ECE657, Spring 2020, Assignment 4

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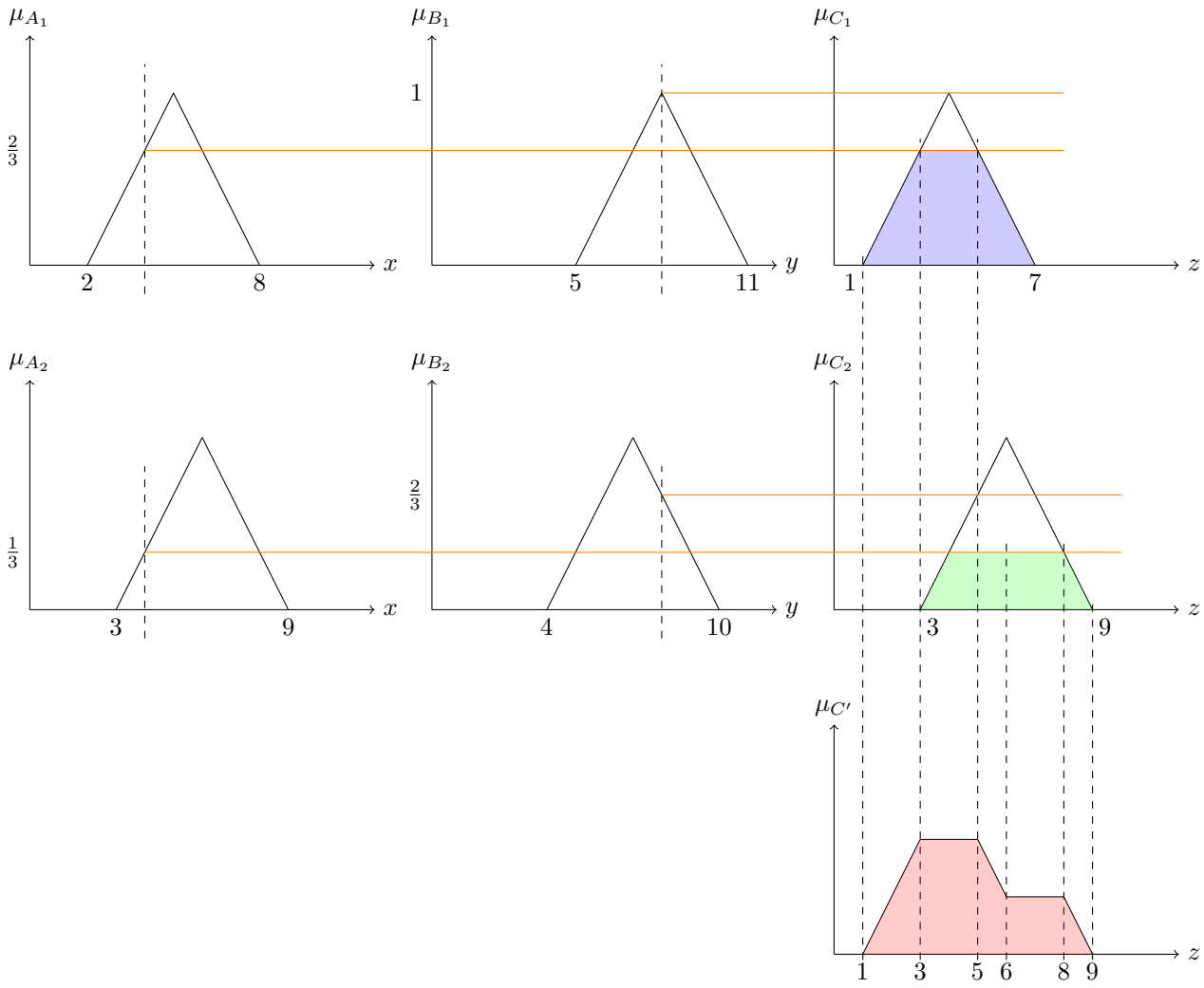
Problem 1



Therefore, if use the Mean of Maximum (MOM) defuzzifcation strategy, the output is 4.

If use the largest of maximum (lom) defuzzification strategy, the output is 5.

