Computational Intelligence: Homework 2

Use Genetic Algorithm to train Fuzzy Controller for truck reversing control [1].

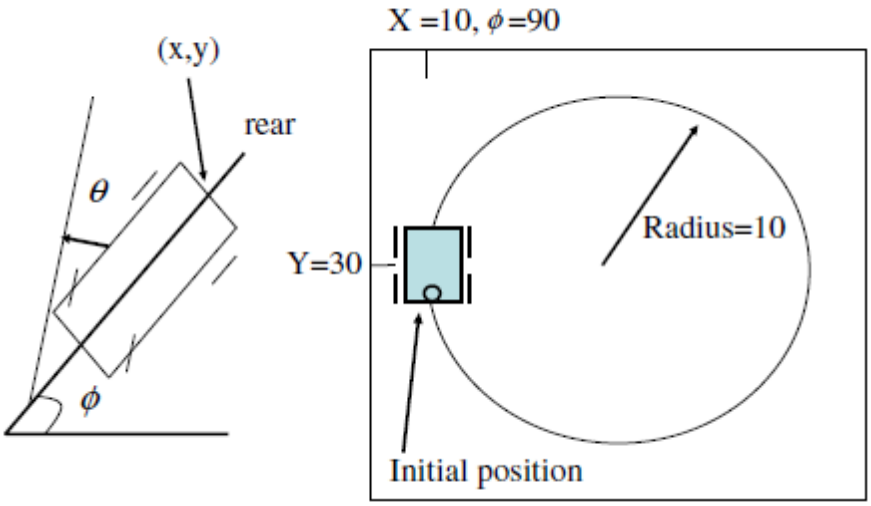

Figure shows the simulated truck. The truck position is precisely determined by the three state variables ϕ, x and y, where ϕ is the angle of the truck with the horizon as shown in Figure. The angle of the control signal to the truck is θ, where $\theta \in [-20^{\circ}, 20^{\circ}]$. Only reversing is considered. The truck moves backward by a fixed unit distance every stage. The model of the truck reversing system is

$$x(k+1) = x(k) + \cos[\phi(k) + \theta(k)] + \sin[\theta(k)]\sin[\phi(k)]$$
$$y(k+1) = y(k) + \sin[\phi(k) + \theta(k)] - \sin[\theta(k)]\cos[\phi(k)]$$
$$\phi(k+1) = \phi(k) - \sin^{-1}\left[\frac{2\sin(\theta(k))}{b}\right]$$

where b is the length of the truck and b = 4 in this simulation. Equations above generate the next state when the present state and control are given. The task here is to design a fuzzy controller to reverse the truck following the desired circular path

$$(x-20)^2 + (y-30)^2 = 10^2$$

With an initial state of $(x, y, \emptyset) = (10, 30, 90^{\circ})$. Figure show the initial state and the desired driving path. There are a total of 65 control steps, and the control error is defined as

$$\text{SAE} = \sum_{k=1}^{65} |e(k)|$$

$$\mathrm{e(k)} = \left(((x(k)-20)^2 + (y(k)-30)^2)^{\frac{1}{2}} - 10\right)^2$$

Inputs of the fuzzy controller are $x(k), y(k), \emptyset(k)$, and the output of fuzzy controller is $\theta(k)$.

Requirement:

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.

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

$$w_{yi} = \exp\left(-\left(x - m_{yi}\right)^2 \Big/ \sigma_{yi}^2\right),$$

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

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

2. The execution file (.exe) and source codes for learning/training fuzzy controller
3. The execution file (.exe) and source codes for testing obtained controller
4. The testing execution file needs to be able to feed the initial positions and angles.
5. The testing execution file needs to show the trajectory (positions and angles) from the initial position
6. Written report includes at least
   a. What is your algorithm for design of fuzzy controller? Please detail the parameters used in the your 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 SAE of control error?

[1]. C.-F. Juang and C.-Y. Wang, "A self-generating fuzzy system with ant and particle swarm cooperative optimization," *Expert Systems with Applications*, *vol.* 36, pp. 5362–5370, 2009.