Narzędzia Sztucznej Inteligencji

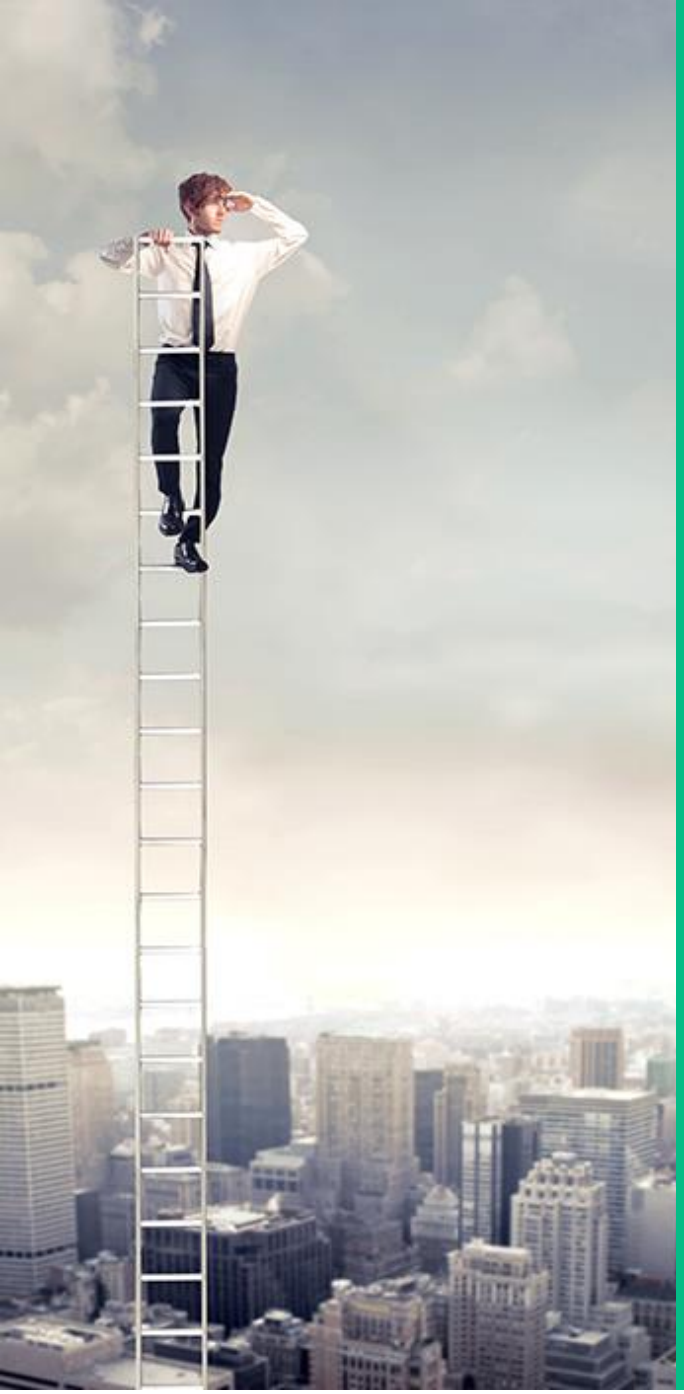
Wykład 02 23.10.2021

Czapiewski Paweł pczapiewski@pjwstk.edu.pl

Source: https://www.youtube.com/watch?v=cdWRo6gdOJ8

http://moonlander.seb.ly/

expert
[ek-spərt], n,
1. Anyone from out of town. 2. The person who predicts the job will take the longest and cost the most.
see also: delusional, pretender



Fuzzy Logic

Fuzzy Logic

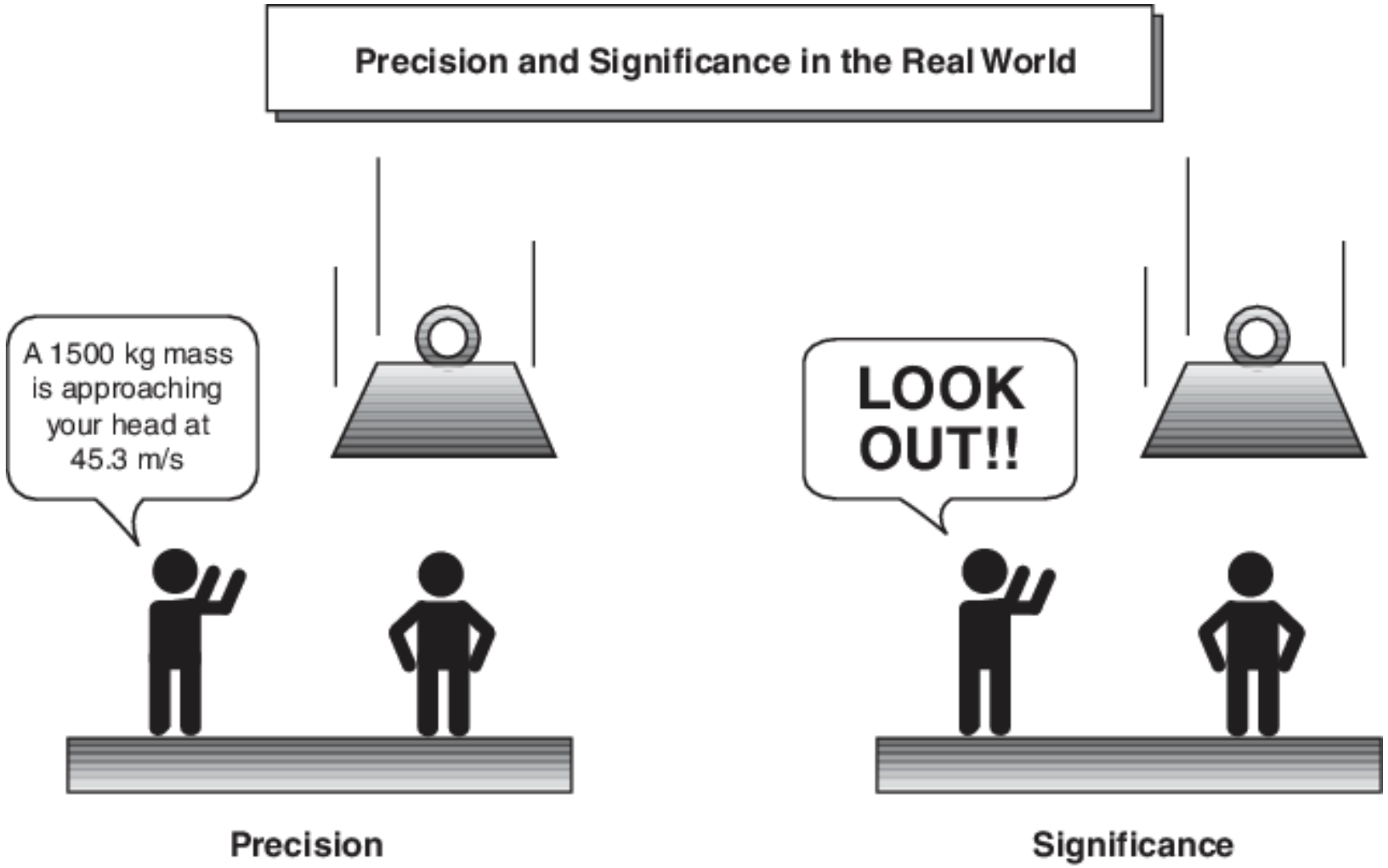
To what degree is something true or false?

