



Artificial Intelligence and Expert Systems

Project 2 - Machine Learning

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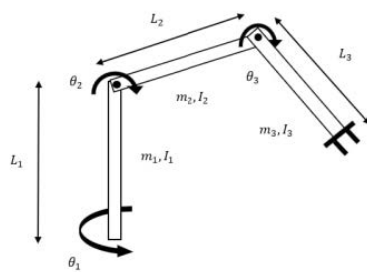
Due Date: 28 Tir, 1403

Project Description

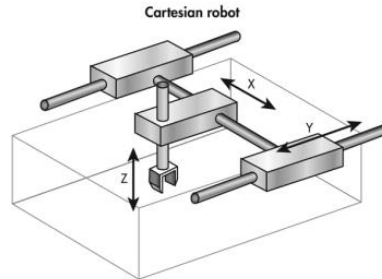
The first phase of the project is involved with Fuzzy Logic Control. Based on your interest, you can choose of the following robots shown in Figure 1 for this phase. Then follow the steps bellow:

- Design a PID controllers for joints, to move the end effector of the robot from an arbitrary point A to point B.
- Design a fuzzy logic controller for controlling system.
- Compare the results and write your own conclusion.

Please pay attention to the template which is uploaded in the website. You can choose this template in order to write your reports.



(a) 3R-robot (non-planar)



(b) 3P-cartesian robot



(c) Mobile robot with 3R manipulator

Figure 1: Schematics of robotic systems for this project

Bonus Score Section:

Document the design, implementation, and analysis of the additional fuzzy controller. Include a comparison with the PID and standard fuzzy controllers. Some examples of additional fuzzy controllers that you can explore for the bonus section:

- (a) Fuzzy PID Controller
- (b) Optimized Fuzzy Controller
- (c) Fuzzy Sliding Mode Controller
- (d) Fuzzy Predictive Controller
- (e) Fuzzy Gain Scheduling Controller
- (f) ...

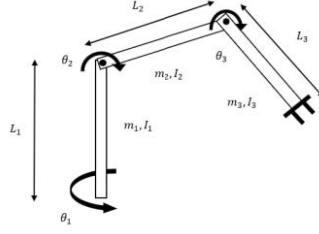
Important Notes

- Please submit your homework assignment as a zip file containing **(a)** a PDF report (analysis, results, methodology, ...), and **(b)** code files necessary to reproduce your results.
- All grading will be based on the content of the PDF report. Make sure to include and explain your code in the report.
- Please make sure to submit your solutions by the due date. No late submissions will be accepted.
- Assignments are to be completed individually. Any similarities between assignments will be subject to reduced grades.
- If you have any questions, feel free to ask.

Good Luck!

Appendix

3R-robot (non-planar)



Parameters:

$$L_1 = 1.5\text{m}, L_2 = 0.8\text{m}, L_3 = 0.7\text{m}$$

$$M = 1\text{Kg}, m_1 = 2\text{Kg}, m_2 = 1\text{Kg}, m_3 = 1\text{Kg}, g = 9.8 \frac{\text{m}}{\text{s}^2}$$

$$I_1 = \begin{bmatrix} 0.1875 & 0 & 0 \\ 0 & 0.1875 & 0 \\ 0 & 0 & 0.375 \end{bmatrix} \text{Kg.m}^2, I_2 = \begin{bmatrix} 0.0267 & 0 & 0 \\ 0 & 0.0267 & 0 \\ 0 & 0 & 0.0533 \end{bmatrix} \text{Kg.m}^2,$$

$$I_3 = \begin{bmatrix} 0.0204 & 0 & 0 \\ 0 & 0.0204 & 0 \\ 0 & 0 & 0.0408 \end{bmatrix} \text{Kg.m}^2$$

Where M is the mass of the object which the robot is expected to carry.

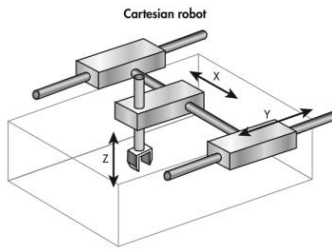
The equations of motion for 3R non-planar robot can be written as follows:

$$\ddot{\theta}_1 = \frac{-670\dot{\theta}_1\dot{\theta}_2\sin(\theta_3) + 290\dot{\theta}_1(\dot{\theta}_2 + \dot{\theta}_3)\sin(2\theta_2 + 2\theta_3) + 670\dot{\theta}_1\dot{\theta}_2\sin(2\theta_2 + \theta_3) + 380\dot{\theta}_1\dot{\theta}_2\sin(2\theta_2) + 2400\tau_1}{340\cos(2\theta_2 + \theta_3) + 190\cos(2\theta_2) + 340\cos(\theta_3) + 150\cos(2\theta_2 + 2\theta_3) + 1500},$$

$$\ddot{\theta}_2 = -0.38\sin(2\theta_2)\dot{\theta}_1^2 - 18\cos(\theta_2) + 4.7\tau_2 - 4.7\tau_3,$$

$$\ddot{\theta}_3 = 16\cos(\theta_2 - \theta_3) + 85\cos(\theta_2 + \theta_3) + 18\cos(\theta_2) - 0.86\dot{\theta}_1^2\sin(\theta_3) - 1.7\dot{\theta}_2^2\sin(\theta_3) + 0.32\dot{\theta}_1^2\sin(2\theta_2 - \theta_3) - 0.38\dot{\theta}_1^2\sin(2\theta_2 + 2\theta_3) - 0.54\dot{\theta}_1^2\sin(2\theta_2 + \theta_3) + 0.38\dot{\theta}_1^2\sin(2\theta_2) + 11\tau_3 - 4.7\tau_2.$$

3P-cartesian robot



Parameters:

$$M = 1\text{Kg}, m_1 = 15\text{Kg}, m_2 = 10\text{Kg}, m_3 = 5\text{Kg}, g = 9.8 \frac{\text{m}}{\text{s}^2}$$

Where m_i is the mass of link i and M is the mass of the object which the robot is expected to carry. The equations of motion for 3P cartesian robot can be written as follow:

$$\ddot{x} = 0.0625F_1$$

$$\ddot{y} = 0.0323F_2$$

$$\ddot{z} = 0.1667(F_3 - 58.8)$$