Artificial Intelligence

SCALAB

Grupo de Inteligencia Artificial

Universidad Carlos III de Madrid

2017-2018

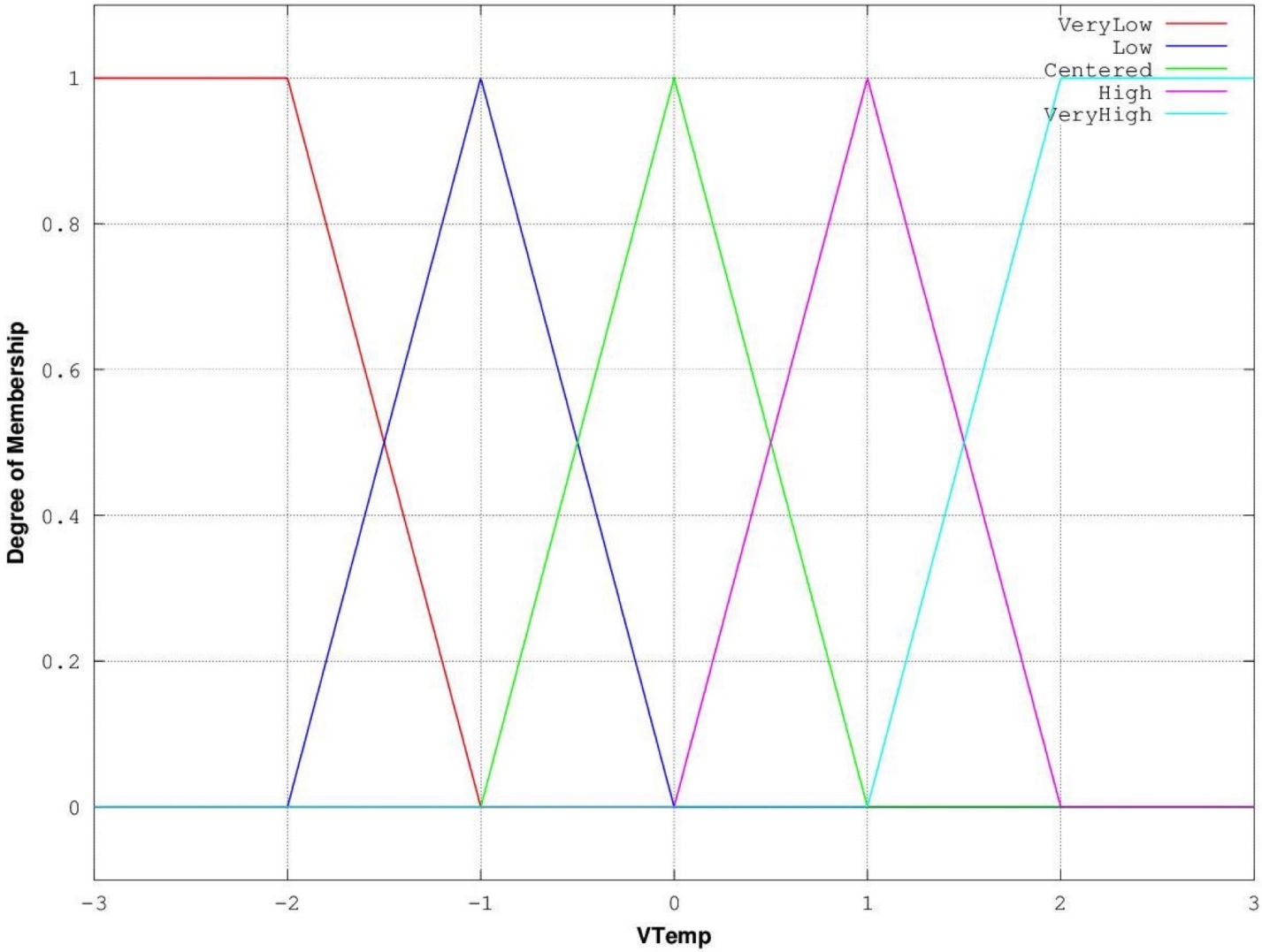
Fuzzy Controllers – Exercises

Exercise 1

We have a fuzzy controller to control the temperature and humidity of a room. Temperature should be of 18 degrees. Humidity should be of 70 %. The controller is composed of two rule systems. They relate the variations in temperature and humidity to the openness of two valves: water valve and freon gas valve.