Fuzzy Logic

- **Flexible and easy** to implement machine learning technique
- Helps you to **mimic** the logic of **human** thought
- Logic may have **two values** which represent two possible solutions
- Highly suitable method for **uncertain** or **approximate reasoning**
- Fuzzy logic views inference as a process of **propagating elastic constraints**
- Fuzzy logic allows you to build **nonlinear** functions of **arbitrary** complexity.
- Fuzzy logic should be built with the complete **guidance of experts**

Source: https://www.guru99.com/what-is-fuzzy-logic.html#10

Fuzzy Logic


Precision and Significance in the Real World
A 1500 kg mass is approaching your head at 45.3 m/s
LOOK OUT!!
Precision
Significance

Fuzzy Logic Set

Classical Set

Slow

Speed = 0

Fast

Speed = 1

Fuzzy Set

Slowest

[0.0 – 0.25]

Slow

[0.25 – 0.50]

Fast

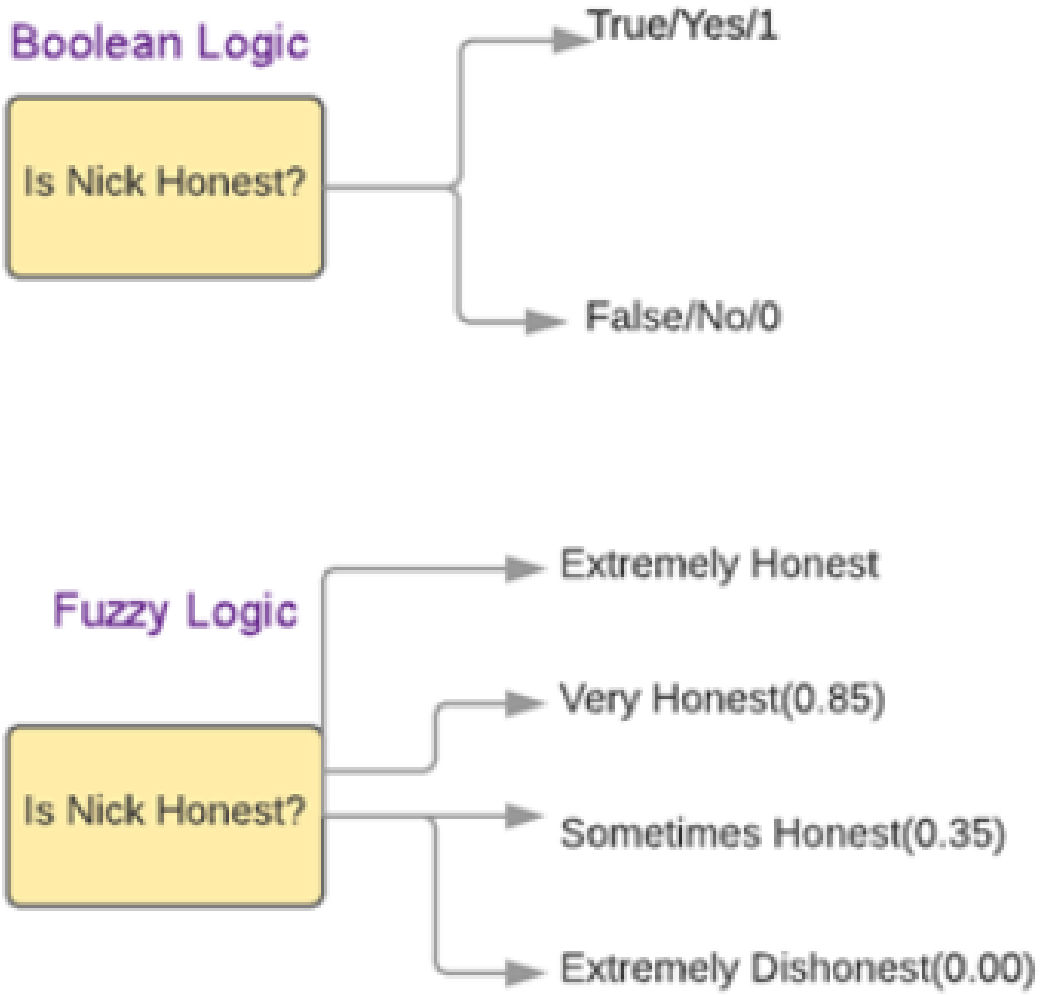
[0.50 – 0.75]

Fastest

[0.75 – 1.00]

