Homework 1
Due Date: Thursday, 17 October 2024

1) i) Write down the state space equations (differential equations) for the following robots. For each robot identify the state variables and the control variables.
   a) Unicycle model
   b) Differential drive robot
   c) Simplified car model
   d) Planar Quadrotor

ii) For a given robot, what do the state variables and control variables represent? Please explain.

iii) Describe the differences in dynamics between the robot models a, b and c.

2) Simulate the differential equations for the unicycle robot model using Euler's method for t ∈ [0, 10] and time step Δt = 0.1. Use the following control input:

$$v = 1 \quad 0 \leq t \leq 10$$

$$\omega = \begin{cases} 3 & 0.5 \leq t \leq 1.5 \\ -3 & 2 \leq t \leq 3 \\ -3 & 4 \leq t \leq 5 \\ 3 & 6 \leq t \leq 7 \\ -3 & 8 \leq t \leq 9 \\ 0 & all\ other\ t \end{cases}$$

With initial conditions x(0) = 0, y(0) = 0, θ(0) = 1.

   a) Plot x vs y, x vs t, y vs t and θ vs t. Submit your code and plots.
   b) If you plot x vs y at each time step, you'll able to see a movie of the robot moving in 2D space.

Feel free to simulate different initial conditions and control input sequences to gain a greater understanding.

3) Simulate the state space equations for the differential drive robot model using Euler's method for t ∈ [0, 10] and time step Δt = 0.1. Use the following control input:

$$\omega_l = \begin{cases} 12 & 4 \leq t \leq 6 \\ 12 & 6 \leq t \leq 8 \\ 1 & all\ other\ t \end{cases} \quad \omega_r = \begin{cases} 12 & 0.5 \leq t \leq 1.5 \\ 12 & 2 \leq t \leq 4 \\ 1 & all\ other\ t \end{cases}$$

With r = 0.1, L = 1 and initial conditions x(0) = 0, y(0) = 0, θ(0) = 1.

   a) Plot x vs y, x vs t, y vs t and θ vs t. Submit your code and plots.
   b) If you plot x vs y at each time step, you'll be able to see a movie of the robot moving in 2D space.

Feel free to simulate different initial conditions and control input sequences to gain a greater understanding.