Problem 2

(a) $\min(\mu_A, \mu_B)$ $\begin{bmatrix} 0.1 & 0.2 & 0.2 & 0.2 & 0.1 \\ 0.1 & 0.4 & 0.4 & 0.4 & 0.1 \\ 0.1 & 0.4 & 0.6 & 0.4 & 0.1 \\ 0.1 & 0.4 & 0.8 & 0.4 & 0.1 \\ 0.1 & 0.4 & 0.6 & 0.4 & 0.1 \\ 0.1 & 0.4 & 0.4 & 0.4 & 0.1 \\ 0.1 & 0.2 & 0.2 & 0.2 & 0.1 \end{bmatrix}$, $(1 - \mu_A)$ $[0.8, 0.6, 0.4, 0.2, 0.4, 0.6, 0.8]$

Therefore,

$\mu_R(A_i, B_i)$ $\begin{bmatrix} 0.8 & 0.8 & 0.8 & 0.8 & 0.8 \\ 0.6 & 0.6 & 0.6 & 0.6 & 0.6 \\ 0.4 & 0.4 & 0.6 & 0.4 & 0.4 \\ 0.2 & 0.4 & 0.8 & 0.4 & 0.2 \\ 0.4 & 0.4 & 0.6 & 0.4 & 0.4 \\ 0.6 & 0.6 & 0.6 & 0.6 & 0.6 \\ 0.8 & 0.8 & 0.8 & 0.8 & 0.8 \end{bmatrix}$

(b) (i)

$$\max_{rows}\left(\min_{columns}\left(\begin{bmatrix} 0 \\ 0.5 \\ 0.7 \\ 0.95 \\ 0.7 \\ 0.5 \\ 0 \end{bmatrix}, \begin{bmatrix} 0.8 & 0.8 & 0.8 & 0.8 & 0.8 \\ 0.6 & 0.6 & 0.6 & 0.6 & 0.6 \\ 0.4 & 0.4 & 0.6 & 0.4 & 0.4 \\ 0.2 & 0.4 & 0.8 & 0.4 & 0.2 \\ 0.4 & 0.4 & 0.6 & 0.4 & 0.4 \\ 0.6 & 0.6 & 0.6 & 0.6 & 0.6 \\ 0.8 & 0.8 & 0.8 & 0.8 & 0.8 \end{bmatrix}\right)\right)$$

$$\max_{rows}\left(\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0.5 & 0.5 & 0.5 & 0.5 & 0.5 \\ 0.4 & 0.4 & 0.6 & 0.4 & 0.4 \\ 0.2 & 0.4 & 0.8 & 0.4 & 0.2 \\ 0.4 & 0.4 & 0.6 & 0.4 & 0.4 \\ 0.5 & 0.5 & 0.5 & 0.5 & 0.5 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}\right) \tag{1}$$

$[0.5, 0.5, 0.8, 0.5, 0.5]$

Therefore, $\underset{\sim}{T}$ $\left\{\frac{.5}{.25} + \frac{.5}{.27} + \frac{.8}{.3} + \frac{.5}{.33} + \frac{.5}{.35}\right\}$

(ii)

$$\max_{rows}\left(\begin{bmatrix}0 & 0.5 & 0.7 & 0.95 & 0.7 & 0.5 & 0\end{bmatrix}\cdot\begin{bmatrix}0.8 & 0.8 & 0.8 & 0.8 & 0.8\\ 0.6 & 0.6 & 0.6 & 0.6 & 0.6\\ 0.4 & 0.4 & 0.6 & 0.4 & 0.4\\ 0.2 & 0.4 & 0.8 & 0.4 & 0.2\\ 0.4 & 0.4 & 0.6 & 0.4 & 0.4\\ 0.6 & 0.6 & 0.6 & 0.6 & 0.6\\ 0.8 & 0.8 & 0.8 & 0.8 & 0.8\end{bmatrix}\right)$$

$$\max_{rows}\left(\begin{bmatrix}0 & 0 & 0 & 0 & 0\\ 0.3 & 0.3 & 0.3 & 0.3 & 0.3\\ 0.28 & 0.28 & 0.42 & 0.28 & 0.28\\ 0.19 & 0.38 & 0.76 & 0.38 & 0.19\\ 0.28 & 0.28 & 0.42 & 0.28 & 0.28\\ 0.3 & 0.3 & 0.3 & 0.3 & 0.3\\ 0 & 0 & 0 & 0 & 0\end{bmatrix}\right) \tag{2}$$

$[0.19, 0.38, 0.76, 0.38, 0.19]$

Therefore, $\underset{\sim}{T}$ $\left\{\frac{.19}{.25}+\frac{.38}{.27}+\frac{.76}{.3}+\frac{.38}{.33}+\frac{.19}{.35}\right\}$

Problem 3

Genetic Algorithm represents an important class of evolutionary computing techniques, which is inspired from the biological process of evolution and the survival of the fittest concept, able of accurately solving a wide range of optimization problems. Genetic Programming is to find the computer program that best fit users' need, for example, the computer program acts as a solution candidate like a binary string in Genetic Algorithm.