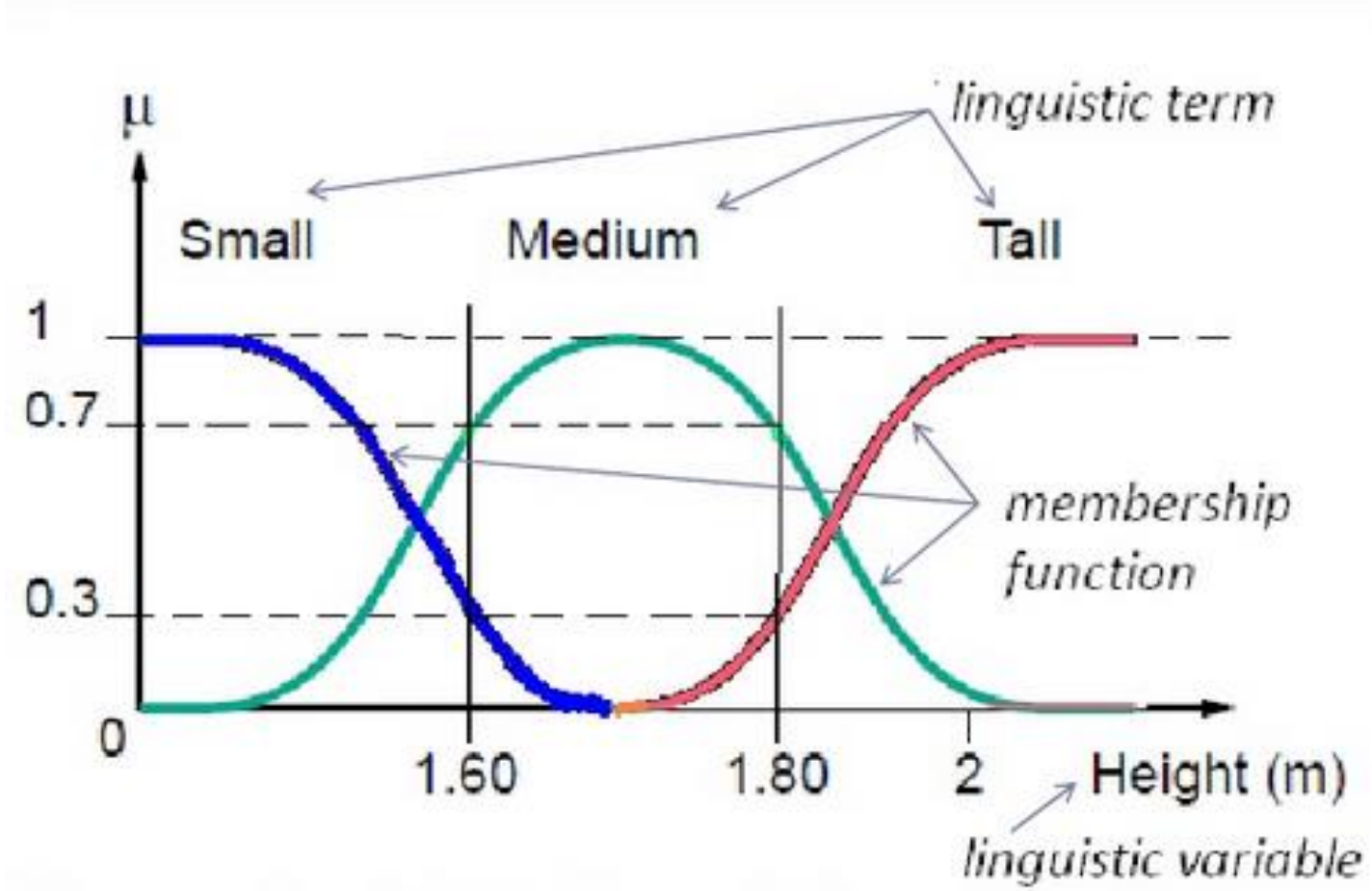
Source: https://www.slideshare.net/todkarmahesh/fuzzylogic

Fuzzy Logic Set



Source: https://www.guru99.com/what-is-fuzzy-logic.html#10

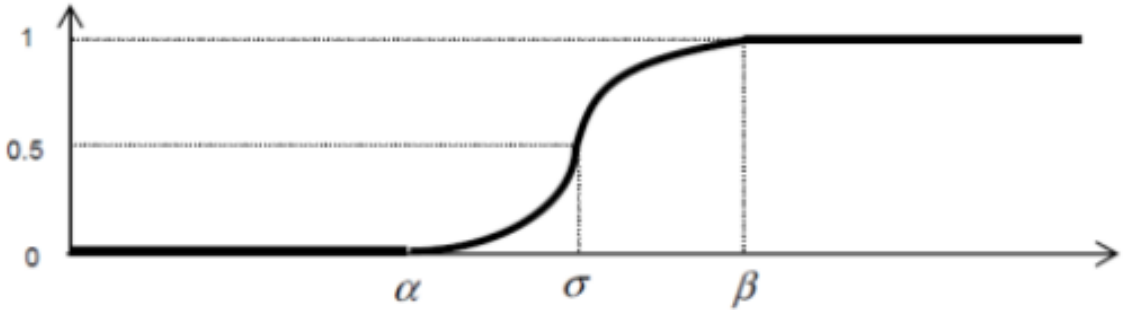
Membership Functions



Source: https://www.slideshare.net/todkarmahesh/fuzzylogic

Membership Functions

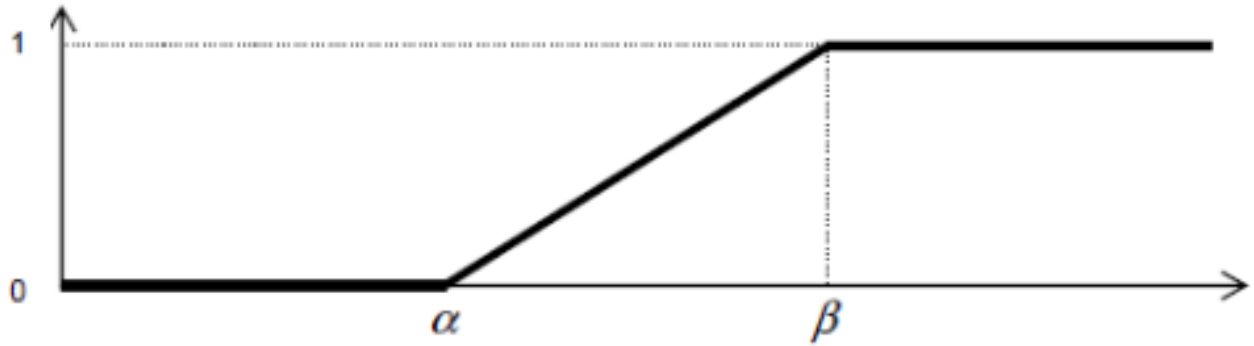
$$S(x,\alpha,\sigma,\beta)=\begin{cases}0 & for\ \ x\le\alpha\\ 2\left(\frac{x-\alpha}{\beta-\alpha}\right)^2 & for\ \ \alpha<x\le\sigma\\ 1-2\left(\frac{x-\beta}{\beta-\alpha}\right)^2 & for\ \ \sigma<x\le\beta\\ 1 & for\ \ x>\beta\end{cases}$$



Source:
https://www.researchgate.net/publication/279916783_Development_of_Intelligent_Traffic_Light_System_Based_On_Congestion_Estimation_Using_Fuzzy_Logic

