Vishwa Singh
PA10 C1032110273

Soft Computing

Lab Assignment 2

Title: Write a program to generate the following parameterized fuzzy membership functions and visualize them for different parameter values.

Aim: Program to generate the following membership function

a) Triangular MF
b) Trapezoidal MF
c) Gaussian MF
d) Sigmoidal MF

Objective: Write the equation for a triangular membership function that is independent of the centre point and the width and visualize the graphs for it.

Theory :

a) **Triangular MF :** Eqn : $\text{triangle}(x; a, b, c) = \max\left(\min\left(\frac{x-a}{b-a}, \frac{c-x}{c-b}\right), 0\right)$

This is equivalent to,

$$\text{triangle}(x; a, b, c) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ \frac{c-x}{c-b}, & b \leq x \leq c \\ 0, & c \leq x \end{cases}$$

b) **Trapezoidal MFs :** Eqn : $\text{trapezoid}(x; a, b, c, d) = \max\left(\min\left(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right), 0\right)$

This is equivalent to,

$$\text{trapezoidal}(x; a, b, c, d) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & b \leq x \leq c \\ \frac{d-x}{d-c}, & c \leq x \leq d \\ 0, & d \leq x \end{cases}$$

c) **Gaussian MFs**

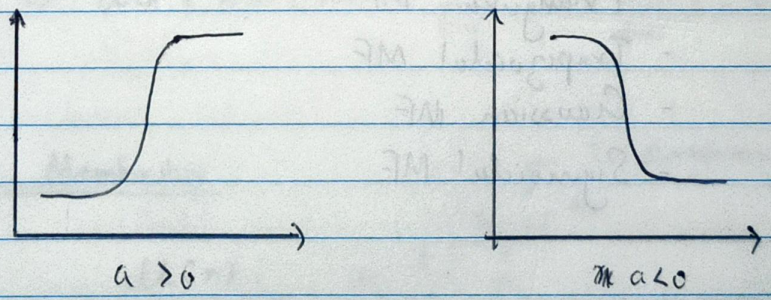
$$\text{gaussian}(x; c, \sigma) = e^{-\frac{1}{2}\left(\frac{x-c}{\sigma}\right)^2}$$

Here, c represent the MFs center and sigma determines the MFs width.

d **Sigmoid MF :**

$$\text{Sig}(x; a, c) = \frac{1}{1 + \exp(-a(x-c))}$$

c is the point of sig = 0.5. Depending on the ~~point~~ sign of parameter a, the graph is either open left or open right.



Input : Fuzzy set values
Output : Graphs.

Conclusion : Thus, we successfully implemented various fuzzy membership functions with visualization its graph.

FAQ

Description : The goal is to code and test out different fuzzy membership functions and check their plots with different parameters.

MF Function :

- Triangular MF
- Trapizoidal MF
- Gaussian MF
- Sigmoidal MF

=> **Triangle MF derivation :**

$$\mu_A(x) = \begin{cases} 0 & x \le a \\ \frac{x-a}{b-a} & a \le x \le b \\ \frac{c-x}{c-b} & b \le x \le c \\ 0 & x \ge c \end{cases}$$

$$\Rightarrow \mu_A(x) = \max\left(\min\left(\frac{x-a}{b-a}, \frac{c-x}{c-b}\right), 0\right)$$

=> **Trapezoidal MF derivation :**

$$\mu_A = \begin{cases} 0 & x \le b \\ \frac{x-a}{b-a} & a \le x \le b \\ 1 & b \le x \le c \\ \frac{d-x}{d-c} & c \le x \le d \\ 0 & d \le x \end{cases}$$

$$\Rightarrow \mu_A = \max\left(\min\left(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right), 0\right)$$

3> **Gaussian Membership :**

$$\mu(x) = e^{-\frac{1}{2}\left|\frac{x-c}{s}\right|^m}$$

To determine the mean point

to determine the width

Sigmoid :

$$\mu(x) = \frac{1}{1 + e^{-a(x-c)}}$$

c → determine the 0.5 point

a → the width & direction

Uses :

★ **Triangular & Trapezoidal membership :**
- Semantic analysis of linguistic terms
- Measuring compressive strength
- Fuzzy controllers & classifiers

★ **Gaussian Distribution :**
- Signal Processing
- Gaussian Blurs
- RL methods for multiarm bandit problems

★ **Sigmoid :** Probabilistic Modeling
Activation for neural networks

Observation :

→ Trapezoidal is similar to a triangular MF but with a broader region for $\mu(x) = 1$

→ The sigmoid can be left open or right open based on the sign of a

→ Smaller value of a ~~is~~ leads to a more linear graph