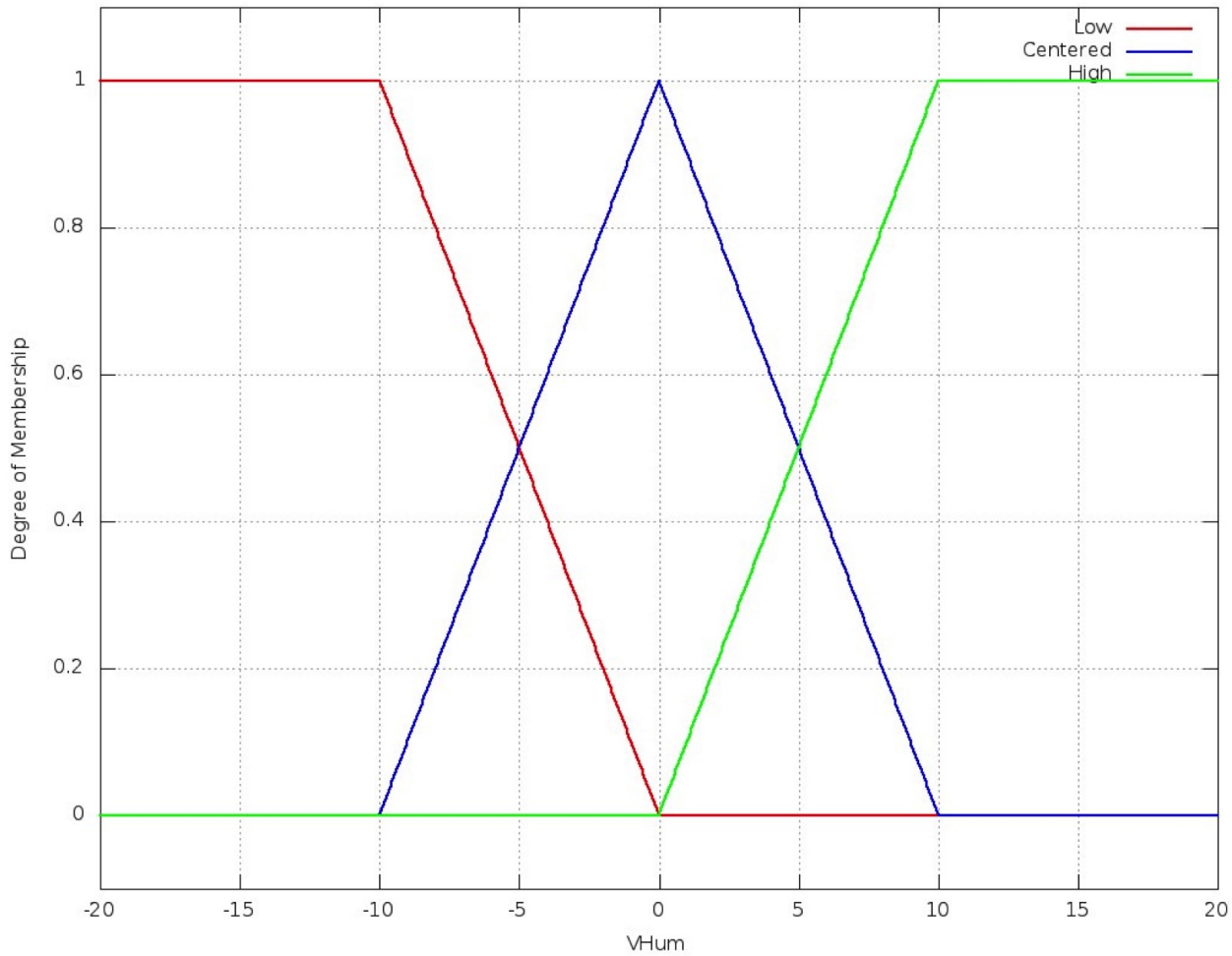
Exercise 1

Variation in temperature



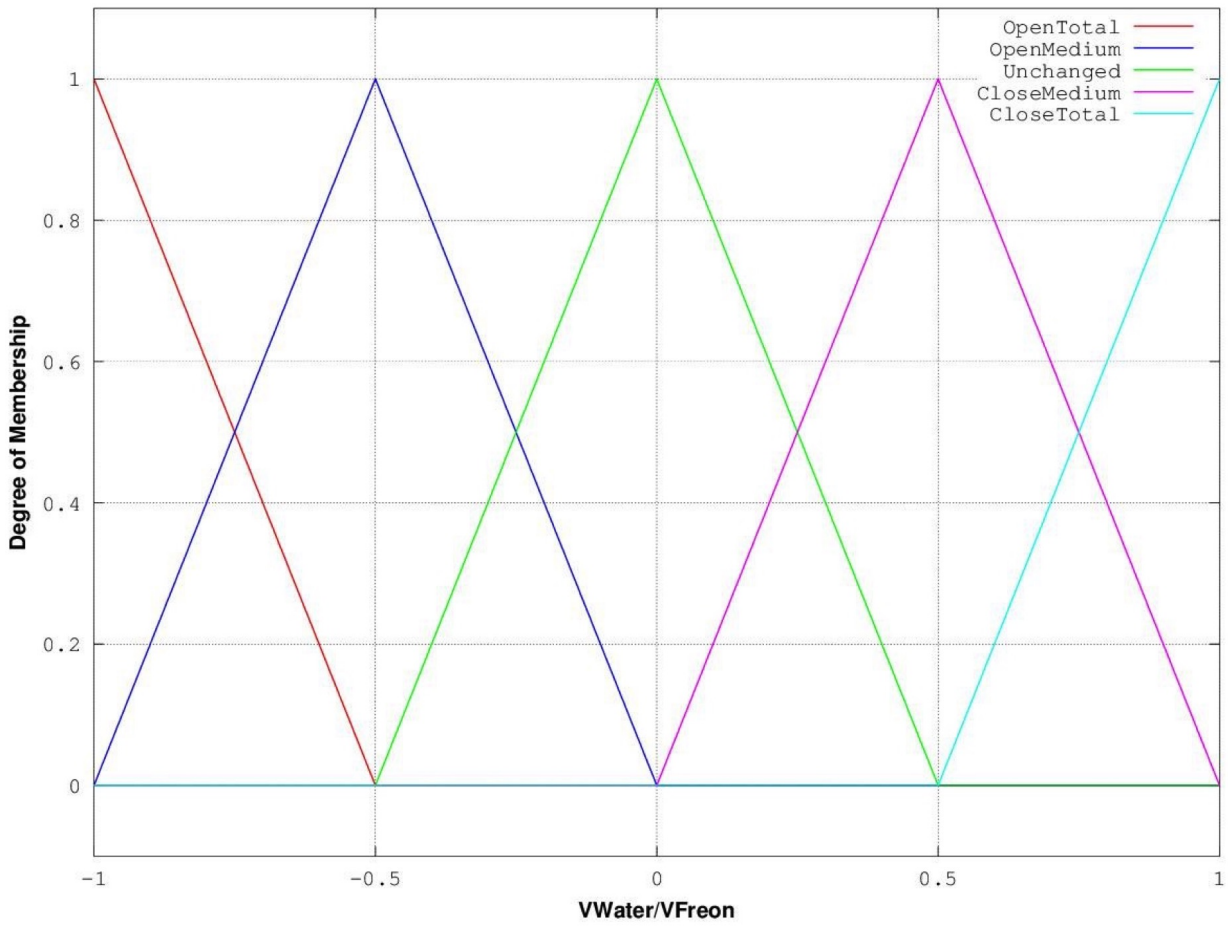
Exercise 1

Variation in humidity



Exercise 1

- Openness for water and freon gas



Exercise 1

- Rules for the water valve: VHum, VTemp $\rightarrow$ Openness Water

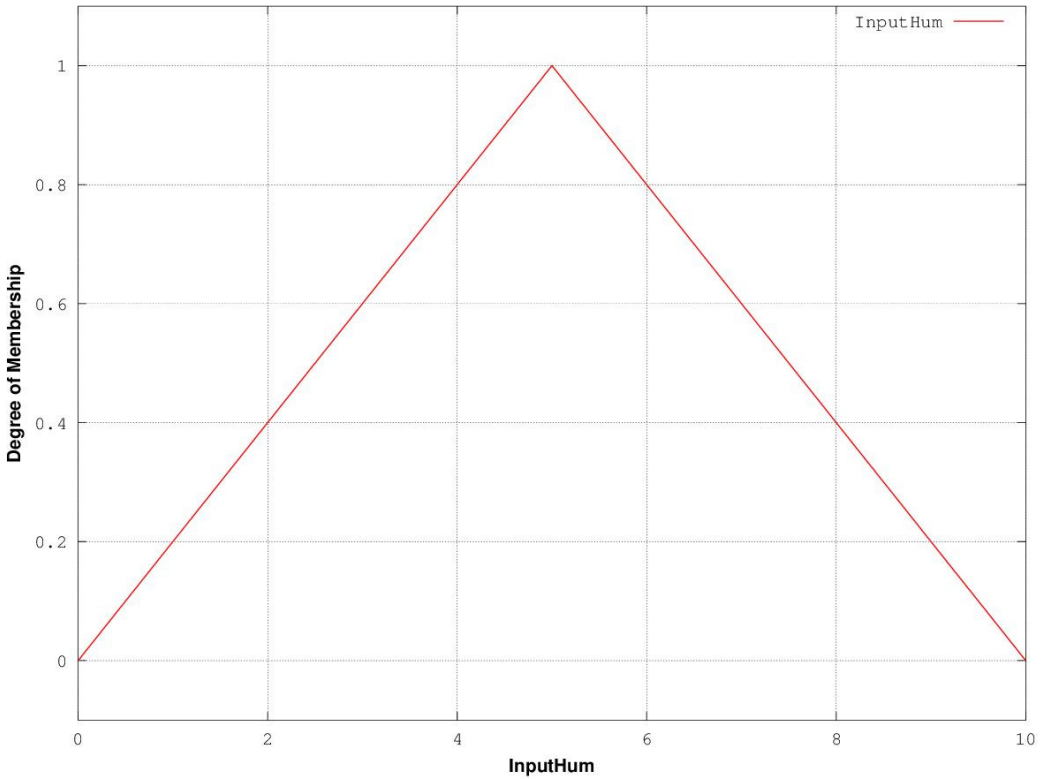
VHum/VTemp	VL	L	C	H	VH
L	OT	OT	OM	OM	U
C	U	U	U	U	OM
H	CT	CT	CM	U	U

- Rules for the freon gas valve: VHum, VTemp $\rightarrow$ Openness freon gas

VHum/VTemp	VL	L	C	H	VH
L	OT	OT	U	U	OM
C	OT	OM	U	OM	OM
H	OM	U	U	OM	OT

Exercise 1

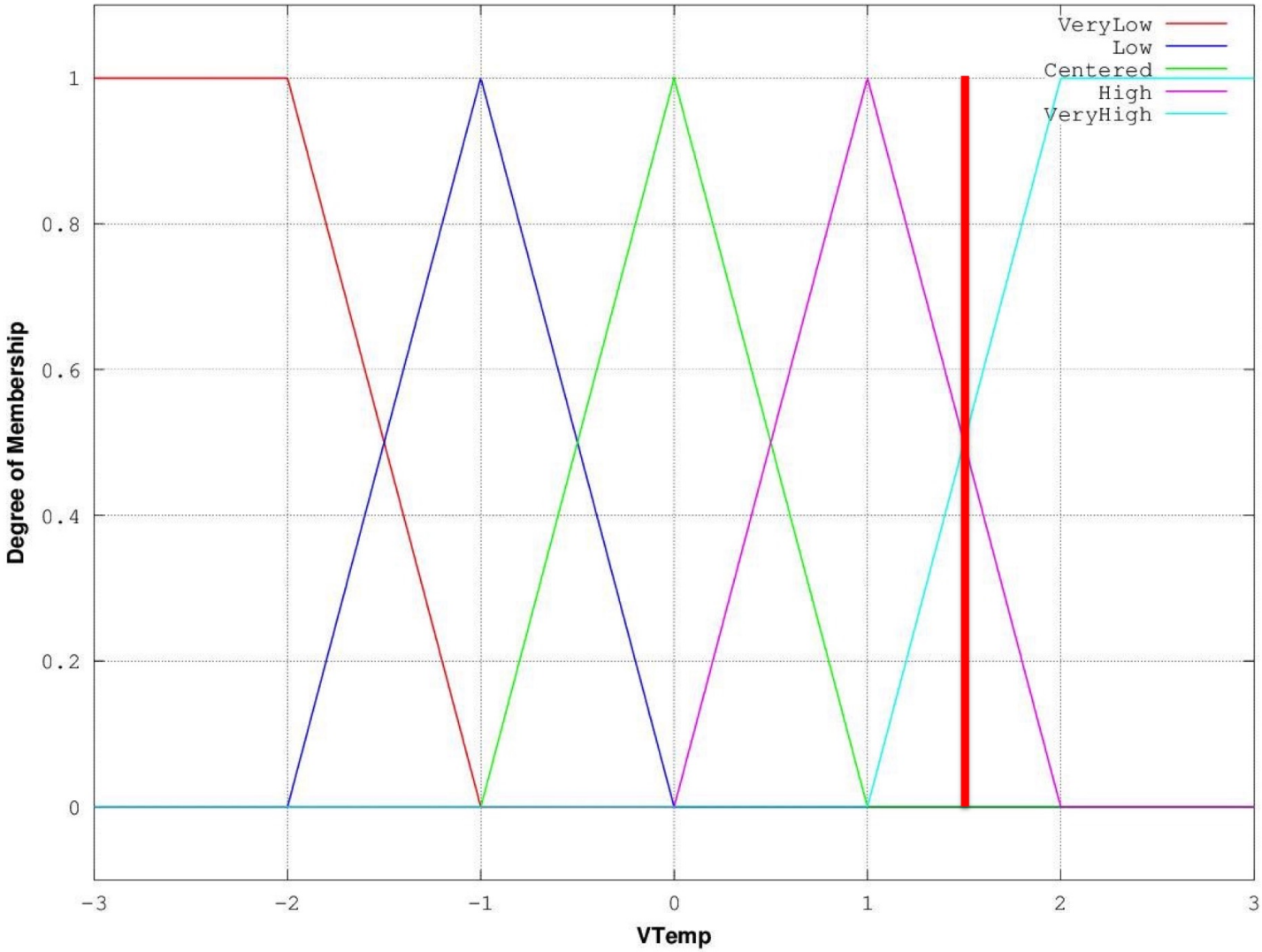
- Currently we have an increase of both, temperature and humidity. The increase of temperature is of +1.5 degrees. However, the increase of humidity is known with less accuracy. It is given by the following distribution



- Apply Mandami inference to obtain the controller proposal about the openness of both valves

