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.

Ans:

The strength of rule 1 is $\min[0.5, Q_1] = 0.4/4 + 0.5/5 + 0.5/6$

The strength of rule 2 is $\min[0.4, Q_2] = 0.1/4 + 0.2/5 + 0.3/6$

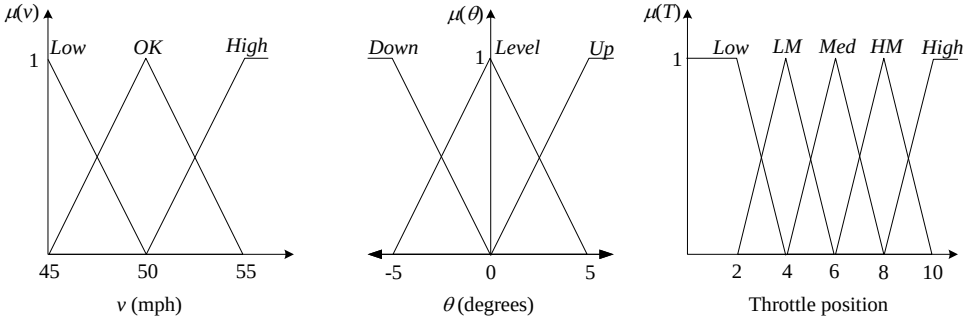
So, output fuzzy set F is $0.4/4 + 0.5/5 + 0.5/6$

Defuzzify F using the center-of-area method.

Ans:

$$COA = \frac{0.4(4) + 0.5(5) + 0.5(6)}{0.4 + 0.5 + 0.5} = \frac{7.1}{1.4} = 5.07$$

2. Cycle 1:

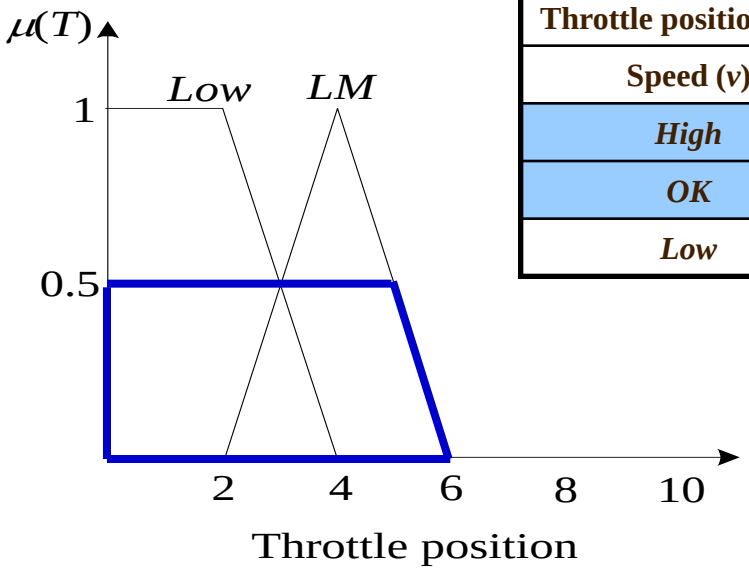


$v_0 = 52.5 \rightarrow High \ \& \ OK$

$\theta_0 = -5 \rightarrow Down$

$IF\ (v = High \wedge \theta = Down)\ \text{THEN}\ (T = Low) \Rightarrow min(0.5, 1) = 0.5\ Low$

$IF\ (v = OK \wedge \theta = Down)\ \text{THEN}\ (T = LM) \Rightarrow min(0.5, 1) = 0.5\ LM$



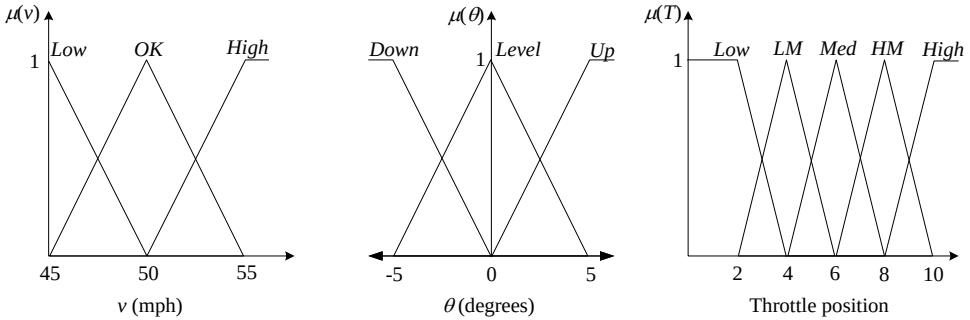
Throttle position (T)	Inclination of the road (θ)		
Speed (v)	*Up*	*Level*	*Down*
High	*LM*	*LM*	*Low*
OK	*HM*	*Med*	*LM*
Low	*High*	*HM*	*HM*

