IIT Bombay
Systems and Control Engineering
Embedded Control and Robotics

SC 649 — ***Assignment 2*** — Maximum Marks: 15

Deadline
Date: 10.09.24, 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 10.09.2024. 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_AS02.
- 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.

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1. Consider the home position be the origin with a fixed XY axis and the robot be located at $R(t)$, $\theta(t)$ at an instant t with respect to the defined axis at home position. Figure 1 illustrates the terminology. The robot is moving along the velocity vector $v(t)$ such that the angle between the velocity vector and X axis is $\alpha(t)$. The dependency on time t has been dropped in the figure for better understanding.

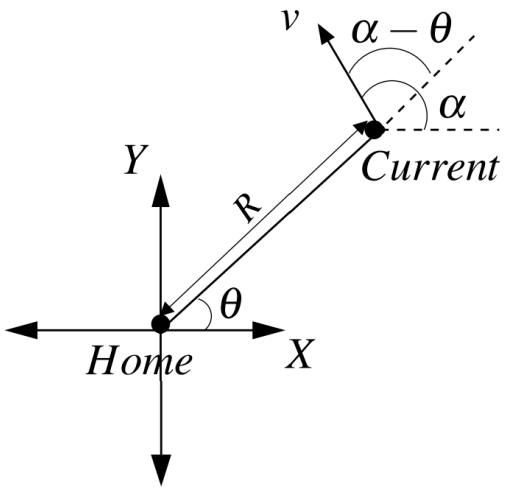

Figure 1: Robot Model

Question 1 continues on the next page...

Consider the following set of equations governing the kinematics of robot model:

$$\begin{aligned} \dot{R} &= vcos(\alpha - \theta) \\ \dot{\theta} &= \frac{v}{R} sin(\alpha - \theta) \\ \dot{\alpha} &= \omega \end{aligned} \tag{1}$$

The states of the model are $\{R, \theta, \alpha\}$ and the control inputs are v and ω.

- Implement a steering control (refer equation 2) that brings the robot to home position. **(To learn more about this controller, interested students can refer the manuscript [1]).**

$$\omega = -K_s sgn(\alpha - \theta - \pi) \tag{2}$$

  where K_s is constant gain and v is constant. (6 marks)

- Simulate the control system, by changing the initial position of robot in each quadrant. **(Present visualizations, graphs, or plots that demonstrate the behavior)**. (4 marks)
- What is the effect of the choice of the control gain on the system's performance? (**Choose gain in varying magnitudes and reason based on the obtained plots**). (3 marks)
- Comment on the stability of the controller. Does the controller fail at any condition? If so, state your reason. (2 marks)

Ensure you provide clear explanations, use relevant equations, and support your answers with appropriate references and examples.

References

[1] Anupa Sabnis, Leena Vachhani, and Neeraj Bankey. Lyapunov based steering control for visual homing of a mobile robot. In *22nd Mediterranean Conference on Control and Automation*, pages 1152–1157, 2014.