IIT Bombay
Systems and Control Engineering
Embedded Control and Robotics
Assignment 3

SC 649 | Maximum Marks: 15

Deadline
Date: 25.10.24, 11.59pm

Instructions:

- Each student is required to make an independent submission. The students without the submission will not be awarded marks. A group of max. 3 students is permissible.
- Submit the answers to this assignment on or before the deadline at 11:59 p.m. on 25.10.2024. This is a strict deadline, and no request for any extension will be entertained.
- All the results and the associated observations/analysis must be compiled in a single pdf file. This pdf and the associated code must also be submitted in a single zip folder on moodle on the relevant submission link.
  Label this folder in the form: FirstName_RollNumber_AS03.
- Please preserve the code and the report till the end of this semester.
- Assumptions made, if any, must be clearly stated and must be justified.
- After the end of each question, the numbers to the right, indicate marks allotted to it.

1 Prerequisites

This assignment has to be carried out on the MIT Race-car model in ROS-Gazebo. You are allowed to attempt his assignment in groups of 3. The relevant ROS packages that are to be installed can be found at the below links.

- https://github.com/mit-racecar/racecar
- https://github.com/mit-racecar/racecar_gazebo

To install these ROS packages inside the ROS Workspace of your PC, run the following commands.

```
sweksha@swe:~$ cd ros_ws/src/
sweksha@swe:~/ros_ws/src$ git clone https://github.com/mit-racecar/racecar
```

```
sweksha@swe:~/ros_ws/src$ git clone https://github.com/mit-racecar/racecar_gazebo
```

Once the git repositories are cloned into the src folder of your workspace, navigate to your workspace folder and run the **catkin_make** command. If the catkin make command throws any errors due to dependencies, run the following command from inside your workspace.

```
sweksha@swe:~$ rosdep install --from-paths src --ignore-src -r -y
```

Once the above command is executed, re-run the **catkin_make** command from inside your workspace folder again. This should ideally solve the dependency issues if they exist and successfully build the packages inside your workspace.

```
sweksha@swe:~$ cd ros_ws/
sweksha@swe:~/ros_ws$ catkin_make
```

- Once the above steps are complete, copy the ROS Package "sc649 assignment 3" from Moodle into the "src folder" of your workspace. **(Note: If the download from moodle is a .zip file, you will have to extract the package folder from it, and copy only the extracted folder into the src folder of your workspace.)**
- Once you are done with the above step, navigate to your workspace folder and run the "catkin make" command again.
- You would now be equipped with the relevant packages to attempt the assignment. **(Note: Ideally, following the above steps should be sufficient for getting the packages installed. In case any other errors pop up, you can try repeating the above steps on the computers of the other group members/ look for fixes for the errors online. If you are still not able to fix the persistent errors, you can then reach out to the TAs.)**

2 Problem Statement

In this assignment, you are supposed to implement the tracking controller on the MIT-Racecar model discussed in the tutorial session. The detailed reference of the controller can be found on **page 804 (Section 34.3.1) in the Handbook of Robotics book** and in the class notes on Moodle.

- It is to be noted that the control design in the above link is computed in terms of (u_1, u_2), which are the linear and angular velocities, respectively.
- A suitable transformation needs to be carried out to convert them to the equivalent linear velocity and steering angle to be applied as the control inputs to the MIT Racecar.

- Consider the reference trajectory to be tracked as $(x_r(t), y_r(t) = Acos(\omega t), Asin(\omega t))$.
  Hint: Refer frenet frame modelling

- A python script is provided to you inside the ROS package uploaded on moodle. You just have to code the control algorithm within that script. The given launch file executes all the required modules.

The report should consist of the necessary elements to answer the following questions.

1. Choose the amplitude A of the reference trajectory from the set 5, 8, 12 and an appropriate ω such that the reference trajectory is not too fast. Study the nature of the induced robot's trajectory and provide your reasoning on the same **(Attach videos/gifs and plots in the report showcasing trajectory tracking to support your arguments)**. [8]

2. What is the effect of the choice of the control gains (K_1, K_2) on the system's tracking performance? (Choose gains in varying magnitudes and reason based on the obtained plots). [3]

3. Do you think a bijective transformation between the control inputs (linear velocity and the angular velocity) obtained from the controller and the equivalent control (linear velocity and steering angle) computed for the MIT Racecar always exists? Provide your reasoning on why/why not. [4]