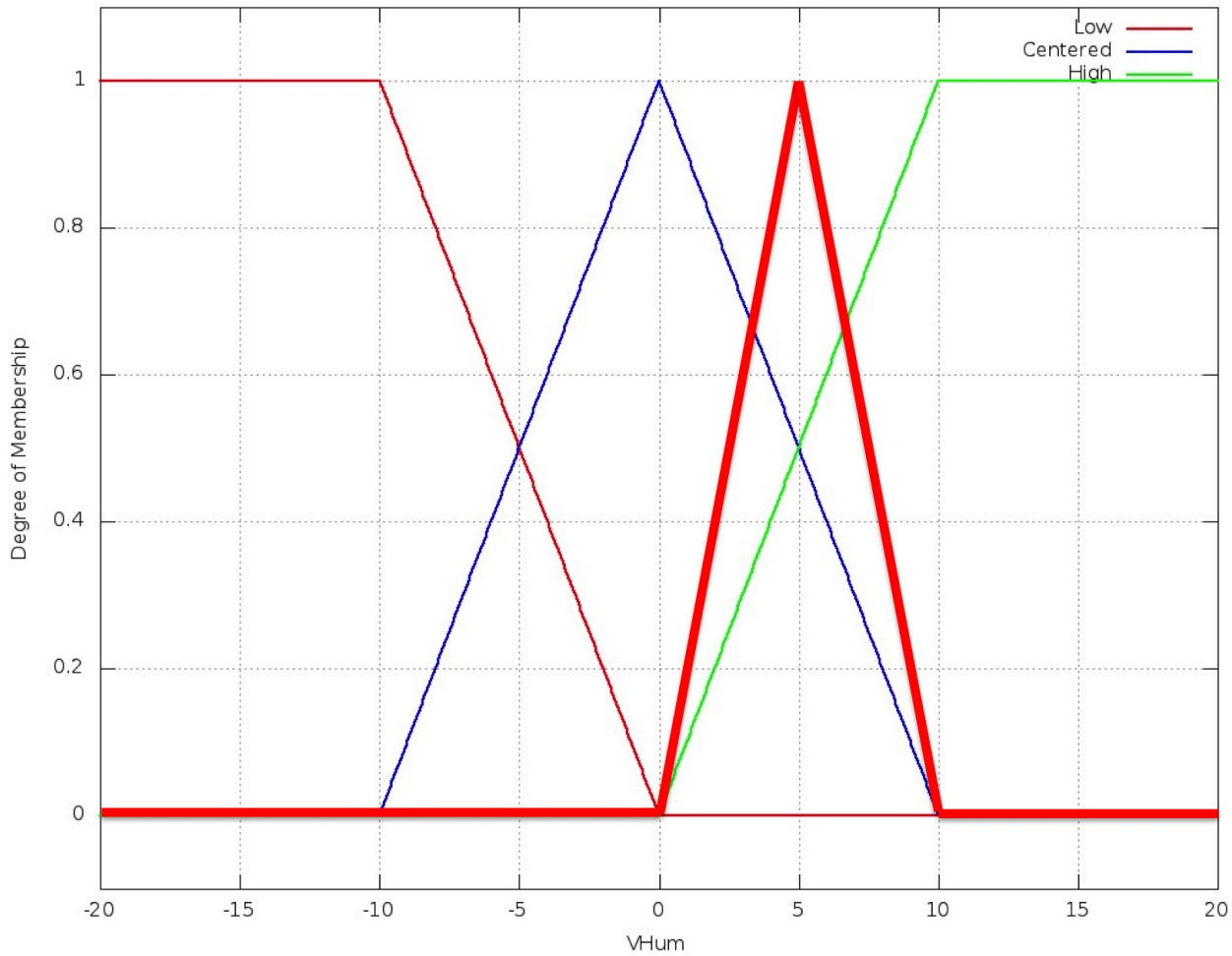
Exercise 1 – solution

1. Fuzzification. Temperature



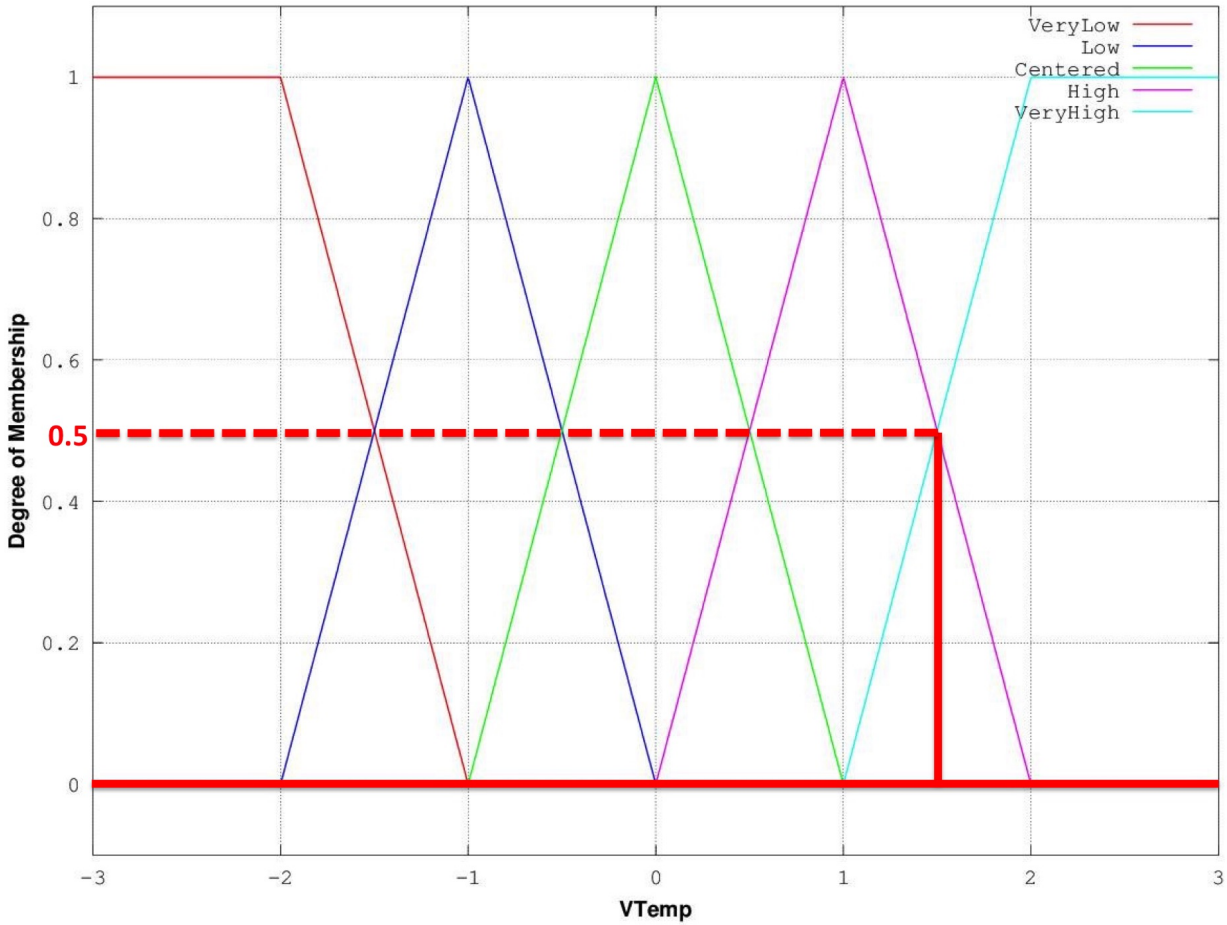
Exercise 1 – solution

1. Fuzzification. Humidity



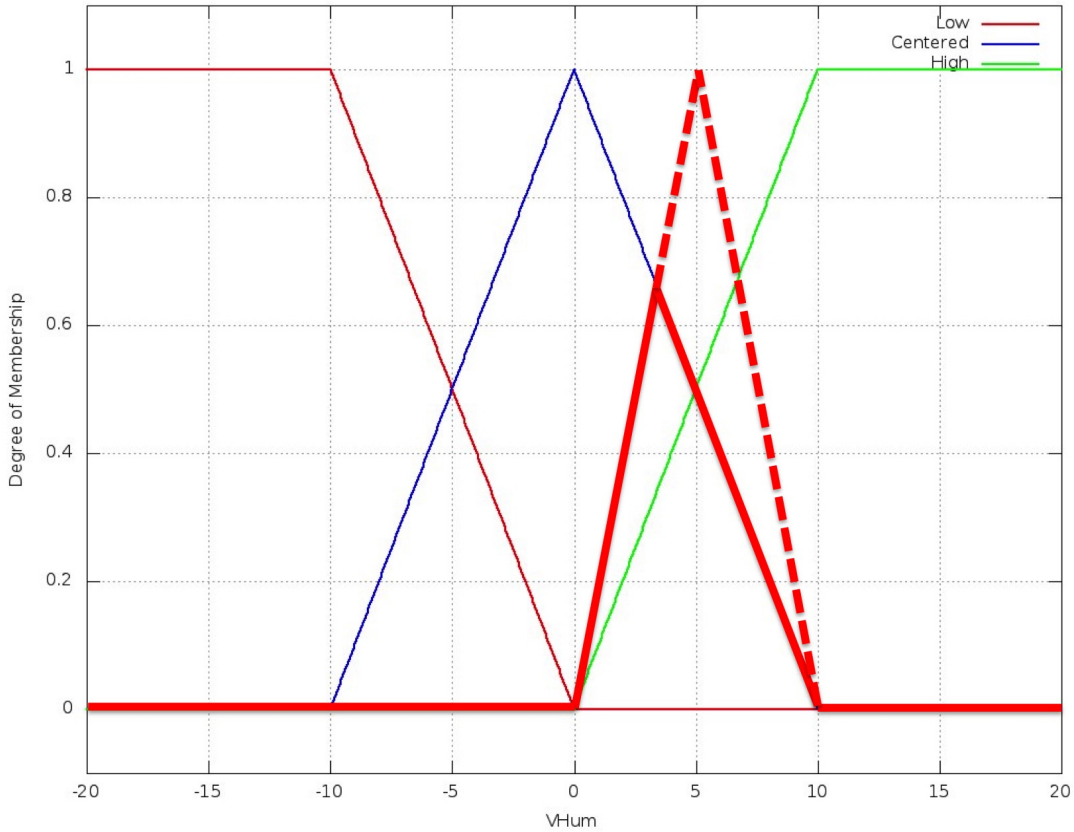
Exercise 1 – solution

2. Inference. Matching temperature
   - Similarity with high (H), degree 0.5
   - Similarity with very high (VH), degree 0.5