So, $T^* \cong 3$, Therefore, $v_1 = 0.9(52.5) + 3 - 0.1(-5) = 50.75$

Cycle 2:

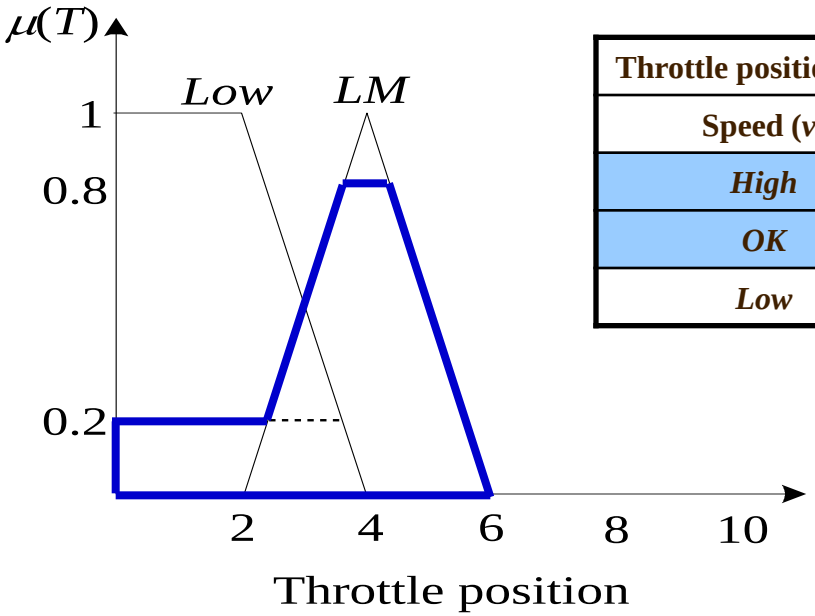
$v_1 = 50.75 \rightarrow High \ \& \ OK$

$\theta_1 = -5 \rightarrow Down$



IF (v = *High* $\wedge$ θ = *Down*) THEN (T = *Low*) $\Rightarrow$ *min(0.2, 1) = 0.2 Low*

IF (v = *OK* $\wedge$ θ = *Down*) THEN (T = *LM*) $\Rightarrow$ *min(0.8, 1) = 0.8 LM*



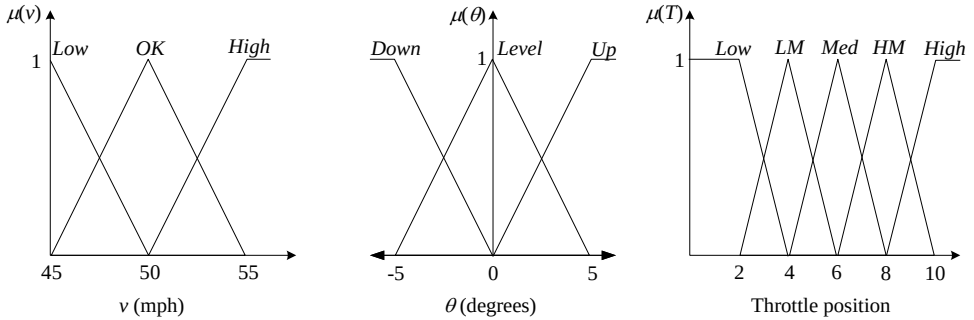
Throttle position (T)	Inclination of the road (θ)		
Speed (v)	***Up***	***Level***	***Down***
High	*LM*	*LM*	*Low*
OK	*HM*	*Med*	*LM*
Low	*High*	*HM*	*HM*

So, $T^* \cong 3.8$, Therefore, $v_2 = 0.9(50.75) + 3.8 - 0.1(-5) = 49.975$

Cycle 3:

$v_2 = 49.975 \rightarrow Low \ \& \ OK$

$\theta_2 = -2.5 \rightarrow Down \ \& \ Level$

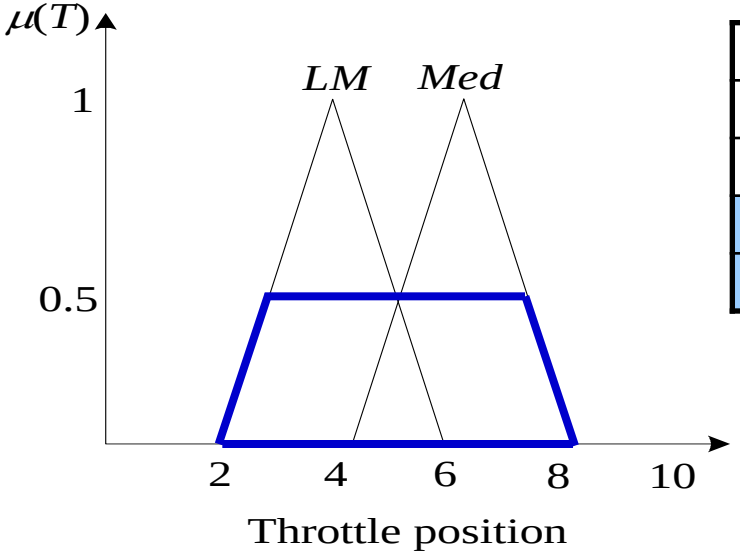


IF $(v = Low \wedge \theta = Down)$ THEN $(T = HM) \Rightarrow min(0.005, 0.5) = 0.005\ HM$

