Problem Design a controller

Design a domestic washing machine with two input variable DIRT and GRESE on cloths. Consider 3 Linguistic values for each inputs The output variable is WASH-TIME and there are five linguistic term.

- Design a Rule base System
- Draw membership functions, the descriptors (values) must be supported by the illustration
- Show that if the clothes are solid to larger degree the wash time will be more and vice versa

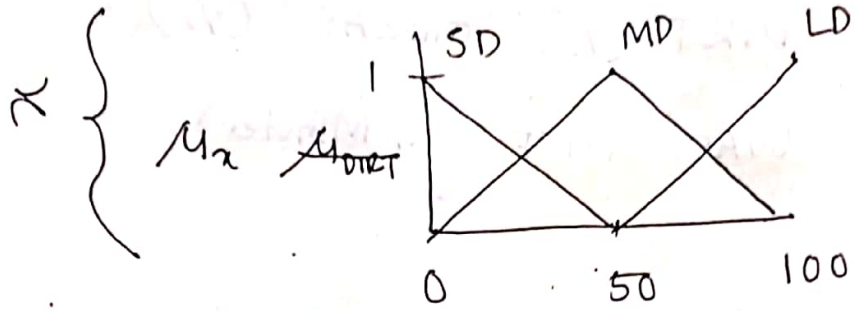
Solution:

Steps

1. Identify I/p and O/p variables and decide about descriptor for the same
2. Define membership functions for each I/p and O/p variables
3. Form a RULE BASE
4. Evaluate Rule
5. Defuzzification

Step2 Define MF for each I/p and O/p Variable

Membership functions for ~~DIRT~~ DIRT



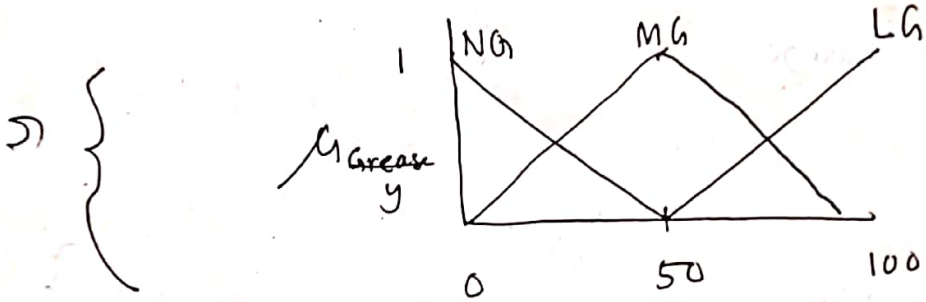
$$\mu_{SD}(x) = \frac{50-x}{50} \quad 0 \le x \le 50$$

$$\mu_{MD}(x) = \begin{cases} \frac{x}{50} & 0 \le x \le 50 \\ \frac{100-x}{50} & 50 \le x \le 100 \end{cases}$$

Dirt (%)

$$\mu_{LD}(x) = \frac{x-50}{50}, \quad 50 \le x \le 100$$

Membership function for Grease



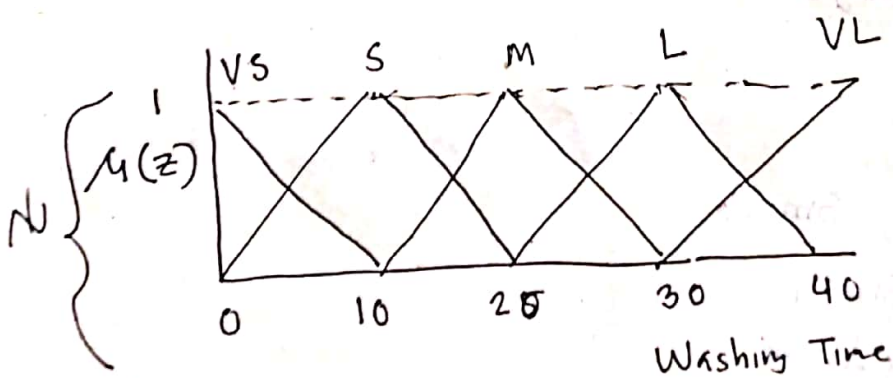
$$\mu_{NG} = \frac{50-y}{50} \quad 0 \le y \le 50$$