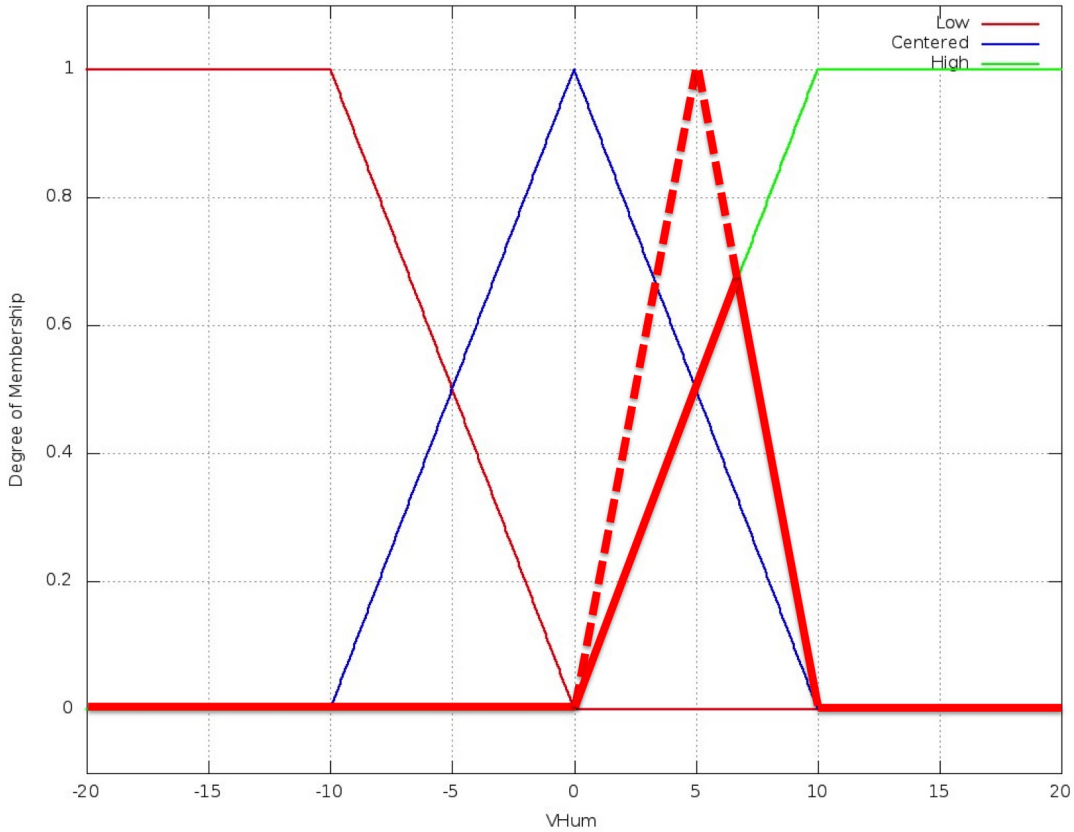
Exercise 1 – solution

2. Inference. Matching humidity (C)



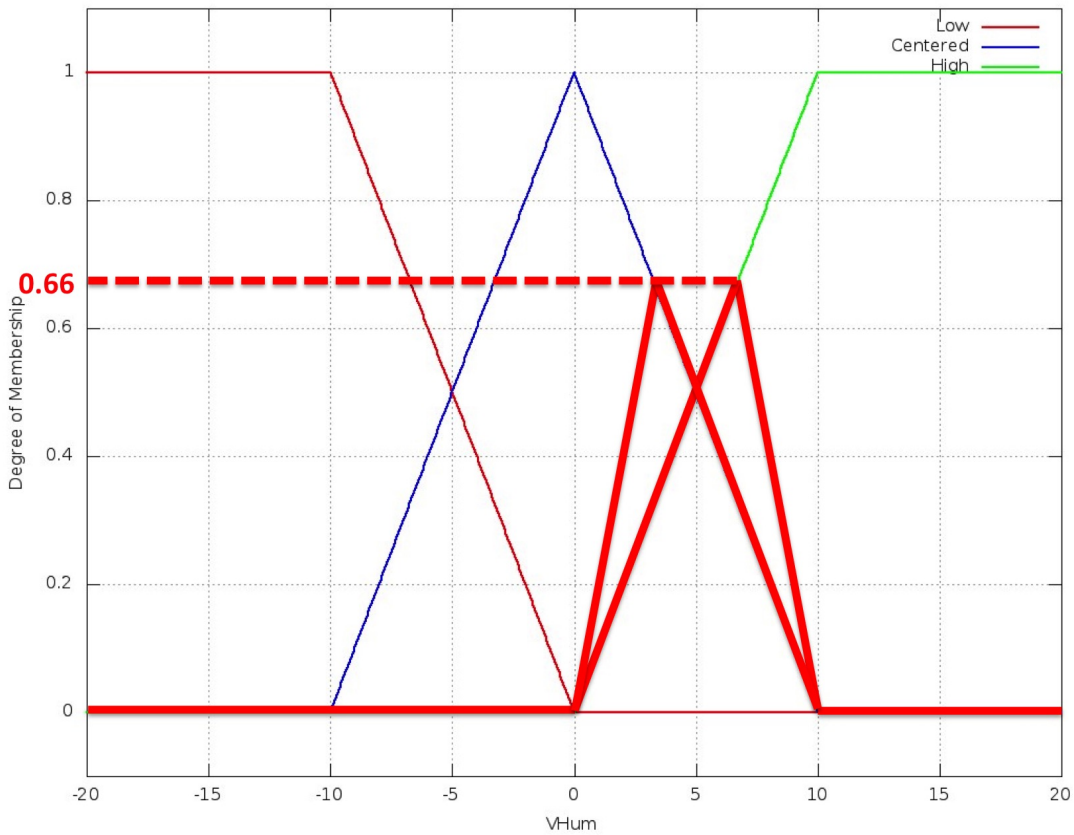
Exercise 1 – solution

2. Inference. Matching humidity (H)



Exercise 1 – solution

2. Inference. Matching humidity (C and H)
   - Similarity with centered (C), degree $\frac{2}{3}$
   - Similarity with high(H), degree $\frac{2}{3}$



Exercise 1 – solution

2. Inference. Matching both VTemp and VHum

- For rule with antecedent VTemp=H and VHum=C
  - similarity for VTemp High(H):
    $S_{VTemp} = \text{máx}_{VTemp}\{\text{mín}\{High(VTemp), Input(VTemp)\}\} = 0.5$
  - similarity for VHum Centered(C):
    $S_{VHum} = \text{máx}_{VHum}\{\text{mín}\{Centered(VHum), Input(VHum)\}\} = \frac{2}{3}$
  - conjunction: $S_{\text{antecedent}} = \text{mín}\{0.5, \frac{2}{3}\} = 0.5$
- the computation is equivalent for the rest of rules

VHum/VTemp	VL	L	C	H	VH
L	0	0	0	0	0
C	0	0	0	0.5	?
H	0	0	0	?	?

Exercise 1 – solution

2. Inference. Matching both VTemp and VHum

VHum/VTemp	VL	L	C	H	VH
L	0	0	0	0	0
C	0	0	0	0.5	0.5
H	0	0	0	0.5	0.5

Openness for water

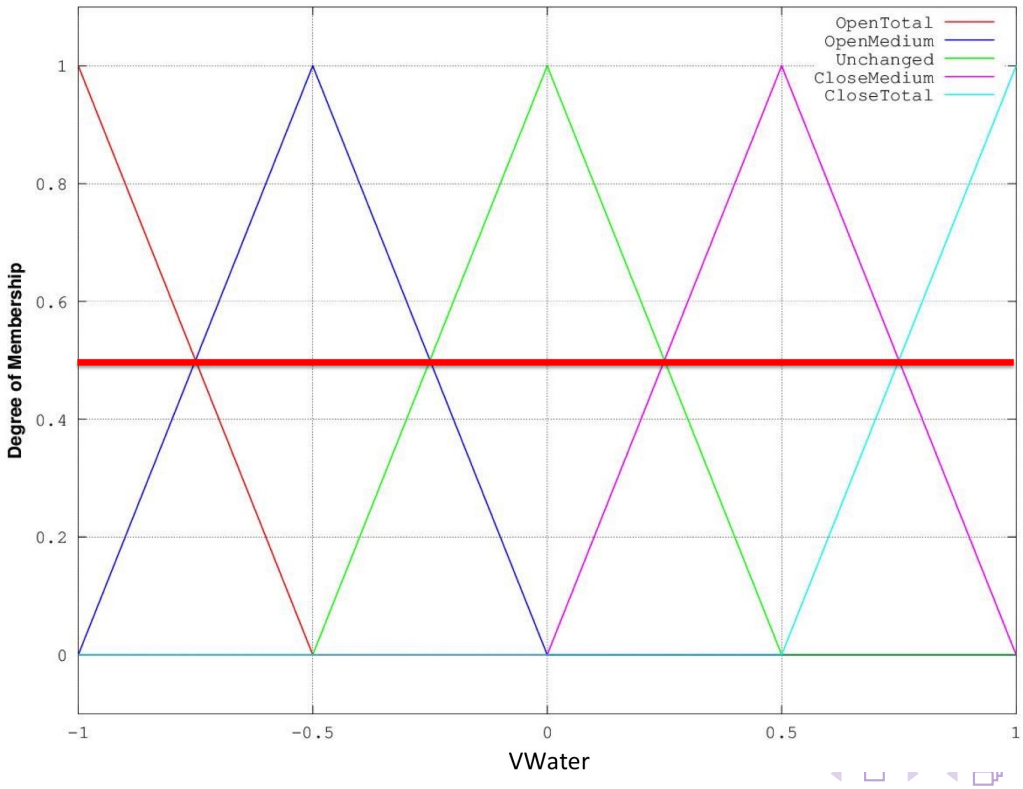
VHum/VTemp	VL	L	C	H	VH
L	OT	OT	OM	OM	U
C	U	U	U	U	OM
H	CT	CT	CM	U	U