Genetic Algorithm is actually some algorithm to search for solutions of optimization problems, whereas Genetic Programming doesn't specify any algorithms but that the computer to find solutions by itself.

Problem 4

1. Membership function

   (a) D

   triangle$(N|0,0,5)$, triangle$(F|0,5,10)$, triangle$(VF|5,10,10)$

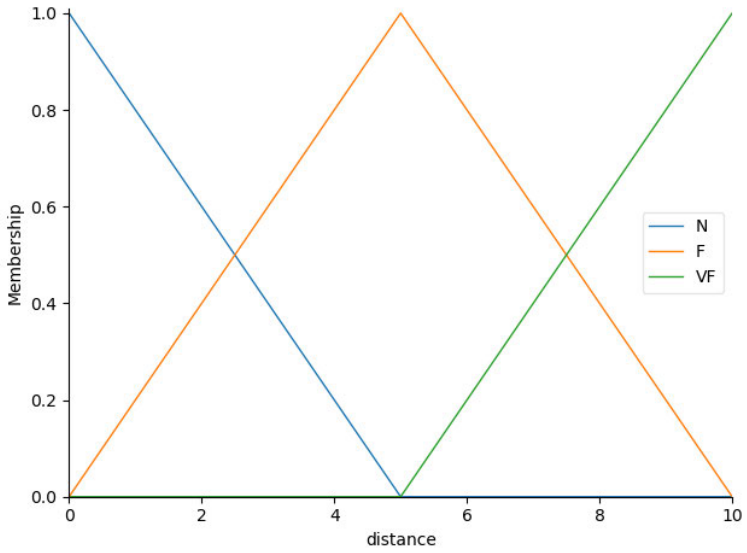


Figure 1: Membership function of D

   (b) A

   triangle$(S|0,0,45)$, triangle$(M|0,45,90)$, triangle$(L|45,90,90)$

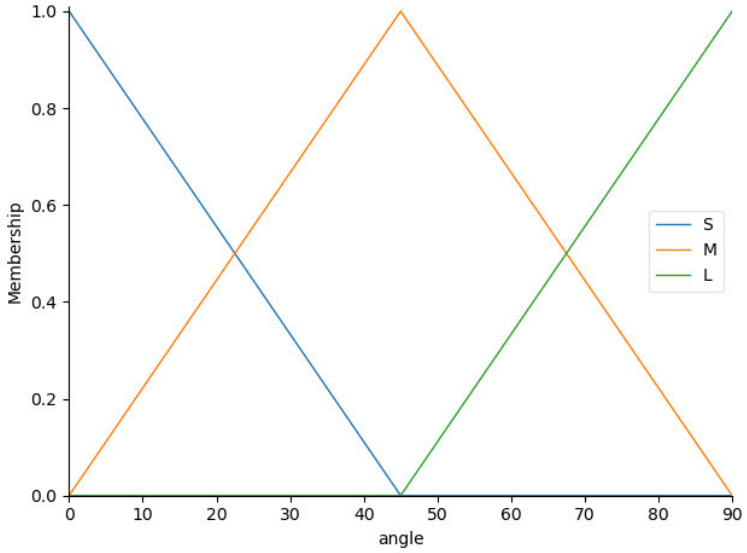


Figure 2: Membership function of A

   (c) S

   triangle$(SS|0,0,2)$, triangle$(MS|0,2,5)$, triangle$(FS|0,3,5)$, triangle$(MXS|3,5,5)$

