EE4305 Introduction to Fuzzy/Neural Systems

Problem-Solving 4

1. A fuzzy system contains the following two fuzzy rules

   if X is P_1 then Y is Q_1

   if X is P_2 then Y is Q_2

   where the fuzzy sets P_1, P_2, Q_1 and Q_2 are defined by

   P_1 = 1/1+ 0.5/2 + 0/3

   Q_1 = 0.4/4+ 0.5/5 + 0.6/6

   P_2 = 0.1/1+ 0.4/2 + 1/3

   Q_2 = 0.1/4+ 0.2/5 + 0.3/6

   For a crisp input of x^* = 2, apply the fuzzy inference to obtain the output fuzzy set F of the system. Defuzzify F using the center-of-area method.

2. Conduct a simulation of an automobile cruise control system. Let speed (v) = 0 to 100 (mph), angle of inclination of the road (θ) = -10 to 10 degrees, and throttle position (T) = 0 to 10. The dynamics of the system are given by the following:

$$T = k_1 v + \theta k_2 + m\dot{v}$$
$$\dot{v} = v(n+1) - v(n)$$
$$T(n) = k_1 v(n) + \theta(n) k_2 + m\left(v_{n+1} - v_n\right)$$

   So,

$$v_{n+1} = \left(1 - \frac{k_1}{m}\right) v(n) + T(n) - \frac{k_2}{m}\theta(n)$$
$$= k_a v(n) + T(n) - k_b \theta(n)$$

   where T = throttle position; k_1 = viscous friction; v = speed; θ = angle of incline; $k_2 = mg\sin\theta$; $\dot{v}$ = acceleration; m = mass; $k_a = 1 - \frac{k_1}{m} = 0.9$; and $k_b = \frac{k_2}{m} = 0.1$.

   The membership function for speed is determined by the cruise control setting, which is assumed to be 50 mph. The membership functions are shown in Figure 1 and the rules are presented in Table 1. The initial condition of speed v = 52.5 mph. Conduct 4 graphical simulation cycles for this system using the center-of-area defuzzification method. Use an angle of incline θ = -5° for the first 2 simulations and an angle of incline θ = -2.5° for the next 2 simulation cycles.

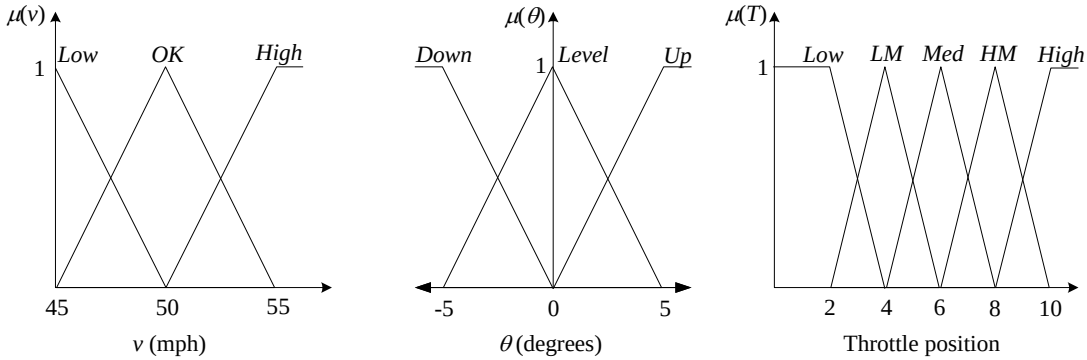

Figure 1

Table 1

Throttle position (*T*)	**Inclination of the road (*θ*)**		
Speed (*v*)	***Up***	***Level***	***Down***
High	*LM*	*LM*	*Low*
OK	*HM*	*Med*	*LM*
Low	*High*	*HM*	*HM*