Openness for freon gas

VHum/VTemp	VL	L	C	H	VH
L	OT	OT	U	U	OM
C	OT	OM	U	OM	OM
H	OM	U	U	OM	OT

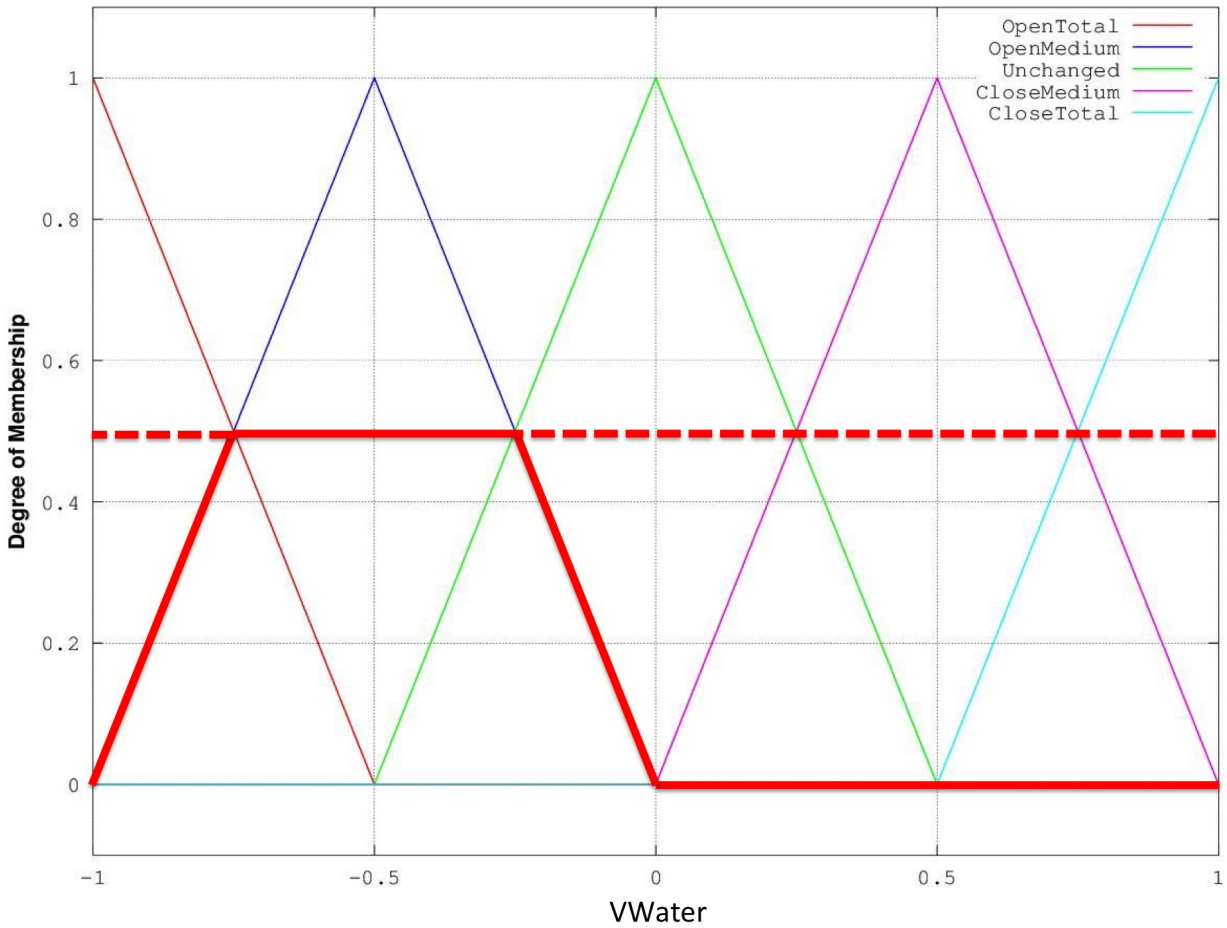
Exercise 1 – solution

2. Inference. Consequent (clipping) for VWater $Q(x) = \text{mín}\{S, \mu_c(x)\}$
   - Openness of water
     - $Q_1(VWater) = \text{mín}\{0.5, \mu_U(VWater)\}$
     - $Q_2(VWater) = \text{mín}\{0.5, \mu_{OM}(VWater)\}$
     - $Q_3(VWater) = \text{mín}\{0.5, \mu_U(VWater)\}$
     - $Q_4(VWater) = \text{mín}\{0.5, \mu_U(VWater)\}$