Membership Functions

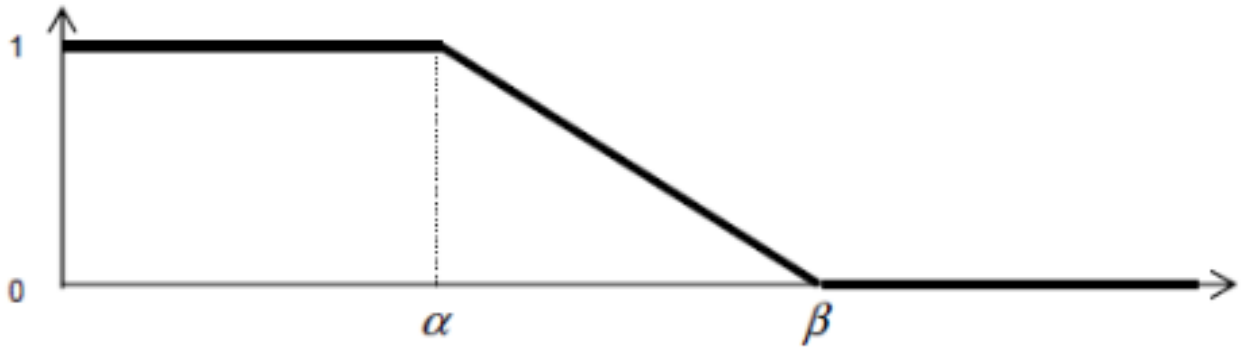
$$\Gamma(x,\alpha,\beta) = \begin{cases} 0 & for \quad x<\alpha \\ \left(\frac{x-\alpha}{\beta-\alpha}\right) & for \quad \alpha \le x \le \beta \\ 1 & for \quad x>\beta \end{cases}$$



Source:
https://www.researchgate.net/publication/279916783_Development_of_Intelligent_Traffic_Light_System_Based_On_Congestion_Estimation_Using_Fuzzy_Logic

Membership Functions

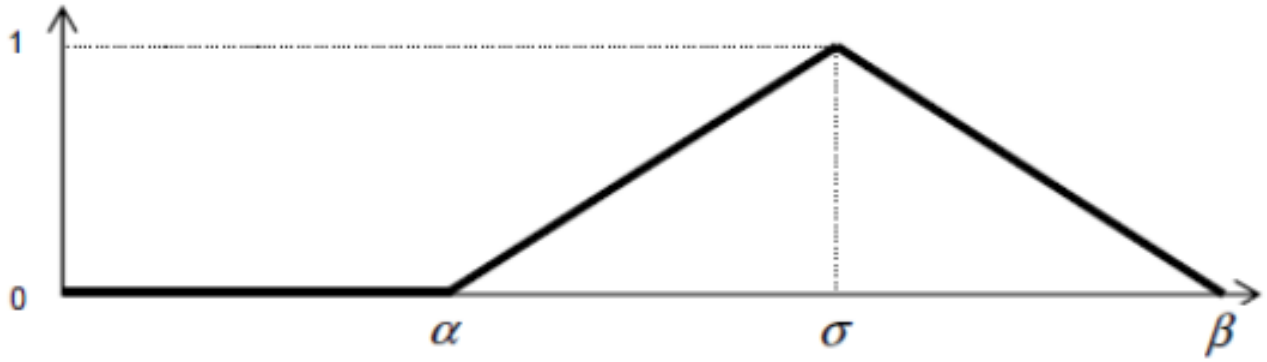
$$L(x,\alpha,\beta)=\begin{cases}1 & for \quad x<\alpha \\ \left(\frac{\beta-x}{\beta-\alpha}\right) & for \quad \alpha\le x\le\beta \\ 0 & for \quad x>\beta\end{cases}$$



Source:
https://www.researchgate.net/publication/279916783_Development_of_Intelligent_Traffic_Light_System_Based_On_Congestion_Estimation_Using_Fuzzy_Logic

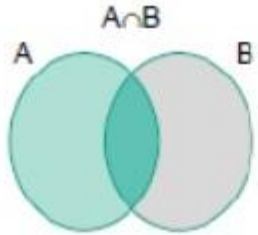
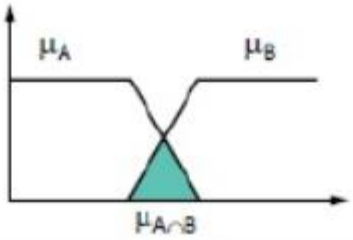
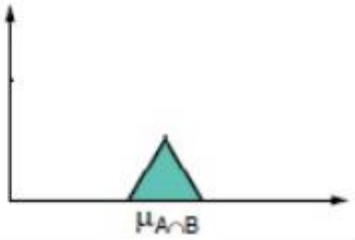
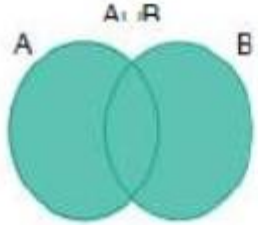
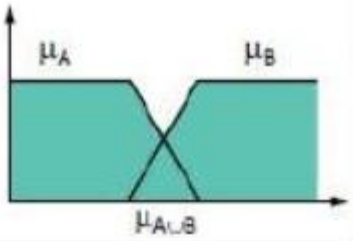
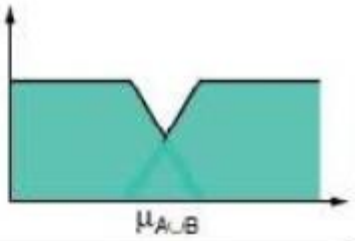
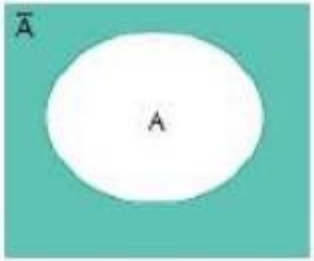
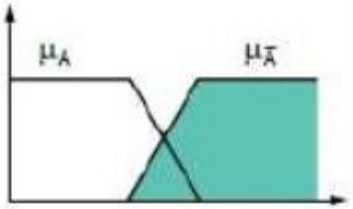
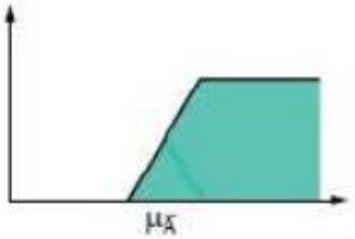
Membership Functions

$$A(x,\alpha,\sigma,\beta)=\begin{cases}0 & for \quad x<\alpha\\ \left(\frac{x-\alpha}{\sigma-\alpha}\right) & for \quad \alpha\le x\le\sigma\\ \left(\frac{\beta-x}{\beta-\sigma}\right) & for \quad \sigma<x\le\beta\\ 0 & for \quad x>\beta\end{cases}$$



