

Computational Intelligence: Homework 3

Topic: Use Particle Swarm Optimization (PSO) to train Fuzzy Controller for Backing Up A Truck

Kinematics of backing up a truck-emulator

$$x' = x + r \cos(\phi')$$

$$y' = y + r \sin(\phi')$$

$$\phi' = \phi + \theta$$

$$0 \leq x \leq 100$$

$$-90 \leq \phi \leq 270$$

$$-30 \leq \theta \leq 30$$

The goal was to make the truck arrive at the loading dock at a right angle ($\phi_f = 90^\circ$) and to align the position (x, y) of the truck with the desired loading dock (x_f, y_f) . We considered only backing up. The truck moved backward by some fixed distance at every stage. The loading zone corresponded to the plane $[0, 100] \times [0, 100]$, and (x_f, y_f) equaled $(50, 100)$.

At every stage the fuzzy and neural controllers should produce the steering angle θ that backs up the truck to the loading dock from any initial position and from any angle in the loading zone.

Requirement:

The speed r is set to 1.

1. Design a **zero-order TSK** fuzzy system with 5 rules for controlling the truck. Use the **Gaussian** function as membership functions of antecedent fuzzy sets, and fuzzy singleton for consequent fuzzy set.

$$w_{xi} = \exp(-(x - m_{xi})^2 / \sigma_{xi}^2),$$

$$w_{\phi i} = \exp(-(\phi - m_{\phi i})^2 / \sigma_{\phi i}^2),$$

$$\theta = \frac{\sum_{i=1}^5 (w_{xi} w_{\phi i} \theta_i)}{\sum_{i=1}^5 (w_{xi} w_{\phi i})}$$

2. The docking error is defined as the square root of the normalized deviations of x , y , ϕ of the truck from the desired dock position and angle when the truck stops.

$$\sqrt{\left(\frac{\phi_f - \phi}{\pi}\right)^2 + \left(\frac{x_f - x}{50}\right)^2 + \left(\frac{y_f - y}{100}\right)^2}$$

3. The objective function to be minimized is the average value of the Docking errors for all 980 (=7x4x35 points) initial conditions for training:
 $x=20,30,40,50,60,70,80$; $y=20,30,40,50$; $\phi=-80,-70,\dots,-10,0,10,\dots,250,260$
4. The execution file (.exe) and source codes for learning/training fuzzy controller
5. The execution file (.exe) and source codes for testing obtained controller
6. The testing execution file needs to be able to feed the initial positions and angles.
7. The testing execution file needs to show the trajectory (positions and angles) from the initial position
8. Written report includes at least
 - a. What is your algorithm for design of fuzzy controller? Please detail the parameters used in the PSO algorithm.
 - b. What is the learning curve? (學習過程的記錄)
 - c. How to execute your files for learning/training and testing?
 - d. What is the average Docking error (over all 6x3x34=612 test trials)?
 Initial points: $x: [25,75]$, $y: [25, 45]$, $\phi: [-75,250]$ (5x3x34 points):
 $x=25,35,45,55,65,75$; $y=25,35,45$; $\phi=-75,-65,\dots,-15,-5, 5,15,\dots,255$.
 - e. What is the average trajectory error (over all 612 test trials as defined in (d))?