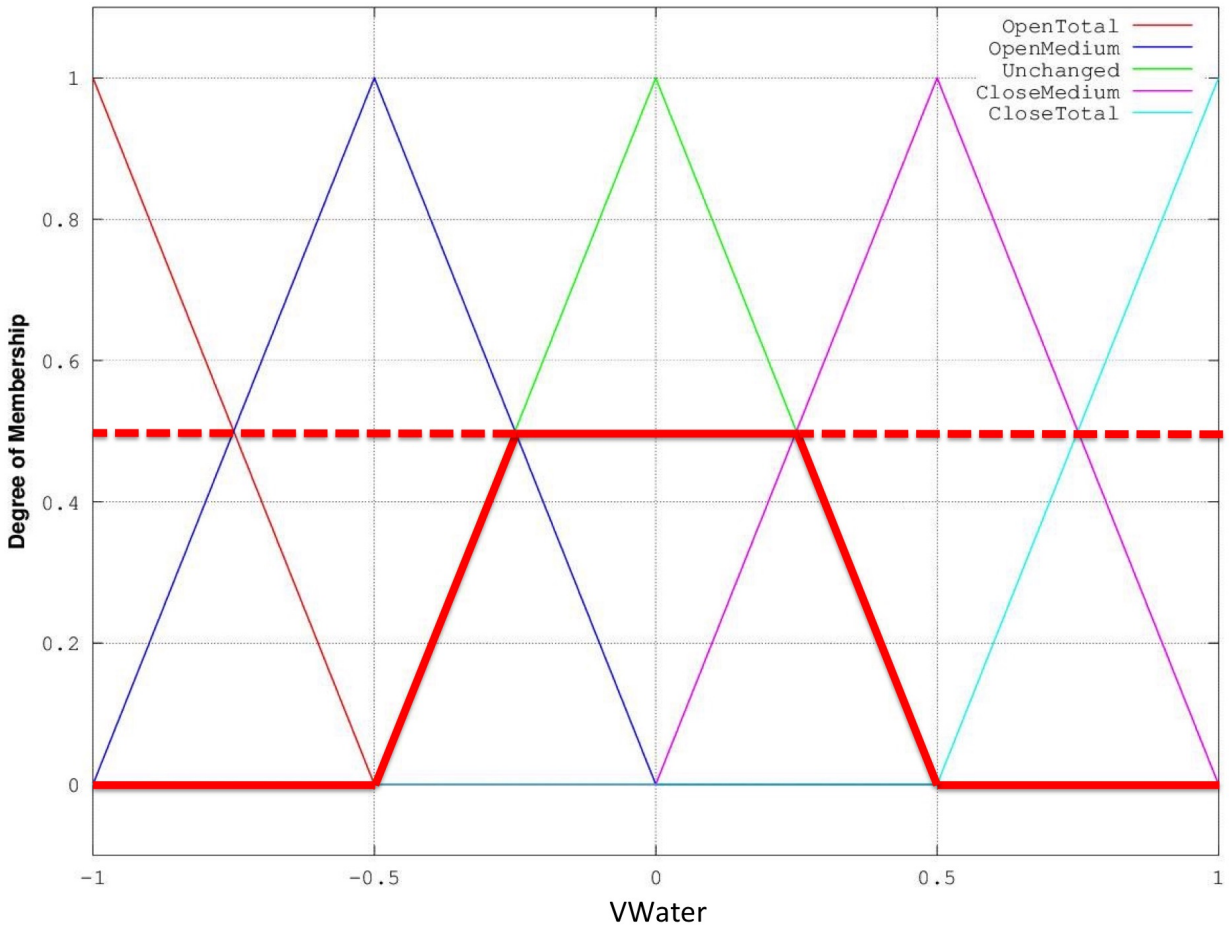
Exercise 1 – solution

2. Inference. Consequent (clipping)



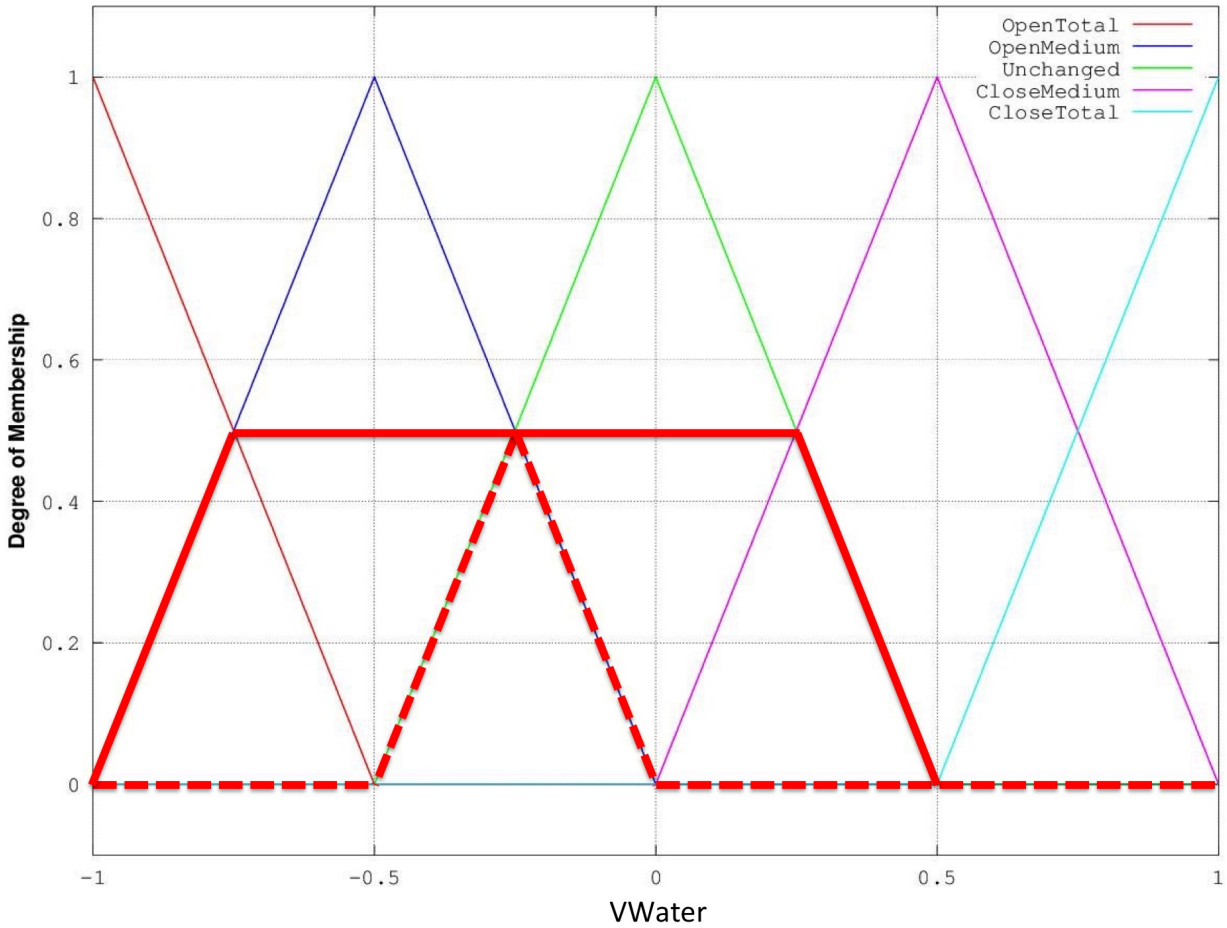
Exercise 1 – solution

2. Inference. Consequent (clipping)



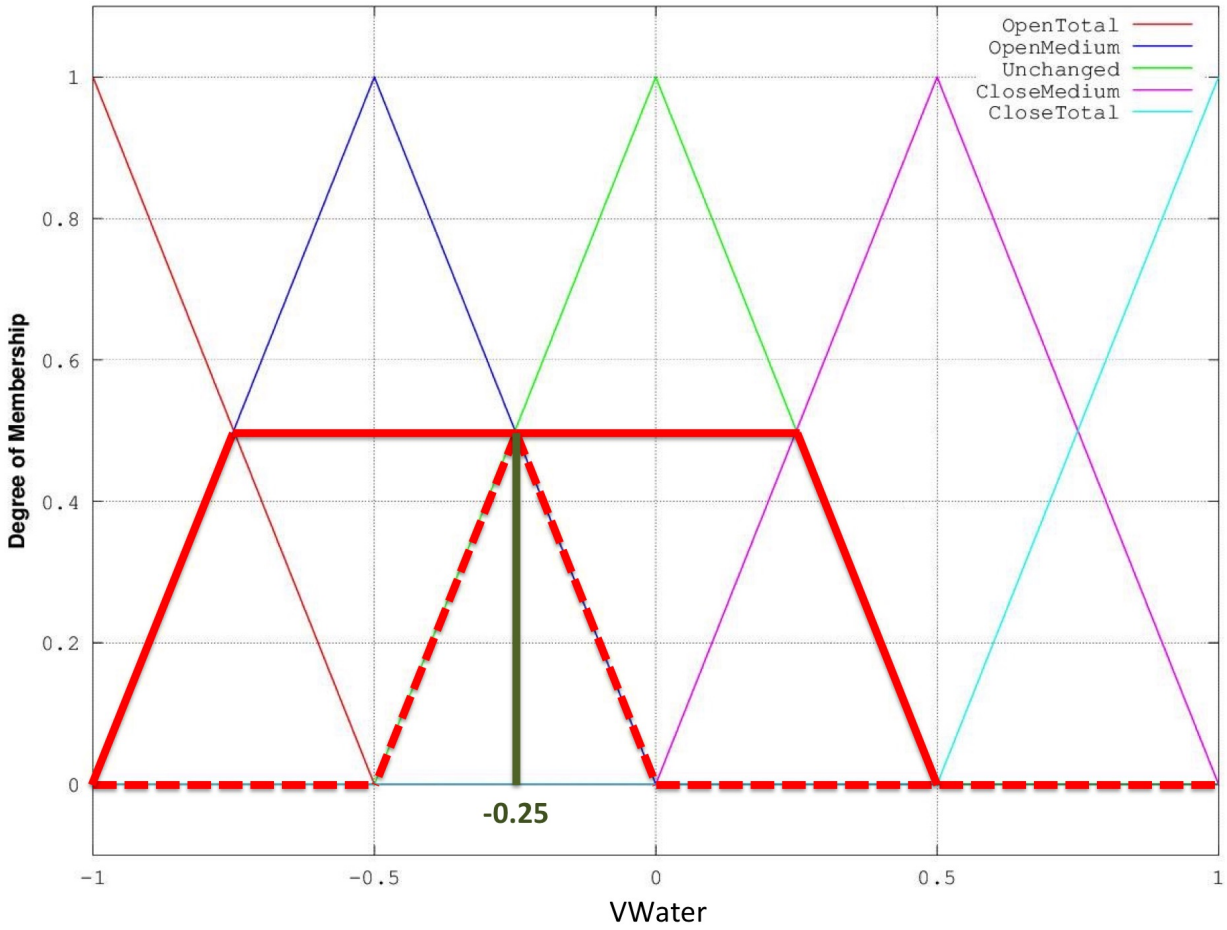
Exercise 1 – solution

2. Inference. Combination (max of all rules for VWater)



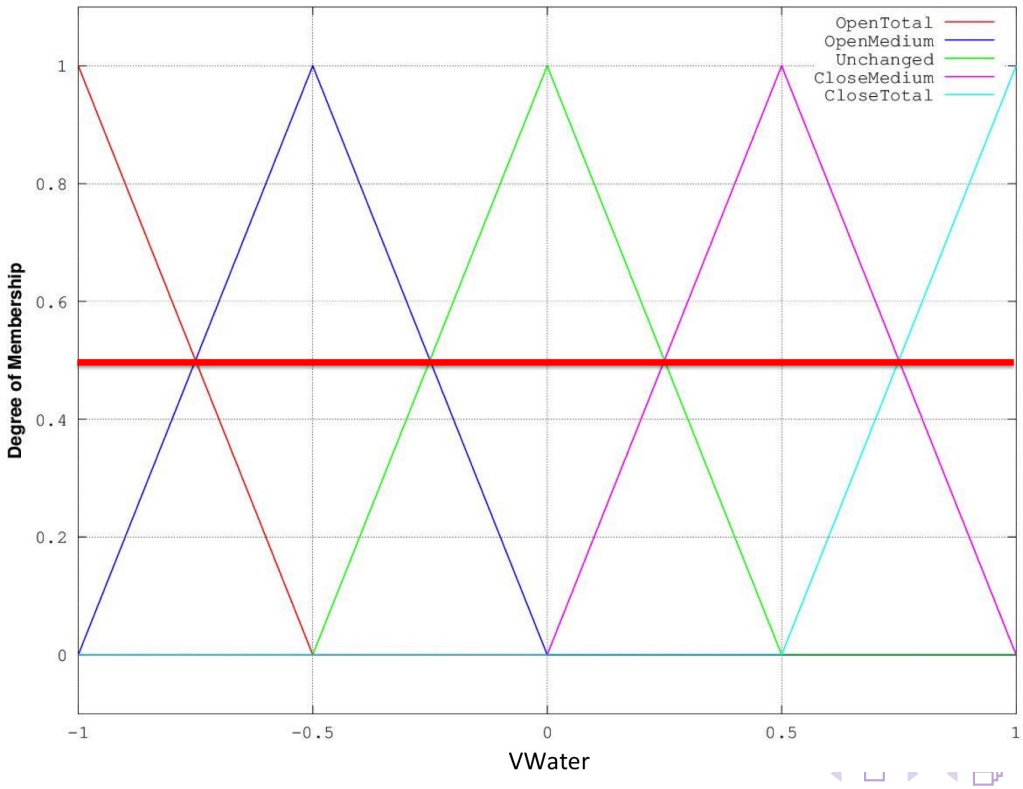
Exercise 1 – solution

3. Defuzzification for Openness of water by centroid: -0.25