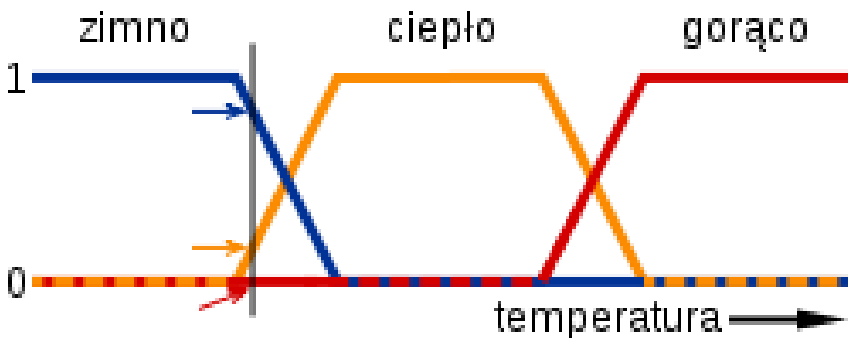
Source:
https://www.researchgate.net/publication/279916783_Development_of_Intelligent_Traffic_Light_System_Based_On_Congestion_Estimation_Using_Fuzzy_Logic

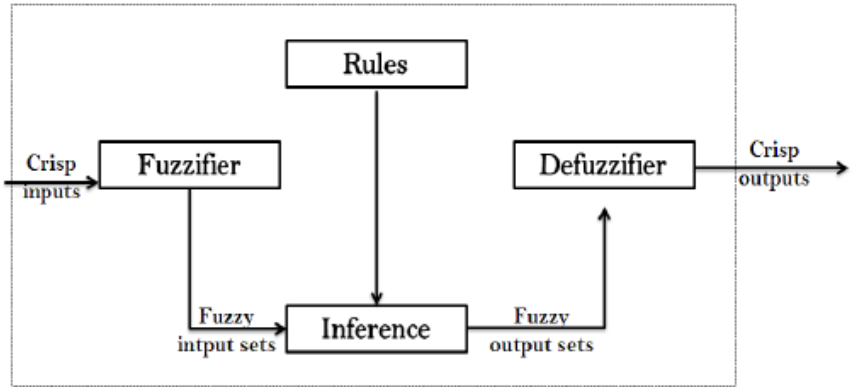
Fuzzy Logic Operation

		ZADEH operator	Logic operation		
Intersection		$\mu_{A\cap B} = MIN(\mu_A, \mu_B)$	AND		
Union		$\mu_{A\cup B} = MAX(\mu_A, \mu_B)$	OR		
Negation		$\mu_{\bar{A}} = 1 - \mu_A$	NOT		

