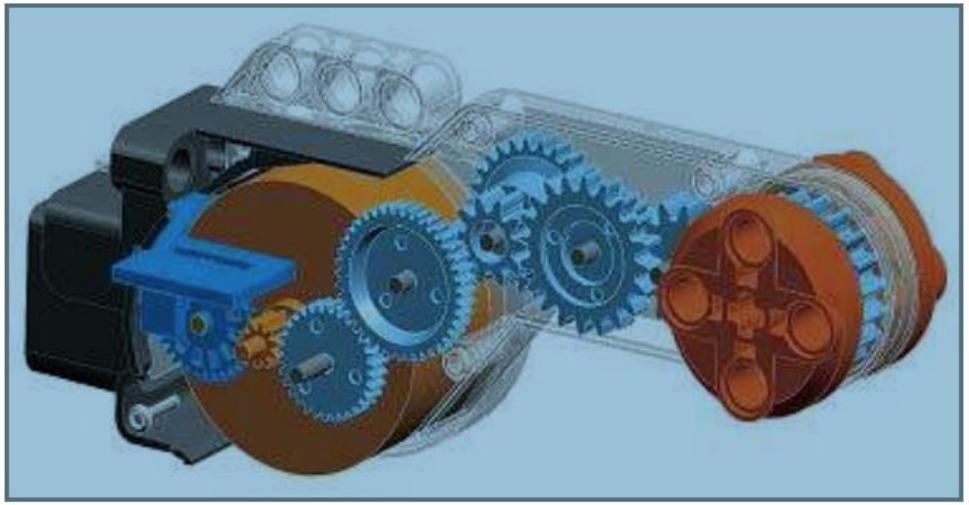
$$\Delta\theta = \frac{v\Delta t}{R_d} = \frac{v\Delta t \sin s}{L} .$$

$$R = \frac{L}{\tan s} \qquad \Delta\theta = \frac{v\Delta t \sin s}{L}$$

Adapted from A.Davison

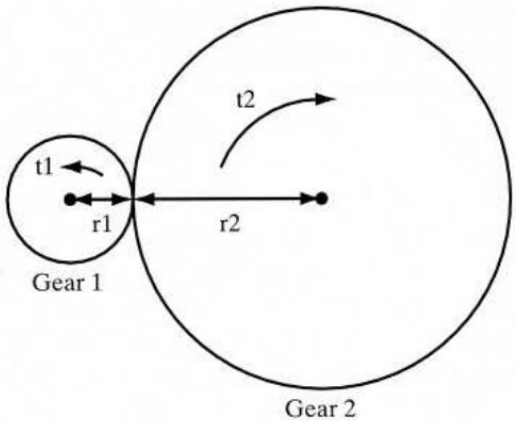
ACTUATION OF DRIVING WHEELS: DC MOTORS

- Most common motors, available in all sizes and types.
- Simple control with voltage or Pulse Width Modulation (PWM).
- For precision, encoders and feedback can be used for *servo* control (the LEGO motors have built-in encoders).



Adapted from A.Davison

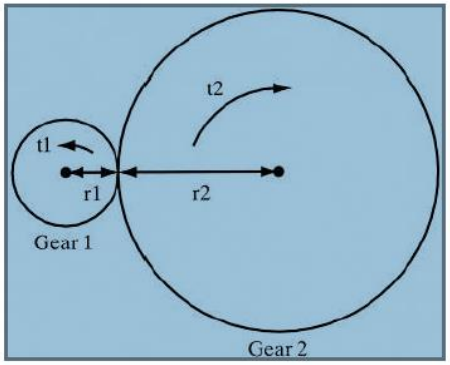
DC motors tend to offer high speed and low torque, so gearing is nearly always required to drive a robot.

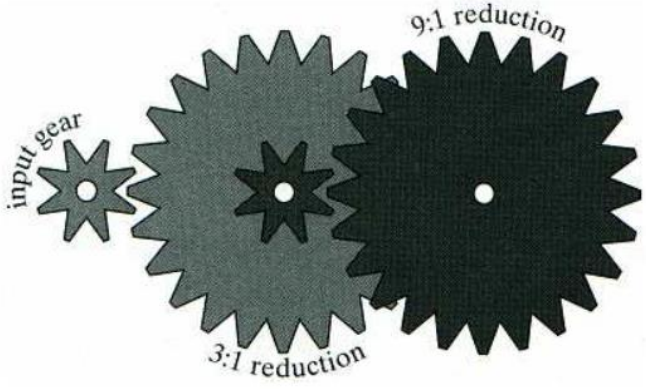


If Gear 1 is driven with torque t_1, it exerts tangential force:

on Gear 2. The torque in Gear 2 is therefore:

Adapted from A.Davison





The change in angular velocity between Gear 1 and Gear 2 is calculated by considering velocity at the point where they meet:

- When a small gear drives a bigger gear, the second gear has higher torque and lower angular velocity in proportion to the ratio of teeth.
- Gears can be chained together to achieve compound effects.

Adapted from A.Davison