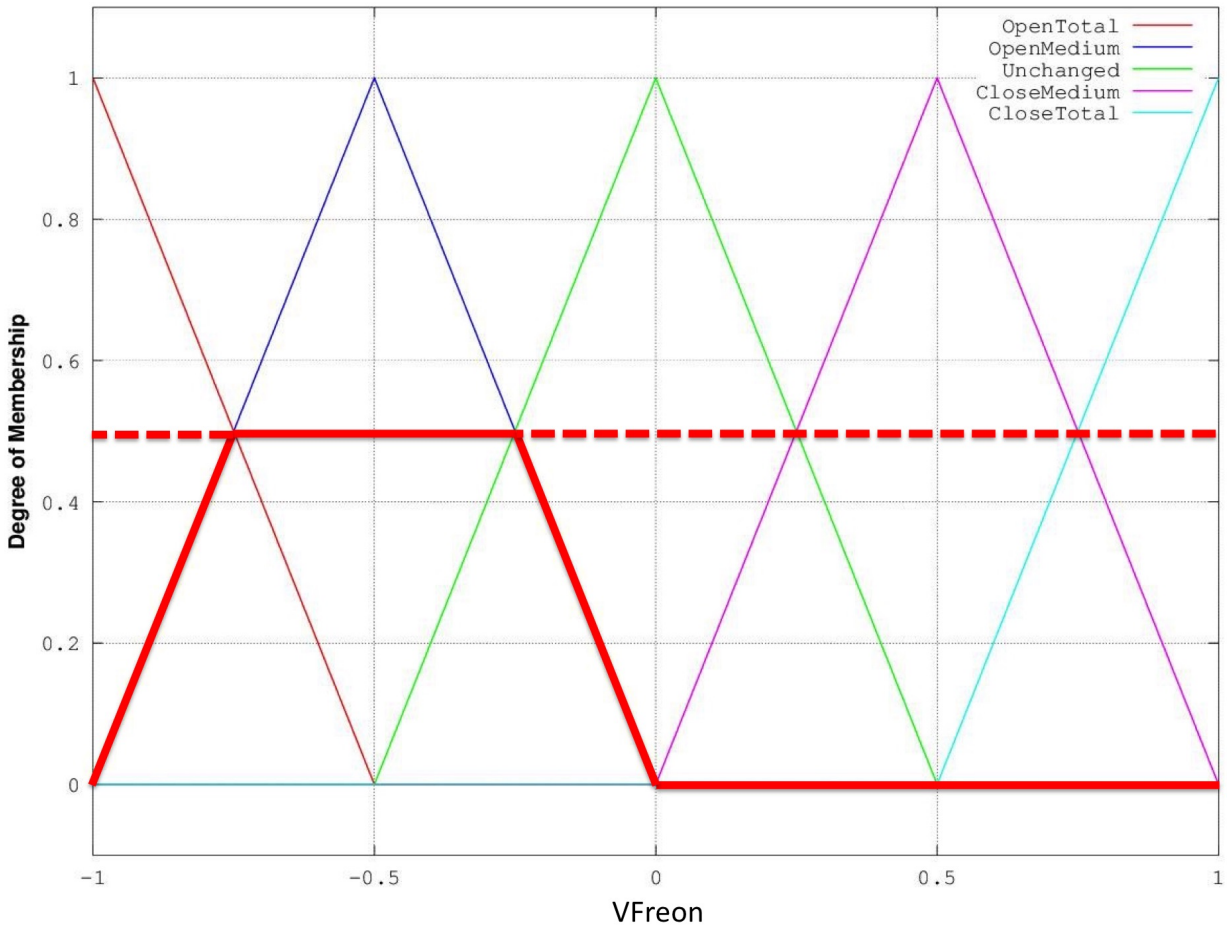
Exercise 1 – solution

2. Inference. Consequent (clipping) for VFreon $Q(x) = \text{mín}\{S, \mu_c(x)\}$
   - Openness of freon
     - $Q_1(VFreon) = \text{mín}\{(0.5, \mu_{OM}(VFreon)\}$
     - $Q_2(VFreon) = \text{mín}\{(0.5, \mu_{OM}(VFreon)\}$
     - $Q_3(VFreon) = \text{mín}\{(0.5, \mu_{OM}(VFreon)\}$
     - $Q_4(VFreon) = \text{mín}\{(0.5, \mu_{OT}(VFreon)\}$