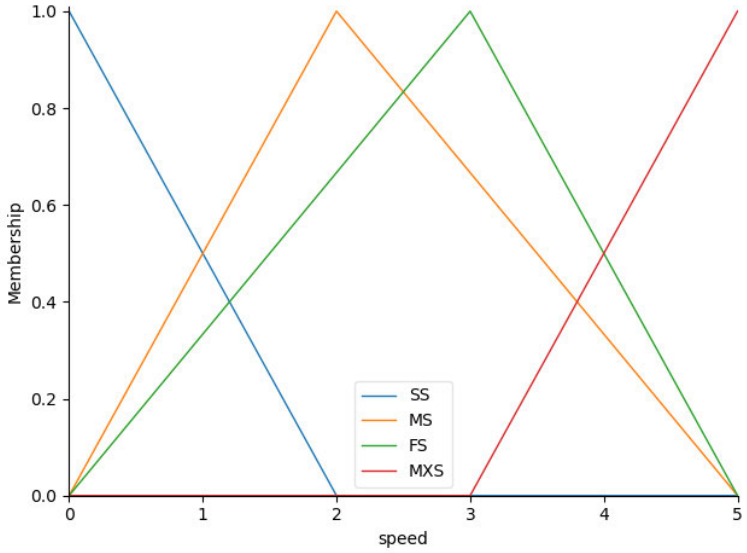


Figure 3: Membership function of S

(d) ST

triangle$(MST|0, 0, 45)$, triangle$(SST|0, 45, 90)$, triangle$(VST|45, 90, 90)$

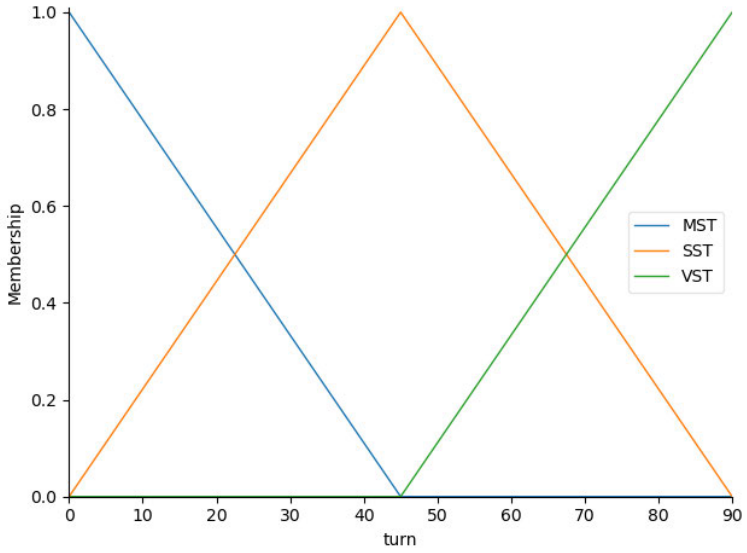


Figure 4: Membership function of ST

2. Rules

IF D is N AND A is S, THEN, ST is MST, S is SS.

IF D is N AND A is M, THEN, ST is SST, S is SS.

IF D is N AND A is L, THEN, ST is VST, S is SS.

IF D is F AND A is S, THEN, ST is MST, S is FS.

IF D is F AND A is M, THEN, ST is SST, S is MS.

IF D is F AND A is L, THEN, ST is VST, S is MS.

IF D is VF AND A is S, THEN, ST is MST, S is MXS.

IF D is VF AND A is M, THEN, ST is SST, S is MXS.

IF D is VF AND A is L, THEN, ST is VST, S is FS.

3. Inferencing system

   We chose Mamdani as our inferencing system because we used fuzzy sets as rule consequent instead of linear functions.

4. Defuzzication method

   We chose Centroid as our defuzzication method because we want the control output more robust.

5. Simlutation result

   Case 1

   When input is D = 5.6, A = 35, the output S is 2.3881982678895644, ST is 43.9451476793249.

   When input is D = 5.6, A = 45, the output S is 2.3625632444922506, ST is 44.614349775784774.

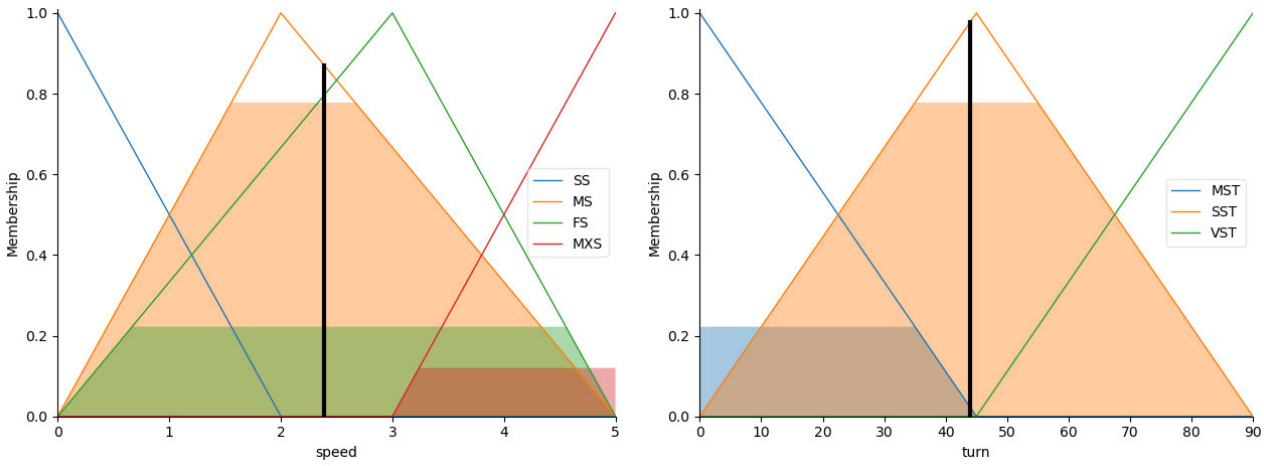


Figure 5: D = 5.6, A = 35

As we can see from Figure above, as the angle increasing, the output speed is decreasing, and the steer turn is increasing.

