FIELD AND SERVICE ROBOTICS (FSR) – a.y. 2023/2024

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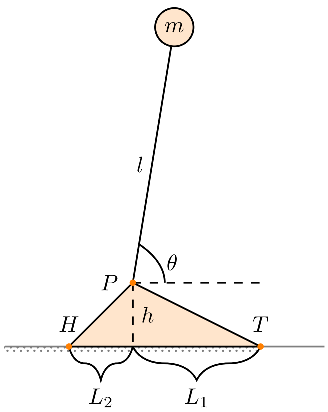
HOMEWORK n. 4

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 a legged robot as in the picture below. The foot and the leg are assumed to be massless. The point T represents the toe, the point H represents the heel, and the point P is the ankle. The value of the angle θ is positive counterclockwise and it is zero when aligned to the flat floor. Answer to the following questions by providing a brief explanation for your them.
   a. Without an actuator at the point P, is the system stable at $\theta = \frac{\pi}{2} + \epsilon$?
   b. Without an actuator at the point P (i. e., $\ddot{\theta} \neq 0, \dot{\theta} \neq 0$), compute the zero-moment point on the ground as a function of θ and the geometric and constant parameters (if necessary).
   c. Supposing to have an actuator at the ankle capable of perfectly cancelling the torque around P due to the gravity (i.e., $\ddot{\theta} = 0, \dot{\theta} = 0$), what value of θ can you achieve without falling?



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). If Moodle server does not work, send an email to the instructor by attaching the submission files.