Source: https://www.slideshare.net/todkarmahesh/fuzzylogic

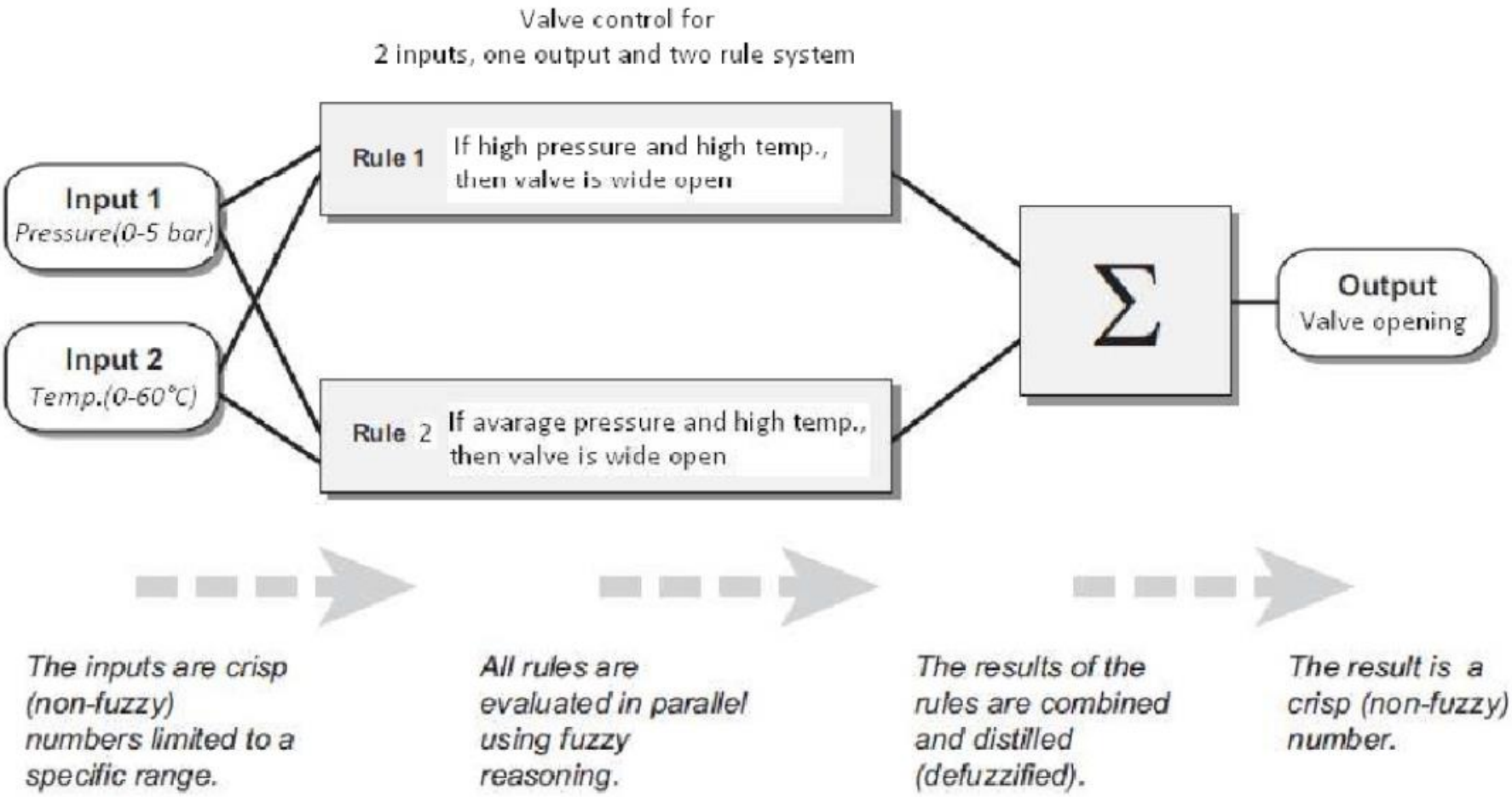
Fuzzy Logic





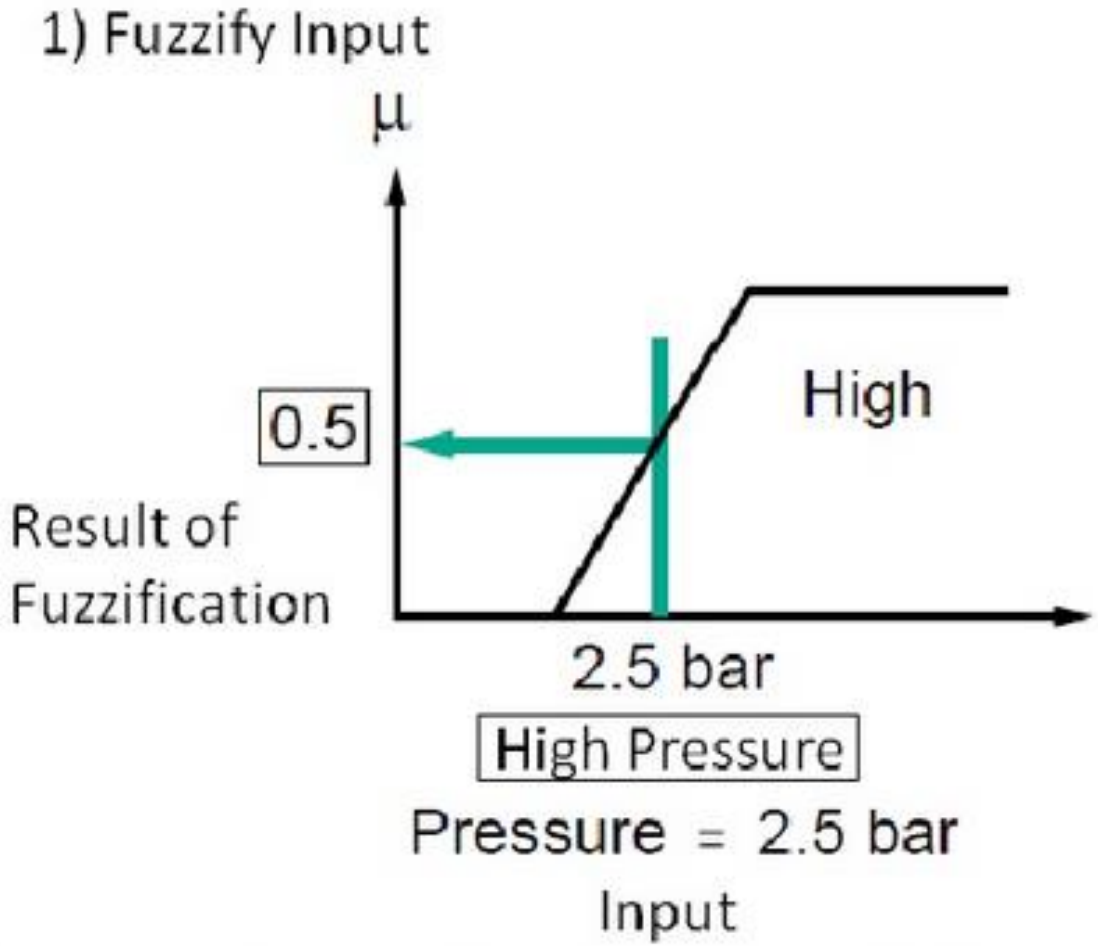

```
IF temperature IS very cold THEN fan_speed is stopped
IF temperature IS cold THEN fan_speed is slow
IF temperature IS warm THEN fan_speed is moderate
IF temperature IS hot THEN fan_speed is high
```

Fuzzy Inference



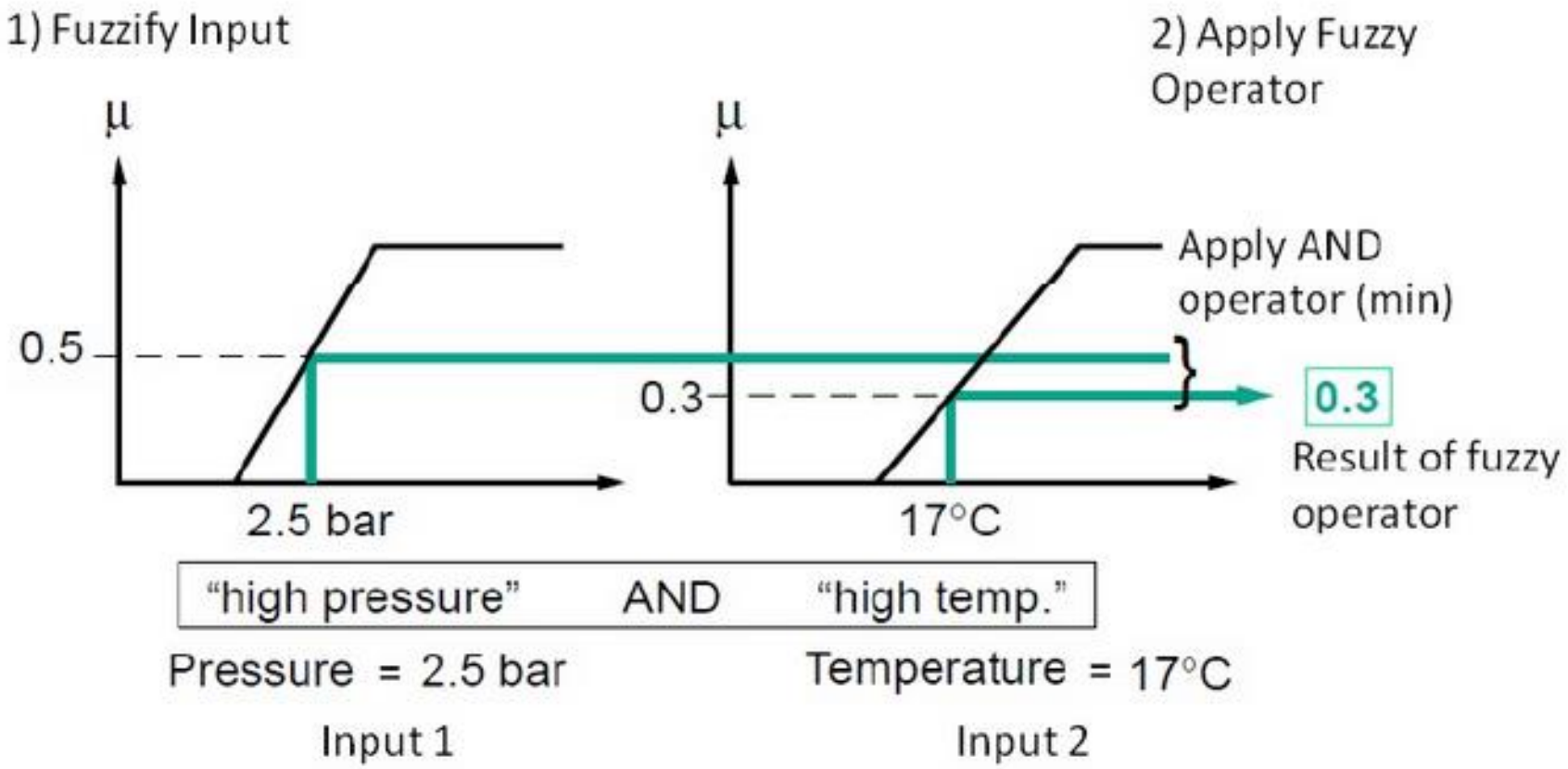
Source: https://www.slideshare.net/todkarmahesh/fuzzylogic