Case 2

When input is D = 9, A = 35, the output S is 3.2978709601321072, ST is 43.9451476793249. As we can see from the Figure below, and compare it to Figure 5, the output speed is increasing as the distance from obstacle is further.

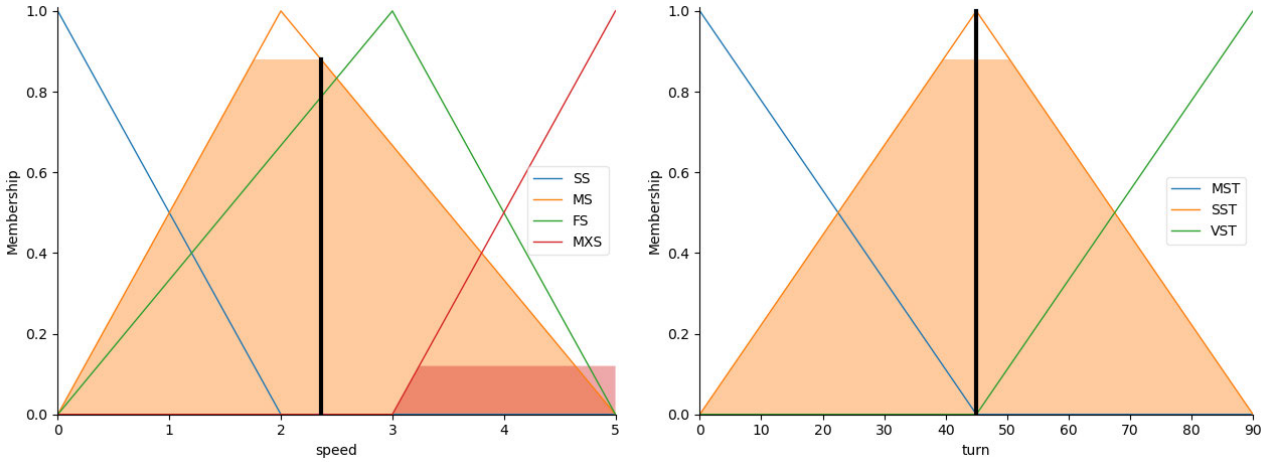


Figure 6: D = 5.6, A = 45

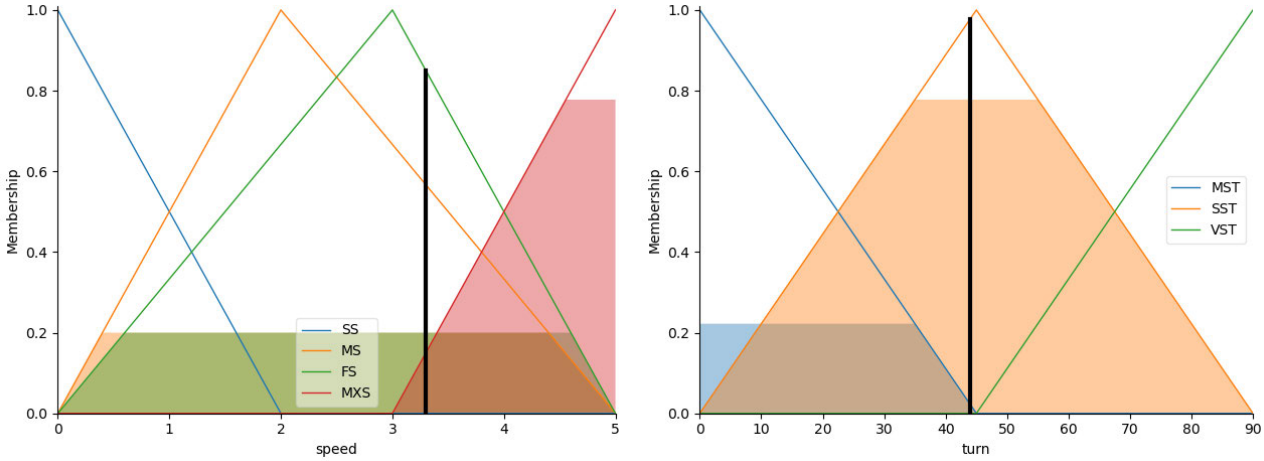


Figure 7: D = 9, A = 35