Lab 9

School of Architecture, Civil and Environmental Engineering

EPFL, SS 2018-2019

http://disal.epfl.ch/teaching/signals_instruments_systems/

What this lab is about

- Sensing and localization
  - Calibration and noise

- Navigation through deadreckoning
- Make it sense and blink
- Digital filtering
  sensing → plotting → filter design→ filter implementation (MATLAB) → filter implementation (C)

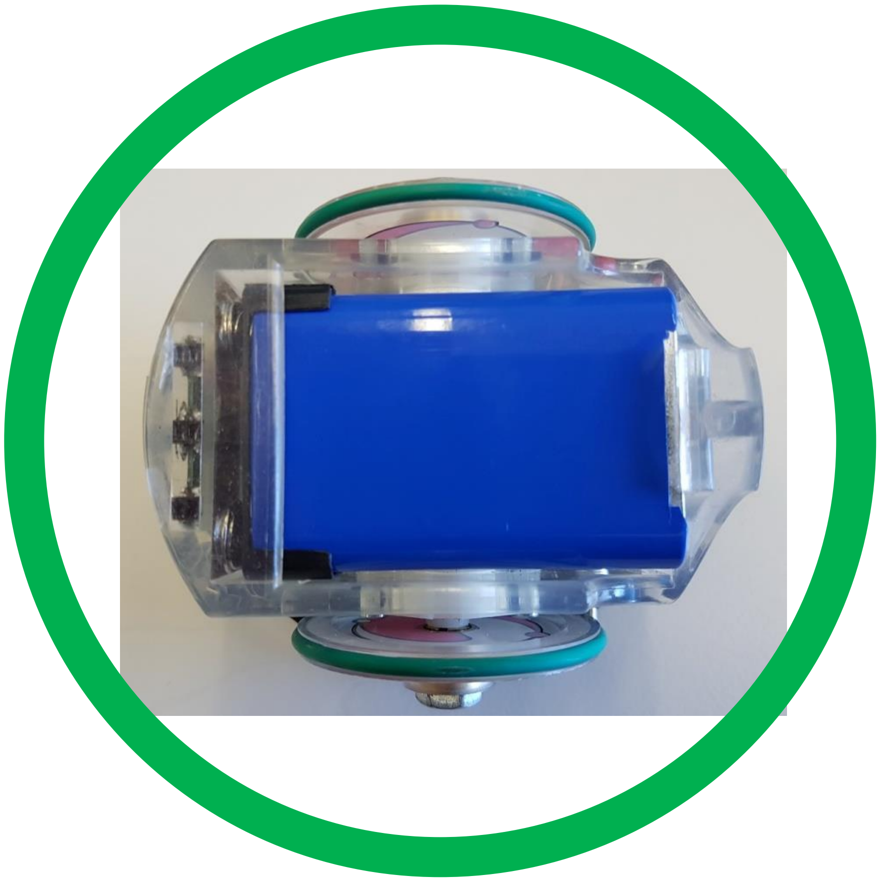
Software

- On a GIT repository
  - download files by executing
    `git clone https://disalgit.epfl.ch/epuck/epuck.git`
  - Content of folder EpuckDevelopmentTree/
  - e-puck library
  - test programs (not needed in this lab)
- Executables: already installed in GR B0 01
  - epuckconnect
  - epuckupload

Hardware

- Everybody will receive:
  - 1 e-puck robot
  - 1 battery
  - 1 USB-Bluetooth dongle

e-puck: insert battery



If you can see the serial number it's wrong

e-puck: Reminder

You will need to use 2 buttons on the robot:

reset

power
(behind right wheel)

Also: watch for the power (green) and the low-power LED (red)

Programming an e-puck

- Turn on robot, plug USB dongle into computer
  `ssh localhost`
- Upload program abc.hex
  `epuckupload -f abc.hex 123`
- Output data to computer from e-puck 123:
  `epuckconnect 123 && cat /dev/rfcomm123`
- Remember:
  Before compiling a C file (abc.c), edit your Makefile:
  `EPUCKLIBROOT=/home/user/mydocs/Epuck/EpuckDevelopmentTree/library`