Step 1: Fuzzify Input (Fuzzification)



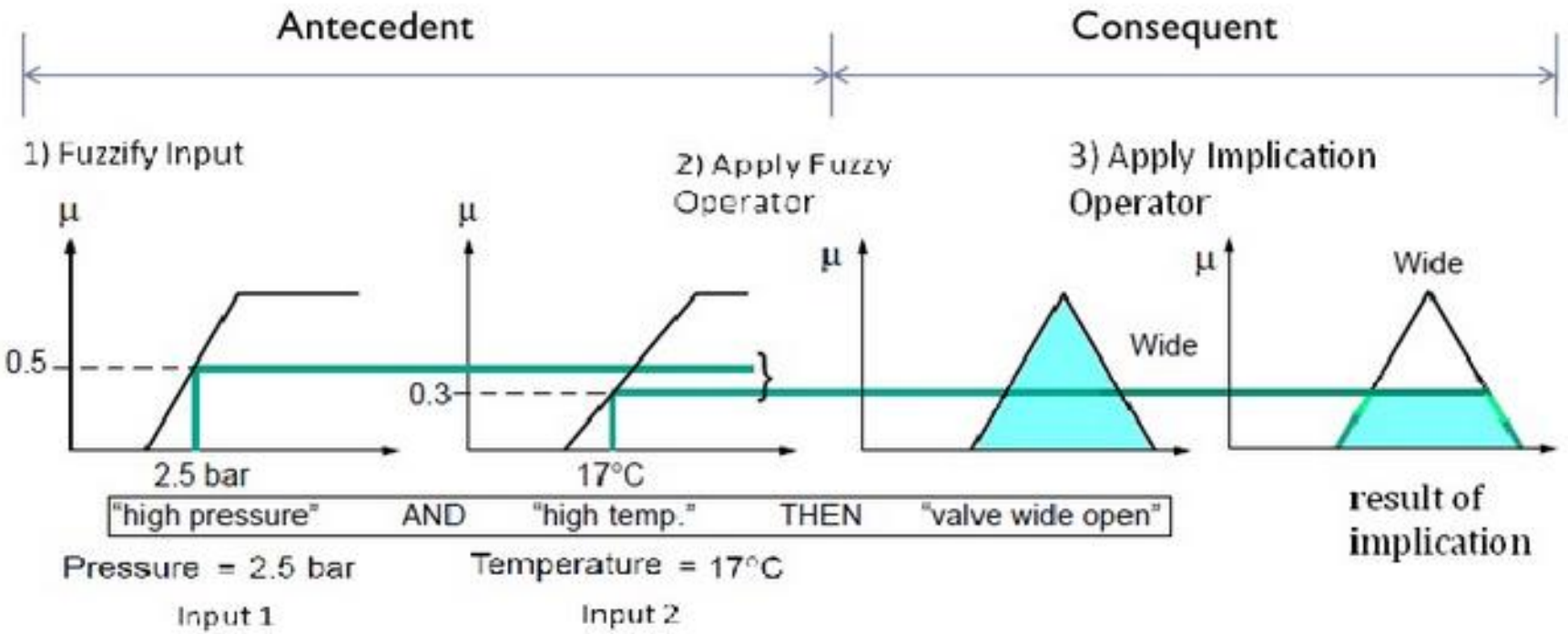
Source: https://www.slideshare.net/todkarmahesh/fuzzylogic

