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4M20 Robotics (2018) Coursework 1

Instructions

Objective	Theoretical and numerical investigation of a robotic manipulator. Solve the tasks stated below and summarise your results in a written report.
Report	Each student should hand in one report, maximum 10 pages A4, minimum font size 11. Undergrad students should use the designated cover sheet with "candidate ID". Postgrad students should indicate name/CRS-ID on cover page.
Submission	Due on 2 November 2018 (4pm) Submission via Moodle: https://www.vle.cam.ac.uk/course/view.php?id=94122

Q1. (20%) Consider a two-legged robot shown in Figure 1 below. By using its three joint motors (shown by white circles), it can walk forward by swinging Foot 2 forward, then Foot 1 forward, for example. Assuming that Foot 1 is fixed on the ground at first, calculate the joint angles θ_1, θ_2, θ_3 to achieve the end of Foot 2 $[X_5, Y_5]$ to be at [0.15m, 0.05m] (with respect to $[X_1, Y_1]$ = [0.0m, 0.0m]. Then what are those joint angles for Foot 2 landing jat $[X_5, Y_5]$ =[0.12m, 0.0m] with the forth link perpendicular to the ground plane. L_1= L_2= L_3= L_4= 0.10m.

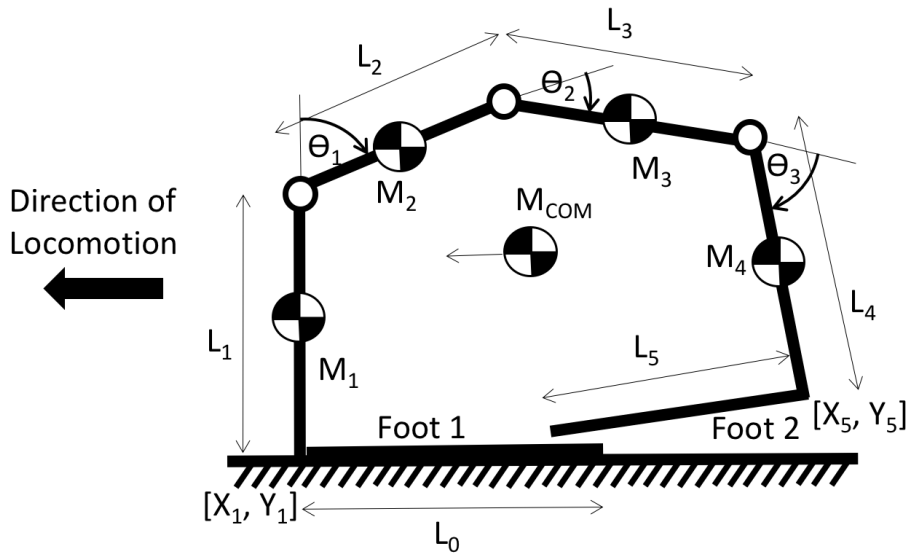

Figure 1: Two-Legged Robot

Q2. (10%) In the same two-legged robot, we consider each link has a point mass M_n at the middle. Derive the Centre of Mass (M_{COM}) of the whole robot and its location as the function of joint angles θ_1, θ_2, θ_3. Consider M_1= M_2= M_3= M_4= 0.10kg.

Q3. (20%) When Foot 1 is not fixed on the ground, in order for this robot not to fall down, the projection of M_{COM} on the ground (X_{COM}) needs to be within $0<X_{COM}<L_0$. Considering L_1= L_2= L_3= L_4= 0.10m, what is the minimum length of Foot 1 L_0 for this robot to achieve "static locomotion" all the time? And what is the maximum stride length (i.e. a possible longest step of Foot 2)? Discuss the drawback to achieve locomotion when L_0 is too large.

Q4. (50%) Given the design above, this robot needs to traverse the terrain with a step shown in Figure 2 below. Calculate the trajectories of θ_1, θ_2, θ_3 such that the robot can reach the goal without falling down at the step. And estimate the minimum torque required for each of three motors, duration required to accomplish this task, and energy efficiency. Discuss whether motor trajectories would influence these performance metrics.

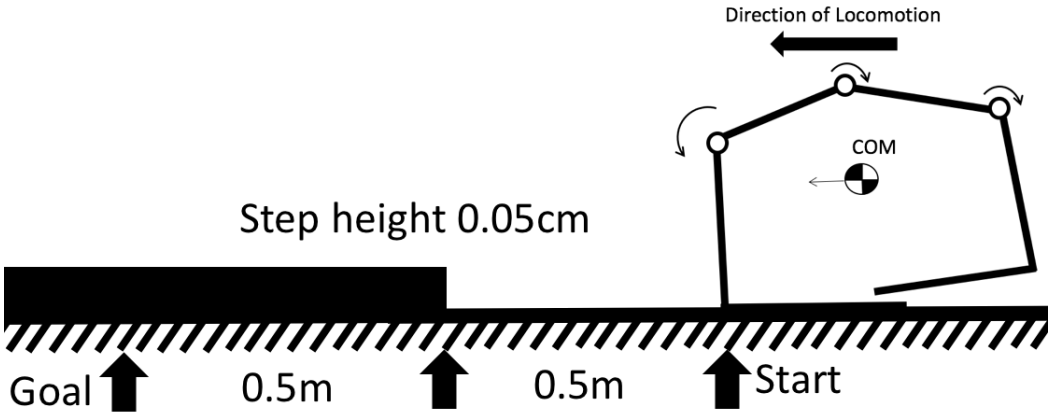

Figure 2: Locomotion terrain