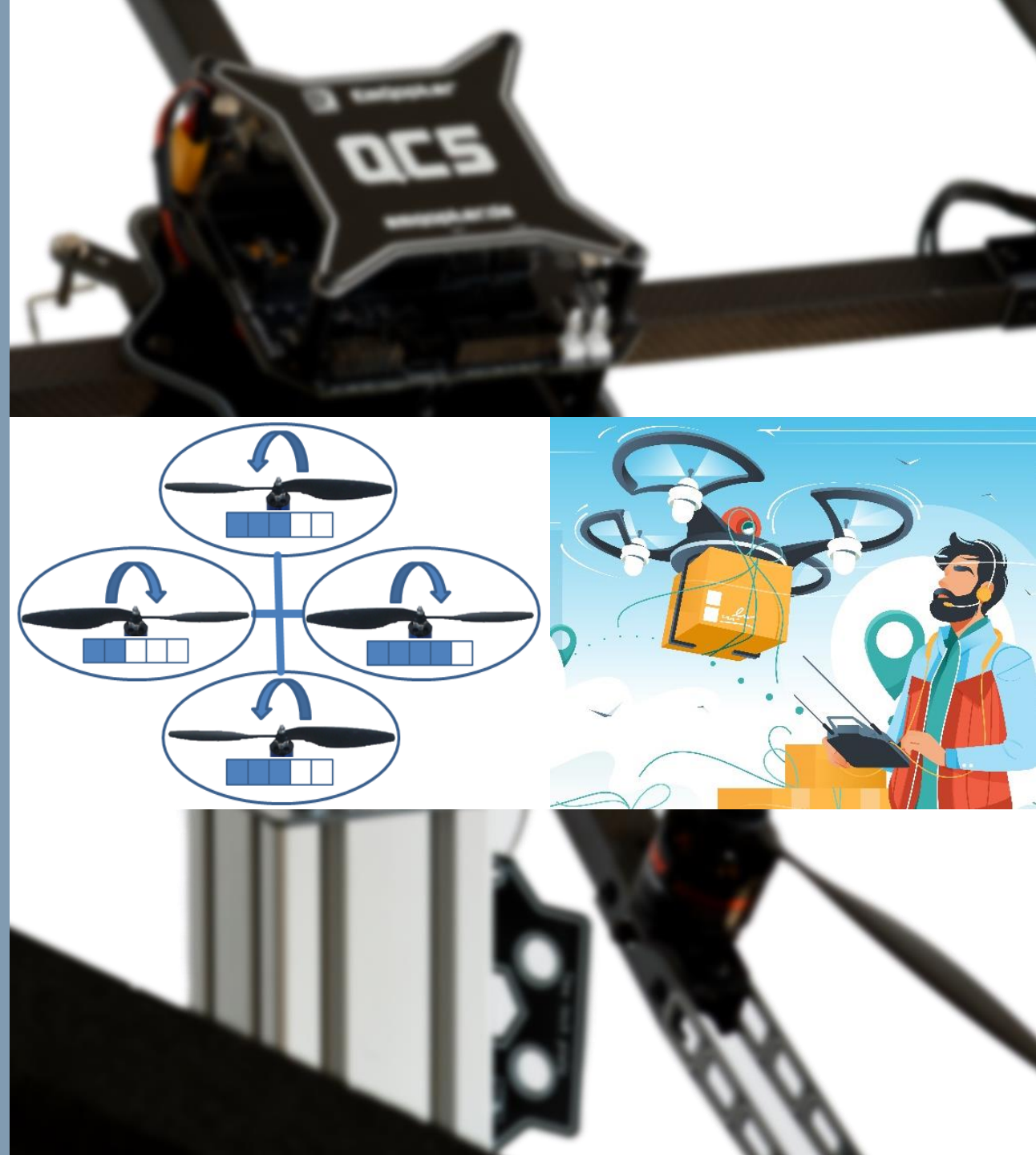


Automation

Control and automation

Lesson 10



Contents



- Control of a quadrocopter
- Safety briefing
- Exercises & instructions

Time scope: approx. 1-3 hours

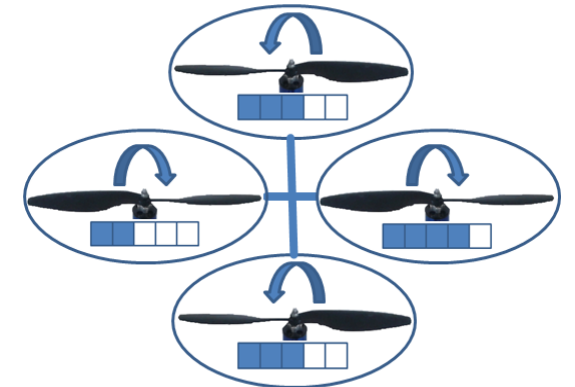


Control of a quadcopter

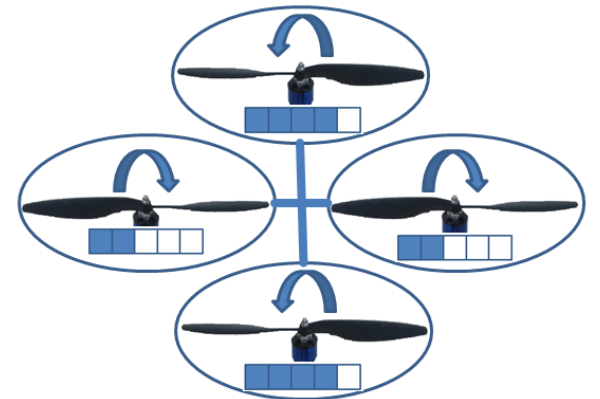


Control of a quadcopter:

- The orientation of the quadcopter (**roll, pitch, yaw**) can be controlled based on the three controllers
- By setting a roll angle, the quadcopter can manipulate its position sideways
- Similarly, the position can be manipulated forwards/backwards by adjusting the pitch angle