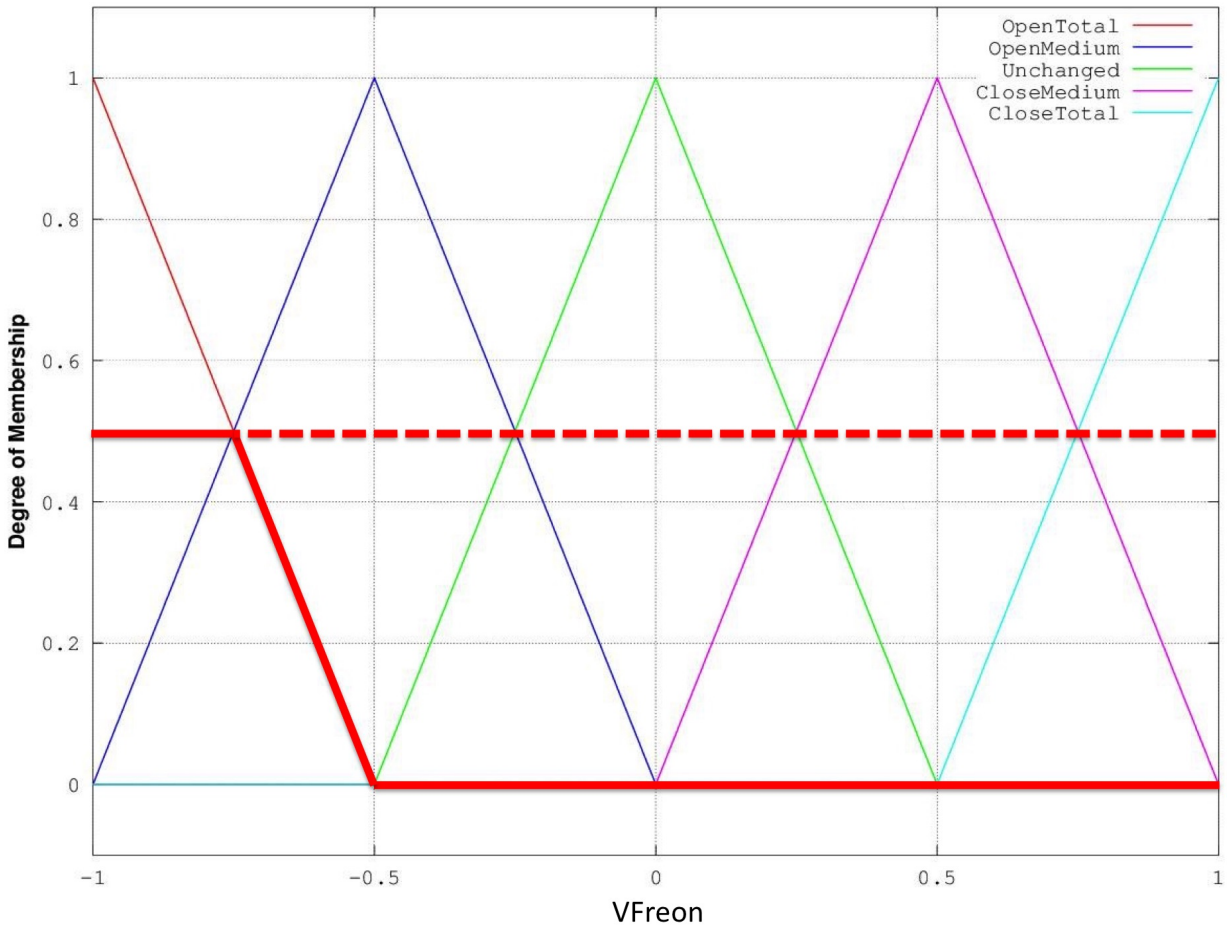
Exercise 1 – solution

2. Inference. Consequent (clipping)



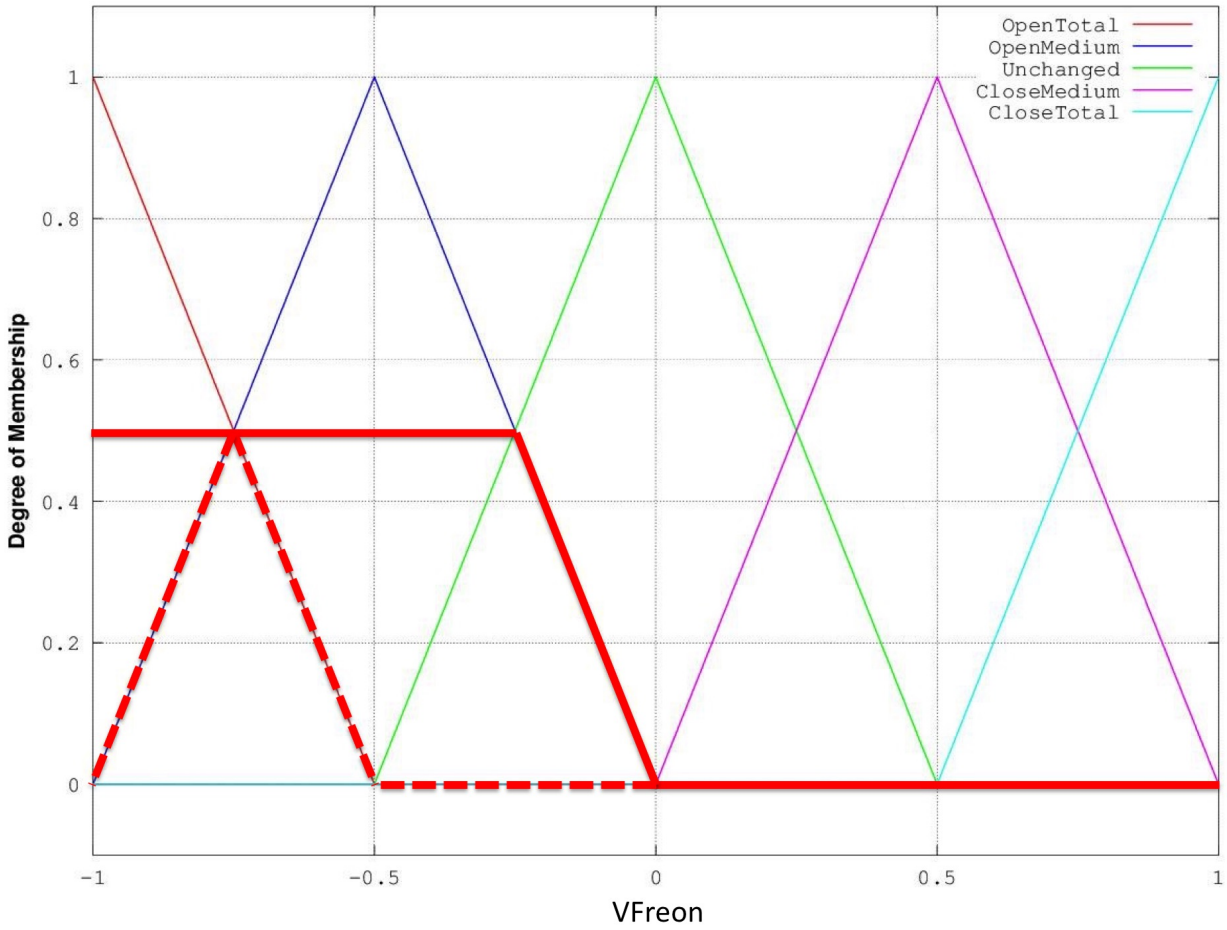
Exercise 1 – solution

2. Inference. Consequent (clipping)



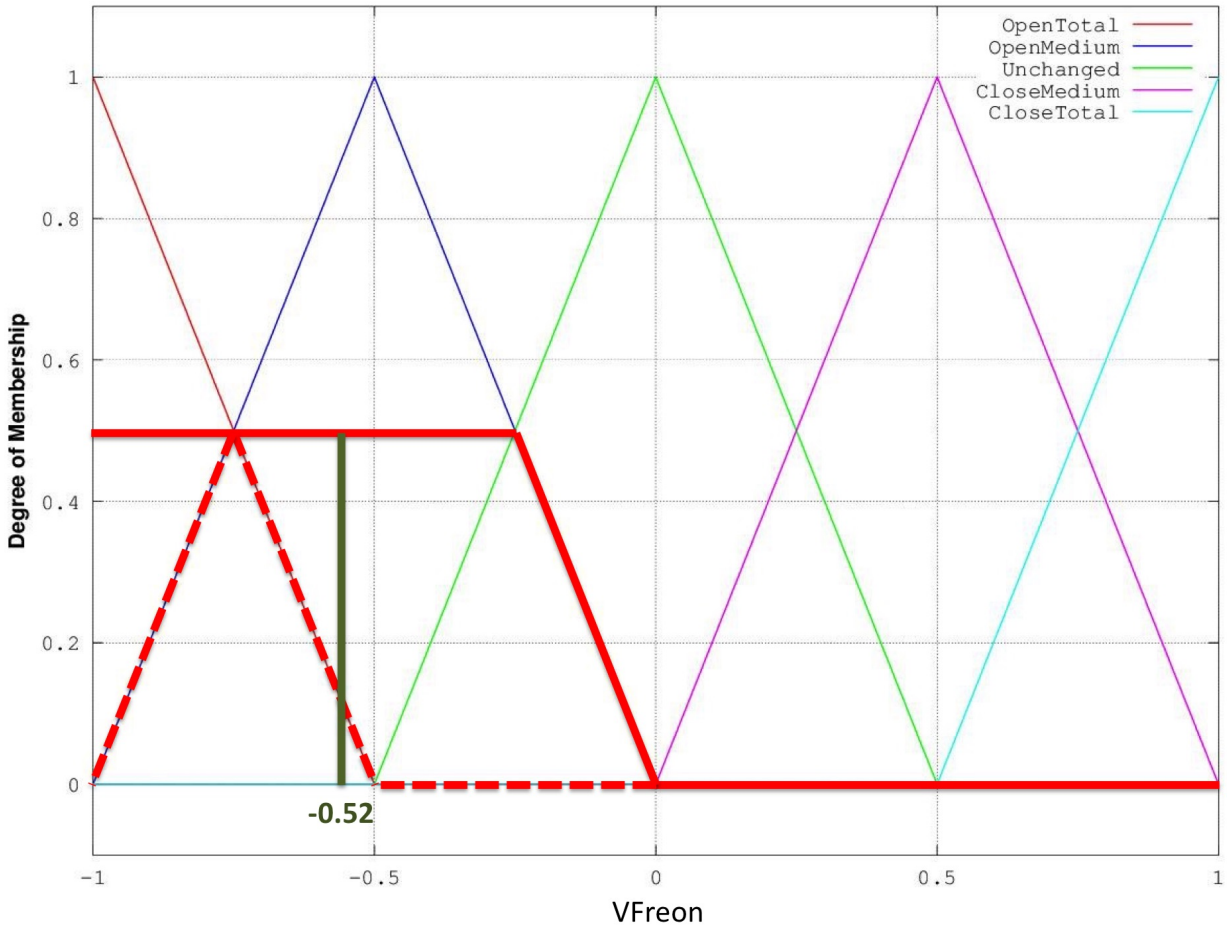
Exercise 1 – solution

2. Inference. Combination (max of all rules for VFreon)



Exercise 1 – solution

3. Defuzzification for VFreon by centroid: -0.52

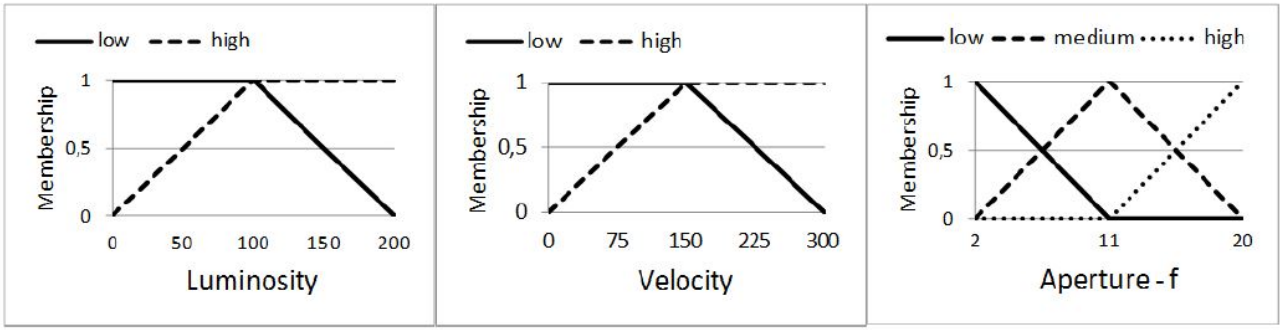


Exercise 2

A photo camera has a fuzzy controller to regulate the aperture from the luminosity captured by the sensor and the estimated speed of the subject to be photographed. The luminosity is measured on a scale of 0 to 200 lumens, while the speed of the subject is estimated in optical flow units which varies between 0 and 300. The aperture is regulated in 'f' units and varies between 0 and 20 for the lens. The membership functions are shown in the figure. The fuzzy rules for the system are:

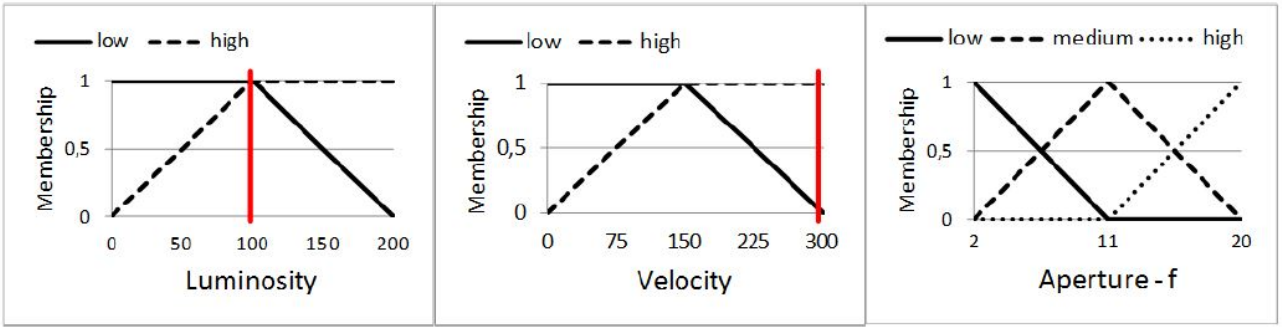
1. If luminosity is low and speed is low, then aperture is medium.
2. If luminosity is low and speed is high, then aperture is high.
3. If luminosity is high and speed is low, then aperture is low.
4. If luminosity is high and speed is high, then aperture is medium.

Calculate the value of the aperture when there is a luminosity of 100 lumens and speed of 300 units, using max-min inference (Mamdani method).



Exercise 2 – solution

Membership degrees:



We know that the luminosity is 100 and the speed is 300.
Calculating input membership levels:

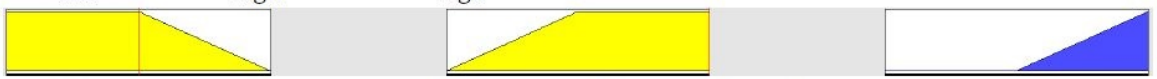
$$L_{low}(100) = 1$$
$$L_{high}(100) = 1$$
$$V_{low}(300) = 0$$
$$V_{high}(300) = 1$$

Exercise 2 – solution

- If L_{low} AND V_{low} THEN A_{medium}

$S(A_{medium}) = \min[L_{low}(100), V_{low}(300)] = \min[1, 0] = 0$

- If L_{low} AND V_{high} THEN A_{high}

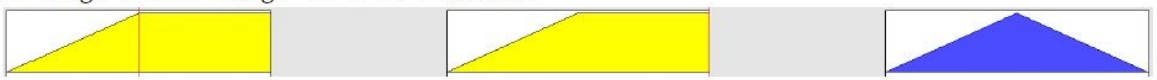


$S(A_{high}) = \min[L_{low}(100), V_{high}(300)] = \min[1, 1] = 1$

- If L_{high} AND V_{low} THEN A_{low}

$S(A_{low}) = \min[L_{high}(100), V_{low}(300)] = \min[1, 0] = 0$

- If L_{high} AND V_{high} THEN A_{medium}



$S(A_{medium}) = \min[L_{high}(100), V_{high}(300)] = \min[1, 1] = 1$

- Aggregation (union of consequences): the Centroid of area is about 12.6.