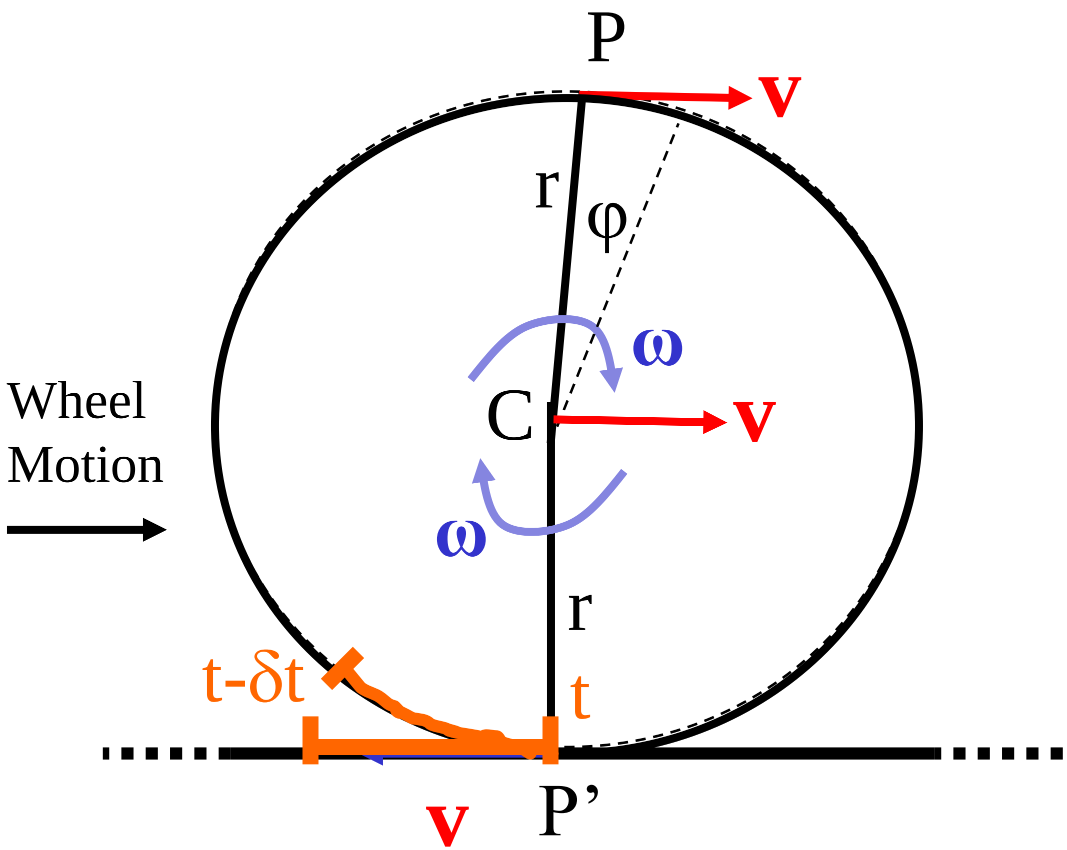
Odometry using Wheel Encoders

Odometry

- The stepper motors of the epuck allow us to know how much they rotated
- Measure the displacement from motor rotations

$$\varphi_{wheel} = 2\pi \frac{N_{steps\ done}}{N_{steps\ per\ turn}}$$

Recap ME/PHY Fundamentals



$$v = \omega r = \dot{\varphi} r$$

v = tangential speed

ω = rotational speed

r = rotation radius

φ = rotation angle

C = rotation center

P = peripheral point

P'= contact point at time t

Rolling!

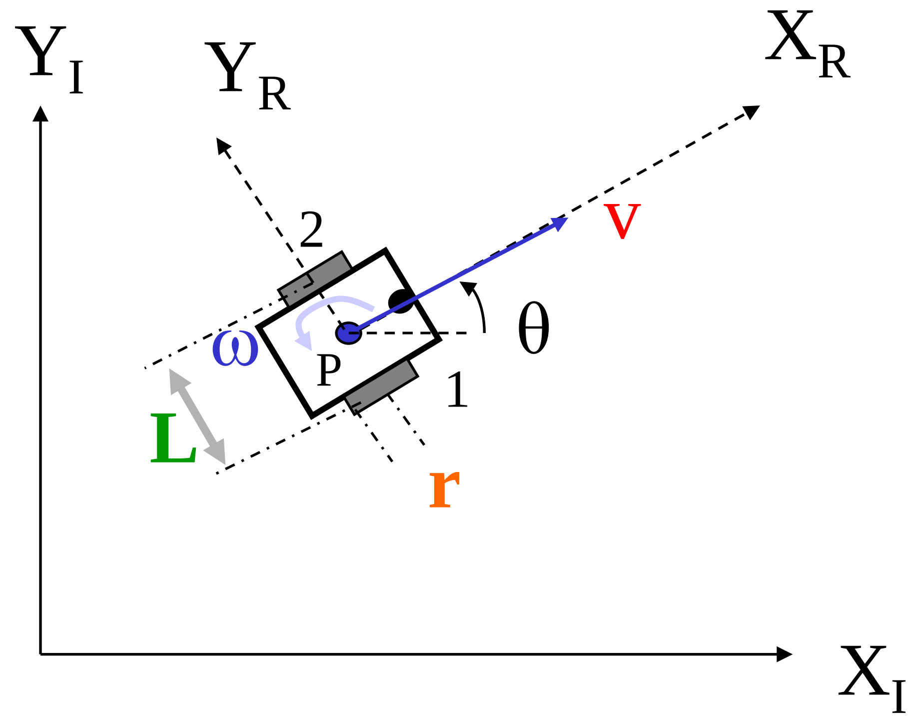
Forward Kinematic Model

Linear speed = average wheel speed 1 and 2:

$$v = \frac{r\dot{\varphi}_1}{2} + \frac{r\dot{\varphi}_2}{2}$$

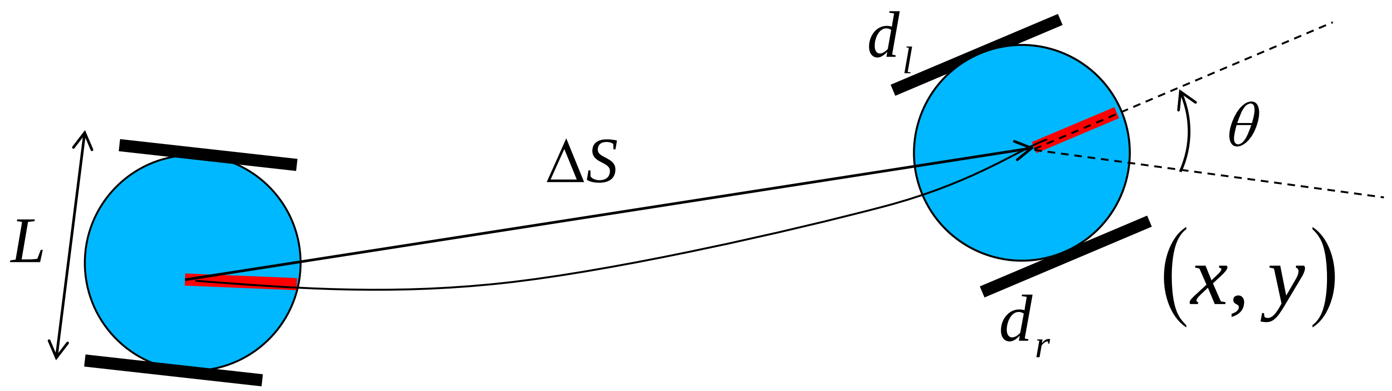
Rotational speed = sum of rotation speeds (wheel 1 clockwise, wheel 2 counter-clockwise):

$$\omega = \frac{r\dot{\varphi}_1}{L} + \frac{-r\dot{\varphi}_2}{L}$$



Idea: linear superposition of individual wheel contributions

Deadreckoning



$$\theta = \frac{(d_r - d_l)}{L}$$

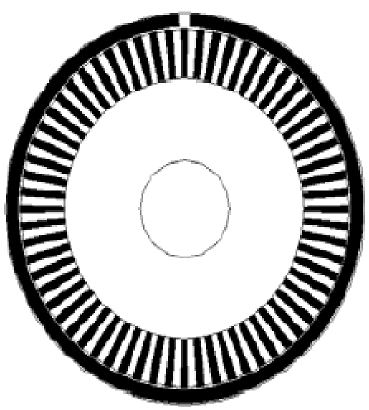
$$\Delta S = \frac{d_r + d_l}{2}$$

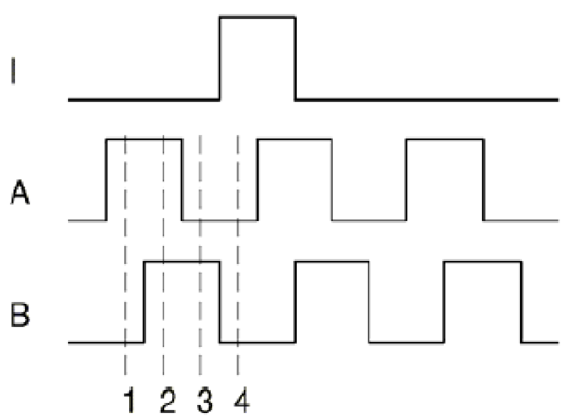
$$\begin{cases} x \approx \Delta S \cos\left(\frac{\theta}{2}\right) \\ y \approx \Delta S \sin\left(\frac{\theta}{2}\right) \end{cases}$$

with $d = r\varphi$

Optical Encoders

- Measure displacement (or speed) of the wheels
- Principle: mechanical light chopper consisting of photo-barriers (pair of light emitter and optical receiver) + pattern on a disc anchored to the motor shaft
- Quadrature encoder: 90º placement of 2 complete photo-barriers, 4x increase resolution + direction of movement
- Integrate wheel movements to get an estimate of the position -> odometry
- Typical resolutions: 64 - 2048 increments per revolution.





State	Ch A	Ch B
S_1	High	Low
S_2	High	High
S_3	Low	High
S_4	Low	Low