IF $(v = Low \wedge \theta = Level)$ THEN $(T = HM) \Rightarrow min(0.005, 0.5) = 0.005\ HM$

IF $(v = OK \wedge \theta = Down)$ THEN $(T = LM) \Rightarrow min(0.995, 0.5) = 0.5\ LM$

IF $(v = OK \wedge \theta = Level)$ THEN $(T = Med) \Rightarrow min(0.995, 0.5) = 0.5\ Med$



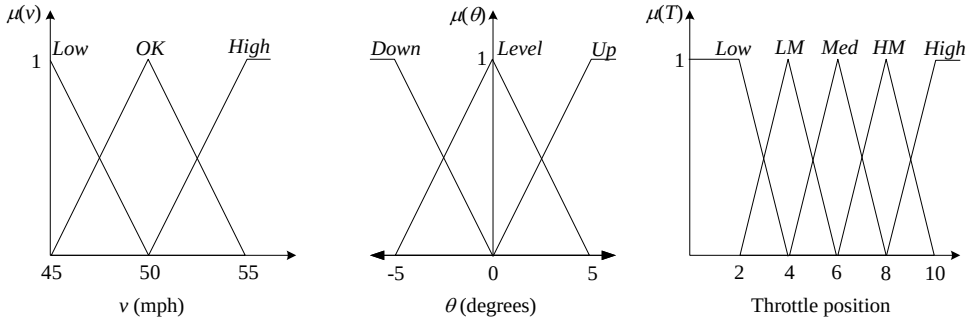
Throttle position (T)	Inclination of the road (θ)		
Speed (v)	***Up***	***Level***	***Down***
High	*LM*	*LM*	*Low*
OK	*HM*	*Med*	*LM*
Low	*High*	*HM*	*HM*

So, $T^* \cong 5$, Therefore, $v_3 = 0.9(49.975) + 5 - 0.1(-2.5) = 50.228$

Cycle 4:

$v_3 = 50.228 \rightarrow High \ \& \ OK$

$\theta_3 = -2.5 \rightarrow Down \ \& \ Level$

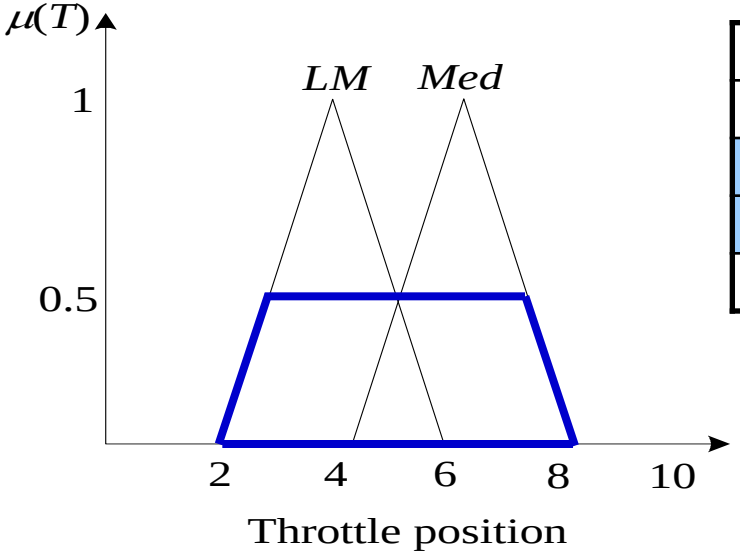


IF ($v = High \wedge \theta = Down$) THEN ($T = Low$) $\Rightarrow min(0.046, 0.5) = 0.046\ Low$

IF ($v = High \wedge \theta = Level$) THEN ($T = LM$) $\Rightarrow min(0.046, 0.5) = 0.046\ LM$

IF ($v = OK \wedge \theta = Down$) THEN ($T = LM$) $\Rightarrow min(0.954, 0.5) = 0.5\ LM$

IF ($v = OK \wedge \theta = Level$) THEN ($T = Med$) $\Rightarrow min(0.954, 0.5) = 0.5\ Med$



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*

So, $T^* \cong 5$, Therefore, $v_4 = 0.9(50.228) + 5 - 0.1(-2.5) = 50.455$