- As the quadcopter can thus turn in all directions (**symmetry**), yawing is not necessary in general, unless:
 - The quadcopter has a preferred direction (e.g. camera) that must be maintained
 - The quadcopter wants to carry its momentum with it during a turn (**energy efficiency**)



Principle: Roll



Principle: Yaw

Control of a quadrocopter

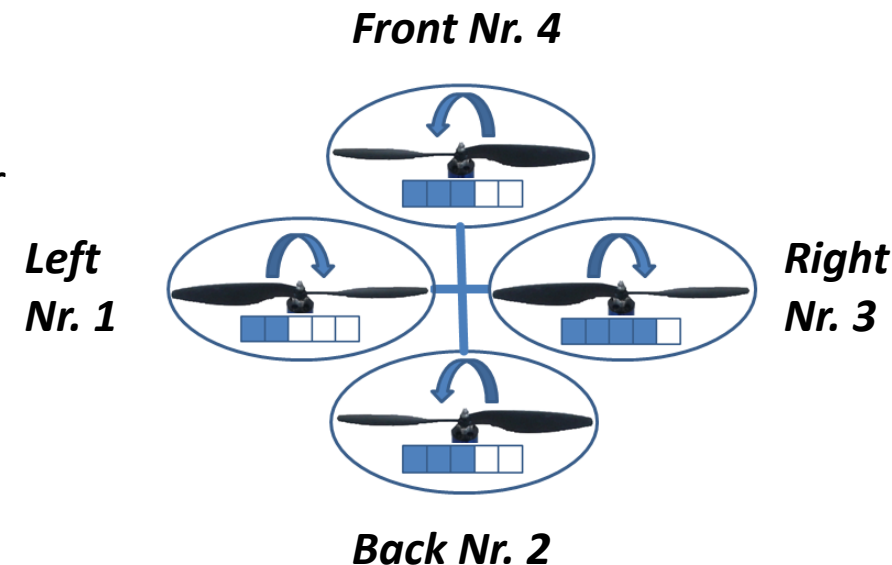


Control of a quadrocopter (forwards / backwards):

- Example of **forward flight**: The quadrocopter tilts forwards. Motor no. 4 turns less and motor no. 2 turns more.
- Example of **reverse flight**: The copter tilts backwards. Motor no. 2 turns less and motor no. 4 turns more.

