Student names: ... (please update)

Instructions: The goal of this session is to get you familiarized with the NeuroRobotics Platform (NRP) developed by the Human Brain Project. During the session you will work with the NRP on two experiments. Namely, a pendulum model and a mouse model. You will have to use the features in the platform to complete simple tasks described below and provide solutions. Also you will be answering questions regarding the usability and features of the platform as you perform the experiments. ***You only need to submit a small report answering the questions described in this below. The report should be no longer than 3 pages in total*** *Submit a single document NRP_report_name1_name2_name3.zip where name# are the team member's last names. Please submit only one report per team!*
This assignment gives a 0.25 (if carried out reasonably well) or 0.5 (if carried out very well) bonus point on the grade for the mini project. For instance, your mini project grade can be increased from 5.0 to 5.5. Deadline May 18, 23h55.

Pendulum Experiment

This experiment contains the model of a simple pendulum actuated by a pair of antagonist muscles. It is similar to the model you have developed and worked with during *Lab 4* and *Lab 5*. The pendulum model is developed to replicate the behavior of mouse hind limb femur and pelvis segments with a single degree of freedom at the hip joint. Hence, the physical properties for the pendulum model are extracted from the mouse data. Table 1 describes the physical properties of the pendulum used in the simulation. The model contains two muscles, one on each side of the joint. The muscle and their functions on the joint is described in 2. For properties of the muscles you can have a look at the pendulum_properties.json in the Experiment Files section on the NRP.

Note : The physics of the model is scaled to avoid numerical instabilities. Please refer to Lab 7 for more details on physics scaling

Segment	**Mass**[g]	**Length** [cm]	**Moment of Inertia**		
			Ixx [$g\ cm^2$]	**Iyy** [$g\ cm^2$]	**Izz**[$g\ cm^2$]
Pendulum	1.11126	1	9.1	4.24	9.10

Table 1: Physical Properties of the Pendulum

Muscle	**Abbreviation**	**Type**	**Hip**	**Knee**	**Ankle**
Psoas Major	PMA	Mono-articular	Flexion	-	-
Caudofemoralis	CF	Mono-articular	Extension	-	-

Table 2: Flexor and Extensor muscles in the pendulum model

Questions

Launch the pendulum model and open Editor function and then navigate to the Transfer Functions tab. Here you will find the three main python files that allow you to control and modify the experiment.

- **apply_torque.py** : Transfer function to apply the computed joint torques to the Gazebo simulation.
- **compute_muscle_torque.py** : Transfer function to step the musculoskeletal model and compute the joint torques. This is the function you need to work with to change the muscle activation patterns while answering the questions.
- **save_csv_joint_state.py** : Transfer function to save the data to a csv file.

1a. Briefly describe the behavior of the pendulum with the default parameters, e.g. in terms of frequency and amplitude of oscillations. Plots are not necessary.

1b. Is the pendulum in a limit cycle behavior? What feature from the NRP did you use to check the limit cycle behavior?

1c. In compute_muscle_torque.py change the muscle activation's frequency of the flexor and extensor by the same factor. Does the pendulum frequency correlate with the applied frequency of the muscle activation's?

1d. Download the csv data file from the Experiment files folder at the end of a simulation. Read the data externally using Python(For example with Spyder) or any other program of your choice. Show a plot containing the joint states (position and velocity) as a function of time and phase plot containing joint position versus velocity

Mouse Experiment

For the mini project you have been working on the mouse locomotion based purely on reflexes and feed backs. The current mouse model(which is part of current research) contains a bio-inspired Central Pattern Generator network developed by [1]. The physical properties and the musculoskeletal parameters of the model are the same as you have seen for the mini project.

Questions

2a. Clone the mouse model to run the experiment. Translate the mouse model by -2 m in the world before starting the simulation.Then start the simulation and observe the behavior. Describe the gait generated by the hind limbs with default parameters. Eg. in terms of duty factor, and phase relationship between left and right legs

2b. Is the mouse model behaving in a qualitatively similar manner to the Webots model?. Briefly discuss similarities and differences

2c. What happens if the mouse model is started in the air rather than on ground? Try different starting heights, and briefly discuss

2d. During the mouse locomotion, interactively add objects into the simulation to create a perturbation and explain how the model behaves in this case. No, need of any plots. Provide a screen shot of the mouse with the inserted objects.

2e. Using the logged csv data plot the muscle activation's of all the muscles in either left or right hind limb by reading the csv file externally using Python or other program of your choice. Briefly describe the muscle activation pattern you observe in the plot.

Neuro-Robotics Platform

Questions

3a. Do you like the idea of accessing the neuromechanical models on remote servers through a web interface?

3b. How do you rate the graphical user interface? Any suggestions on how to improve it?

3c.How do you rate the programming environment? (Obviously there was little time to really test it today). Any suggestions on how to improve it?

3d. Please also complete the following online feedback form

REFERENCES

1. *Central control of inter limb coordination and speed-dependent gait expression in quadrupeds.* : Danner, S. M., Wilshin, S. D., Shevtsova, N. A. and Rybak, I. A. (2016), J Physiol, 594: 6947-6967. doi:10.1113/JP272787 [link]