AME 556 – Robot Dynamics and Control – Final Project

Develop controllers for Unitree A1 robot in MATLAB Simscape for the following tasks.

1. Task 1: Walking

Design a controller that allows the robot to perform the following task:

- Walking forward and backward with a speed of $\geq 0.5\ m/s$.
- Walking sideway with a speed of $\geq 0.5\ m/s$.
- Turning in place with the yaw speed of $\geq 0.5\ rad/s$.

You will get a $\boldsymbol{score = 35}$ ($\boldsymbol{points}$) for completing this task.

2. Task 2: Running on flat ground

- Control the robot to run on flat ground for **10 meters**.
- The score for this task will be calculated as follow:

$$\boldsymbol{score = \frac{200}{travel\ time\ (s)}}$$

where $\boldsymbol{travel\ time}$ is the time in seconds needed for the robot to complete the 10-m distance run. The distance can be verified by the distance along the x-axis of the robot's COM.

- For running, you can select any gait of your choice (bounding, galloping, …) but the requirement is to have a flight phase in the gait schedule.

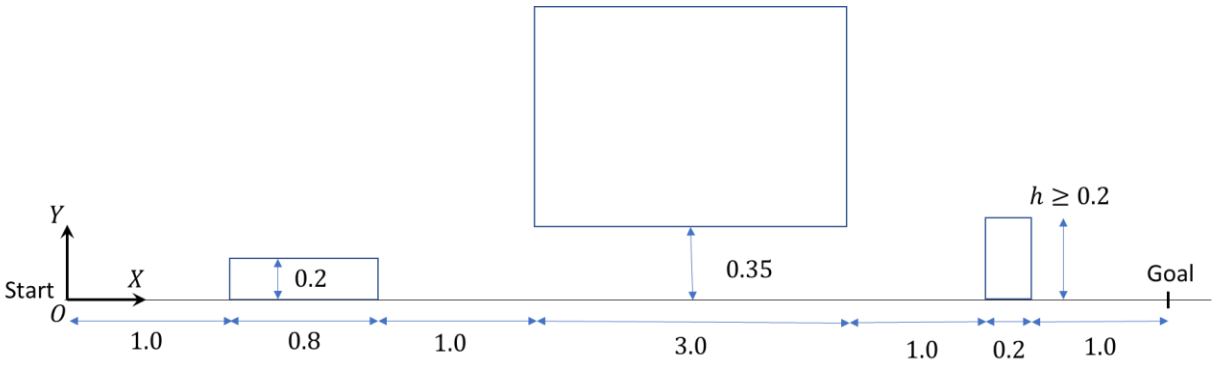
3. Task 3: Stair Climbing

- Control the robot to walk/run on 5 consecutive stairs with the stair rise of $10\ cm$, stair run of $20\ cm$, and stair width of $2\ m$.
- Please make sure that there is no collision between the robot body, robot legs and the stair edges.
- The score for this task will be calculated as follow:

$$\boldsymbol{score = \frac{20}{travel\ time\ (s)}}$$

where $\boldsymbol{travel\ time}$ is the time in seconds needed for the robot to complete the task. The time is counted when the robot start walking and ends when all four feet of the robot pass the edge of the last stair.

4. Task 4: Obstacle course



- Consider the obstacle course as shown in the figure above.
- Please make sure that there is no collision between the robot body, robot legs and the obstacles and terrain.
- The score for this task will be calculated as follow:

$$\boldsymbol{score} = \frac{\mathbf{100}}{\boldsymbol{travel\ time}\ (\boldsymbol{s})} + \mathbf{100} \times (\boldsymbol{h}(\boldsymbol{m}) - \mathbf{0.2})$$

where h is the maximum height of the last obstacle that your approach can handle.

Submission and Timeline:

- Submit 1 single pdf for your team's report. Please include viewable links to simulation videos and codes into the report.
- Each team will send scores and final report via email to the TA and cc me in the email.
- Timeline:
  - Wed, Apr 26: Final project update and discussion + score report (1st time). Each team will need to prepare a short presentation to show your score, videos, plots to verify your performance, and questions about the project if you have any.
  - Wed, May 03: Final project score report (2nd time)
  - Mon, May 08: Final project report

Final Project Report

For the final project report, please submit a single pdf file and include the following information at the start of the report:

- group number + team members (with USC email and ID)
- a link to your simulation video
- a link to your presentation
- a link to your code

The final report format will be similar to our HWs. Please include the following contents to the report:

- Explain briefly your approach, and your code structure so that it can help us to grade it.
- Include necessary plots, links to the videos and code, and details about the calculation of the score for each task. Please verify via plots that your results satisfied all the physical constraints of the robot.

Format: single column, font size 12pt, page limit 15.

Submission guideline:

- Each group please sends me the report via email and cc the TA in the email.
- The submission deadline is **11:59 pm, Mon, May 08.**