$$\mu_{MG} = \begin{cases} y/50 \\ 100-y/50 \end{cases} \quad 50 \le y \le 100$$

Grease (%)

$$\mu_{LG}(y) = \frac{y-50}{50} \quad 50 \le y \le$$

Membership function



$$\mu_{VS}(z) = \frac{10-z}{10} \quad 0 \le z \le$$

$$\mu_S = \begin{cases} z/10 & 0 \le z \le 10 \\ \frac{20-z}{10} & 10 \le z \le 20 \end{cases}$$

$$\mu_m(z) = \begin{cases} \frac{z-10}{10} & 10 \le z \le \\ \frac{30-z}{10} & 20 \le z \le \end{cases}$$

$$\mu_L(z) = \begin{cases} \frac{z-20}{10} & 20 \le z \le 30 \\ \frac{40-z}{10} & 30 \le z \le 40 \end{cases}$$

$$\mu_{VL} = \frac{z-30}{10} \quad 30 \le z$$

(3) Rule Base

x \ y	NG	MG	LG
SD	VS	M	L
MD	S	M	L
LD	M	L	VL

(4) Assume Dirt 60%. Grease 70%.

Dirt 60%.

$\mu_{MD}(x) = \frac{100-x}{50}$ $\mu_{LD}(x) = \frac{x-50}{50}$

$= 4/5$ $= 1/5$

Similarly

Grease 70%.

$\mu_{MG}(y) = \frac{100-y}{50}$ $\mu_{LG}(y) = \frac{y-50}{50}$

$= 3/5$ $= 2/5$

The above 4 equalions lead to 4 rule

Rule1 Dirt is MD and Grease is MG

Rule2 Dirt is MD and Grease is LG

Rule3 Dirt is LargeD and Grease is MG

Rule4 Dirt is LargeD and Grease is LargeG

Since the antecedent part of each of the rules is connected by and operator, we can use min operator to evaluate the strength of the rule.

Strength of rule 1

$$S1 = \min\left(\mu_{MD}(60)\ \mu_{MG}(70)\right)$$

$$= \min\left(4/5, 3/5\right) = 3/5$$

Strength of rule 2

$$S2 = \min\left(\mu_{MD}(60)\ \mu_{LG}(70)\right)$$

$$= \min\left(4/5, 2/5\right) = 2/5$$

Strength of rule 3

$$S3 = \min\left(\mu_{LD}(60), \mu_{MG}(70)\right)$$

$$= \min\left(1/5, 3/5\right) = 1/5$$

Strength of rule 4

$$S4 = \min\left(\mu_{LD}(60), \mu_{LG}(70)\right)$$

$$= \min\left(1/5, 2/5\right) = 1/5$$

x \ y	NG	MG	LG
SD	X	X	X
MD	X	3/5	2/5
LD	X	1/5	1/5

Max Evaluate ⟺

x \ y	NG	MG	LG
SD	X	X	X
MD	X	M	L
	X	L	VL

Step 5 Defuzzification ~~(MoMax)~~

We will use Mean of max.

Maximum Strength

$= \text{Max}(S_1, S_2, S_3, S_4) = (3/5, 2/5, 1/5, 1/5$

$= 3/5$

This correspond to rule 1:

DIRT is Medium and Grease is Medium has ~~average stre~~ maximum strength of 3/

To find out the defuzzified value ~~(z*)~~ (z^*) we now take average of $\mu_M(z)$

$$\mu_M(z) = \frac{z-10}{10} \qquad \mu_M(z) = \frac{30-z}{10}$$

$$3/5 = \frac{z-10}{10} \qquad 3/5 = \frac{30-z}{10}$$

$$\Rightarrow 5z = 80 \qquad \Rightarrow 30 = 150 - 5z$$

$$\Rightarrow z = 16 \qquad \Rightarrow z = \frac{120}{5} = 24$$

$$z^* = \frac{16+24}{2} = \frac{40}{2} = 20 \text{ min}$$