TECHNISCHE UNIVERSITÄT WIEN

ILSB Institute of Lightweight Design and Structural Biomechanics

Computational Bionics
Project Exercise 2

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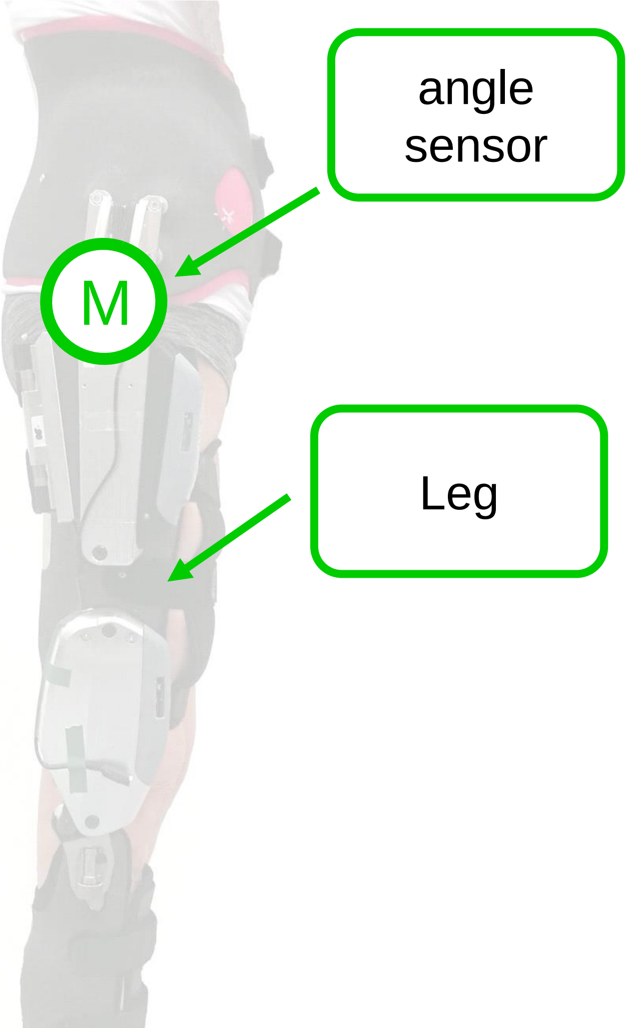
Our mission



Spinal cord injury (SCI) is a common cause of paralysis, according to WHO global incidence is 250.000 – 500.000 cases a year.

Our mission is to get as many people out of the wheelchair as possible. You will be modeling some subcomponents of an exoskeleton to push its development.

In the first exercise you model the subcomponents:

- leg
- hip drive

In this exercise you reuse them to model the system of our exoskeleton.

The following slides provide you with information to build the system model. If you are missing information, make a reasonable assumptions and document it.

Basic system model (15 points)

- Combine the sub models of the leg and the hip drive (exercise 1) to your first system model
- Model a PID controller which controls the hip angle according to the provides gait data.
- Only consider the swing phase. Start your simulation at toe off and stop when the leg has ground contact again
- Chose suitable initial values
- Use an ideal digital controller (no quantization) with a sampling Time $dt_{control} = 0.1$ s
- Choose control parameter which lead to a stable configuration (no optimization necessary)
- Use an ideal analog sensor for the hip and knee angle. You can direct use q_1 and q_2 (no quantization)
- Chose a simple ideal damper in the knee ($M_2 = D^* \omega_2$) to stabilize the system
- Assume the center point of the hip is fixed in space

- Draw a simplified box model with in and outputs and the equation system in the box for your system model
- Run the simulation and discuss the result
- Describe how a validation off your model can be done an what is needed therefore

Real sensor (10 points)

- Quantize the controller output
- Measure the hip angle by a potentiometer (like exercise 1)
- Choose an ADC with input range of 0 to 3 V
- Assume a measurement noise in the sensor with standard deviation of $\sigma = 10mV$
- You don’t need to change the angle signal in the knee (no sensor)
- Adapt your control parameter if necessary (no optimization)

- Update your simplified box model
- Run the simulation with an 8bit ADC and an 10bit ADC
- Compare and discuss the result

Optimize parameter (10 points)

- Use your system model for parameter optimization
- Use the 10bit ADC for your final model
- First step: optimize the control parameter. Minimize the control error.
- Second step: Optimize the chosen damping coefficient in the knee to achieve best fit to the trajectory of the knee angle (gait data)
- For both optimization steps choose the built in minimize function in python according to the lecture

- Run the simulation and discuss the results

What to submit

- Submit your exercise solutions in groups of 1 to 3 students.
- There is no group registration, just write the names of the group members on the protocol.
- Submit a jupyther notebook with the code for all three models. Provide it in the *.ipynb and *.pdf format.
- Write your notebook as a protocol (use markdown cells).
- Explain short how you derive your models, discuss the verification and the results.
- Prepare the protocol so that you can use it for the 15-minute group presentation.