Student names: ... (please update)

Instructions: Update this file (or recreate a similar one, e.g. in Word) to prepare your answers to the questions. Feel free to add text, equations and figures as needed. Hand-written notes, e.g. for the development of equations, can also be included e.g. as pictures (from your cell phone or from a scanner). ***This lab is graded.*** *and needs to be submitted before the* ***Deadline : Friday 10-06-2022 23:59. For project 2, you must submit one final report for all of the following exercises separately from the report of project 1. The code of both projects can be provided together.*** *Please submit both the source file (*.doc/*.tex) and a pdf of your document, as well as all the used and updated Python functions in a single zipped file called final_report_name1_name2_name3.zip where name# are the team member's last names. Please submit only one report per team!*

Questions

9a. Limb – Spine coordination

In this next part you will explore the importance of a proper coordination between the spine and the limb movement for walking.

1. Change the drive to a value used for walking and verify that the robot walks
2. Analyze the spine movement: What are your phase lags along the spine during walking? How does the spine movement compare to the one used for swimming?
3. Notice that the phase between limb and spine oscillators affects the robot's walking speed. Run a parameter sweep on the phase offset between limbs and spine. Include plots showing how the phase offset influences walking speed and comment the results. How do your findings compare to body deformations in the salamander while walking?
4. Explore the influence of the oscillation amplitude along the body with respect to the walking speed of the robot. Run a parameter search on the nominal radius R with a fixed phase offset between limbs and the spine. For the phase offset take the optimal value from the previous sub-exercise. While exploring R, start from 0 (no body bending).

Include plots showing how the oscillation radius influences walking speed and comment on the results.

9b. Land-to-water transitions

1. In this exercise you will explore the gait switching mechanism. The gait switching is generated by a high level drive signal which interacts with the saturation functions that you should have implemented in 8a. Implement a new experiment which uses the x-coordinate of the robot in the world retrieved from the GPS sensor reading (Check simulation.py for an example on how to access the gps data). Based on the GPS reading, you should determine if the robot should walk (it's on land) or swim (it reached water). Depending on the current position of the robot, you should modify the drive such that it switches gait appropriately.
2. Run the MuJoCo simulation and report spine and limb angles, together with the x coordinate from the GPS signal. Record a video showing the transition from land to water and submit the video together with this report.
3. Achieve water-to-land transition. Report spine and limb angles, the x-coordinate of the GPS and record a video.

Hint: Use the record options as shown in exercise_9b.py to easily record videos.

9c. Reserach proposal

Propose a potential additional study that could be performed in simulation and with the real salamander. This should be written like a research proposal using the questions listed below and should not exceed 2 pages (including figures and references). You are free to choose any topic related to sensorimotor coordination and locomotion of the salamander. NOTE : The proposal should be just text (possibly with some figures), there is no need to perform the actual numerical experiments!

1. Provide a scientific question
2. Formulate a hypothesis corresponding to the scientific question
3. Describe an experiment in simulation that could be performed to test the hypothesis
4. Specify which type of simulation (e.g. neural circuits + biomechanics, neural circuits alone, etc.), which level of abstraction, and which assumptions (cf the modeling steps presented in the course)
5. Specify a corresponding experiment that could be performed with the real animal
6. Discuss what you expect and what could be learned from those experiments (in simulation and real)
7. Refer to and include a short bibliography with relevant literature (Example [**?**])