Control of a quadrocopter (left / right):

- Example **right-hand flight**: The quadcopter tilts to the right. Motor no. 3 turns less and motor no. 1 turns more.
- Example **left-hand flight**: The quadcopter tilts to the left. Motor no. 1 turns less and motor no. 3 turns more.





Necessary hardware:

- EMQ3000
- Mini-USB cable for power and flashing
- Mini-USB cable for communication: USART to PC
- QCS in 3DOF control mode

Necessary software:

- AVR Studio 32 installed (with toolchain and flip driver)
- EMQ_Framework (AVR-Code)
- Documents:
 - EMQ_Framework.pdf
- Qt Creator 2.0.1 and Qt 4.7.0 (32bit)
- EMQt_Framework\quatplay\quatplay.pro (Code)

Safety briefing



Safety briefing:

- Before starting the motors, always check that everything is tight:
This applies to all screws, motors, booms, Y-parts, knurled screws, etc.
- **ONLY** connect the power supply unit and start the motors with the authorisation of the supervisor.
- Keep your distance. Warn neighbours. Exercise caution. Have the on/off button ready (finger over it)!



Emergency stop options:

- On/Off button
- Switch off or disconnect the power source
- Disconnect **I2C** cable (pull out)
- Switch off **MCU** (disconnect USB cable)

Exercises



Exercise 1a:

Now the quadrocopter is to perform an automated flight path controlled by a command.

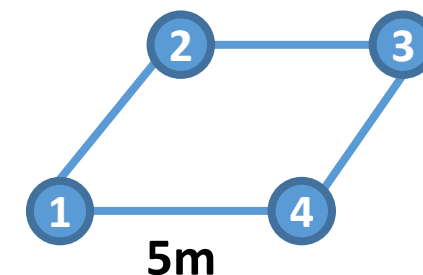
We simulate this on the ground by making the simplified assumption that an inclination of 12° causes an acceleration of 2 m/s^2 and the quadrocopter continues to move at a constant speed without air friction as long as it is standing straight. Decelerations of the **acceleration** when adjusting the inclination are neglected.

The quadrocopter should fly exactly along **the rhombus** with the points **P1**, **P2**, **P3** and **P4** from the illustration at a maximum speed of 1 m/s .

$$P_1 = \langle 0\text{m}, 0\text{m} \rangle \quad P_2 = \langle 3\text{m}, 4\text{m} \rangle \quad P_3 = \langle 8\text{m}, 4\text{m} \rangle \quad P_4 = \langle 5\text{m}, 0\text{m} \rangle$$

During this maneuver, the quadrocopter should **NOT yaw**, i.e. not rotate around the z-axis!

First consider which rotational maneuvers are necessary and with what timing. Note that the system must accelerate/decelerate. Diagonal movements are super-positioned vectorially. The maximum speed must be maintained at all times.



Exercise 1b:

The maneuver is to be executed/stopped by command (**Qt**).

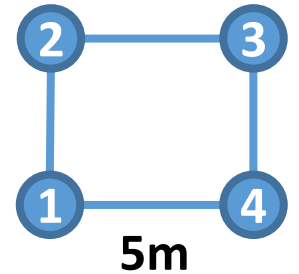
Exercises



Exercise 2a:

The quadcopter should now fly over a **square** with an edge length of 5 meters, as in task 1. To do this, it should **always** approach the targets with the "**nose**" forwards, i.e. now **yaw**. Otherwise, the same requirements apply as in task 1.

Note: Make sure that the cable does not wind up when turning!



Exercise 2b:

In both cases, the quadcopter will not fly the figures very accurately. Explain and discuss the causes. Think about a better alternative for the automatic flight procedure.