FIELD AND SERVICE ROBOTICS (FSR) – a.y. 2024/2025
University of Naples Federico II
Department of Electrical Engineering and Information Technology

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HOMEWORK n. 4

1. Describe the buoyancy effect and why it is considered in underwater robotics while it is neglected in aerial robotics.
2. Briefly justify whether the following expressions are true or false.
   a. The added mass effect considers an additional load to the structure.
   b. The added mass effect is considered in underwater robotics since the density of the underwater robot is comparable to the density of the water.
   c. The damping effect helps in the stability analysis.
   d. The Ocean current is usually considered as constant, and it is better to refer it with respect to the body frame.
3. Consider the Matlab files within the `quadruped_simulation.zip` file. Within this folder, the main file to run is *MAIN.m*. The code generates an animation and plots showing the robot's position, velocity, and *z*-component of the ground reaction forces. In this main file, there is a flag to allow video recording (`flag_movie`) that you can attach as an external reference or in the zip file you will submit. You must:
   a. implement the quadratic function using the QP solver `qpSWIFT` located within the folder (refer to the instructions starting from line 68 in the file `MAIN.m`);
   b. modify parameters in the main file, such as the gait and desired velocity, or adjust some physical parameters in `get_params.m`, such as the friction coefficient and mass of the robot. Execute the simulation and present the plots you find most interesting: you should analyze them to see how they change with different gaits and parameters and comment on them.
4. Consider the MATLAB file `rimless_wheel.m`, which simulates the motion of a rimless wheel. You are required to:
   a. Modify the initial angular velocity (line 12) with both positive and negative values. Run the simulation, examine the time histories of the states and the resulting phase portrait, and provide a critical discussion of the observed behavior. For example, consider the following questions: To which equilibria does the system converge? How many distinct equilibria or limit cycles are present? Can you identify their respective basins of attraction?
   b. Modify the leg length (line 7), the inter-leg angle (line 9), and the slope inclination (line 9), while keeping the initial angular velocity fixed at 0.95 rad/s. Run the simulation and critically analyze the results. In particular, address questions such as: Which parameter changes affect the equilibrium conditions? Do these modifications result in different limit cycles compared to the previous case?

NOTE: It is worth recalling not to report theory in the report. **Put all the plots you think are the most important to understand the performance of the code you implemented, and critically comment on the results.** Attach the code with your submission in a ZIP file. If you overcome the submission limit on Moodle, you may link in the report a GitHub, Dropbox, or Google Drive link (make these links public, if possible, to avoid waiting for permission to download the files).