Step 2: Apply Fuzzy Operator



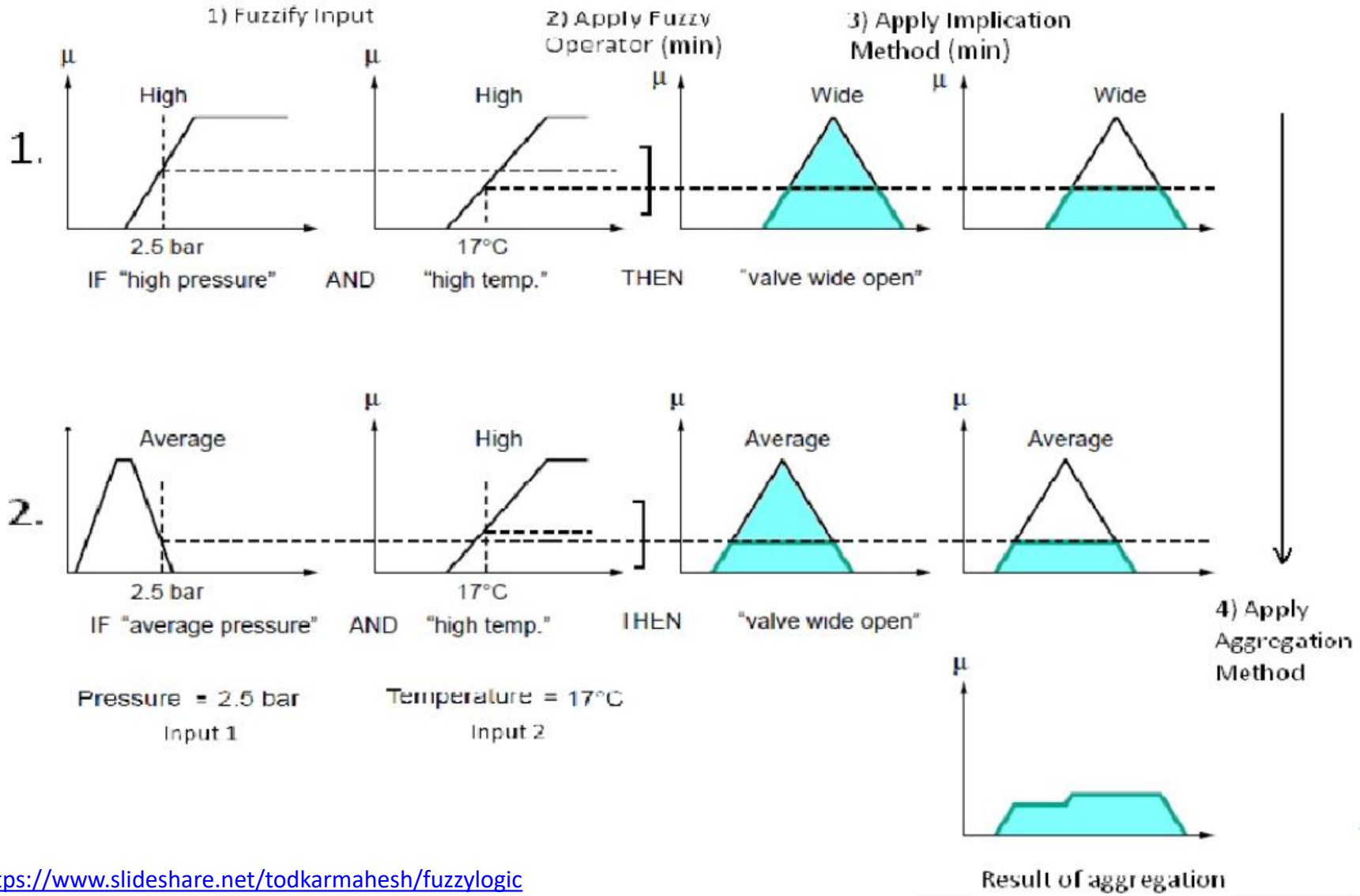
Source: https://www.slideshare.net/todkarmahesh/fuzzylogic

Step 3: Apply Implication Method



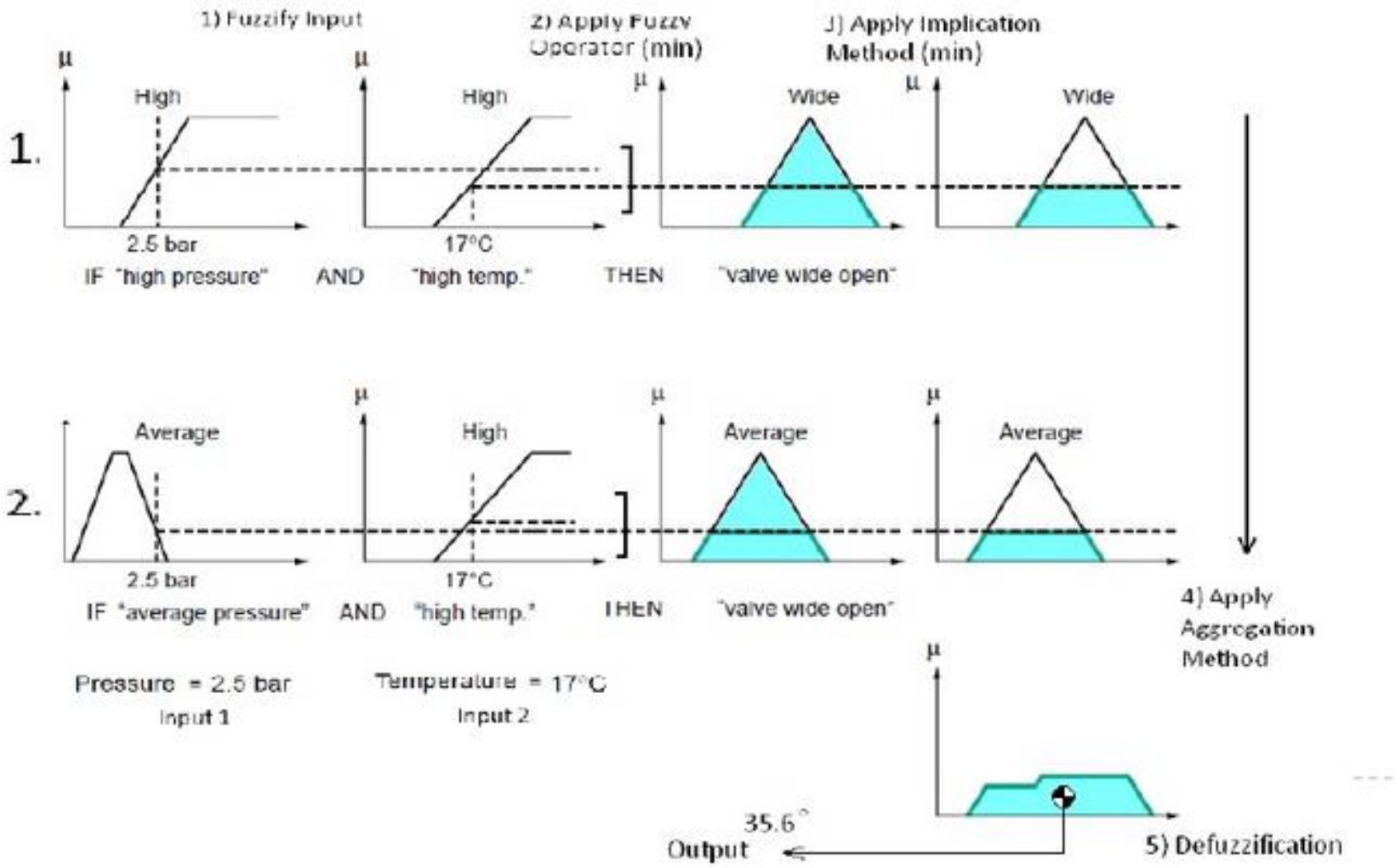
Source: https://www.slideshare.net/todkarmahesh/fuzzylogic

Step 4: Aggregate All Outputs



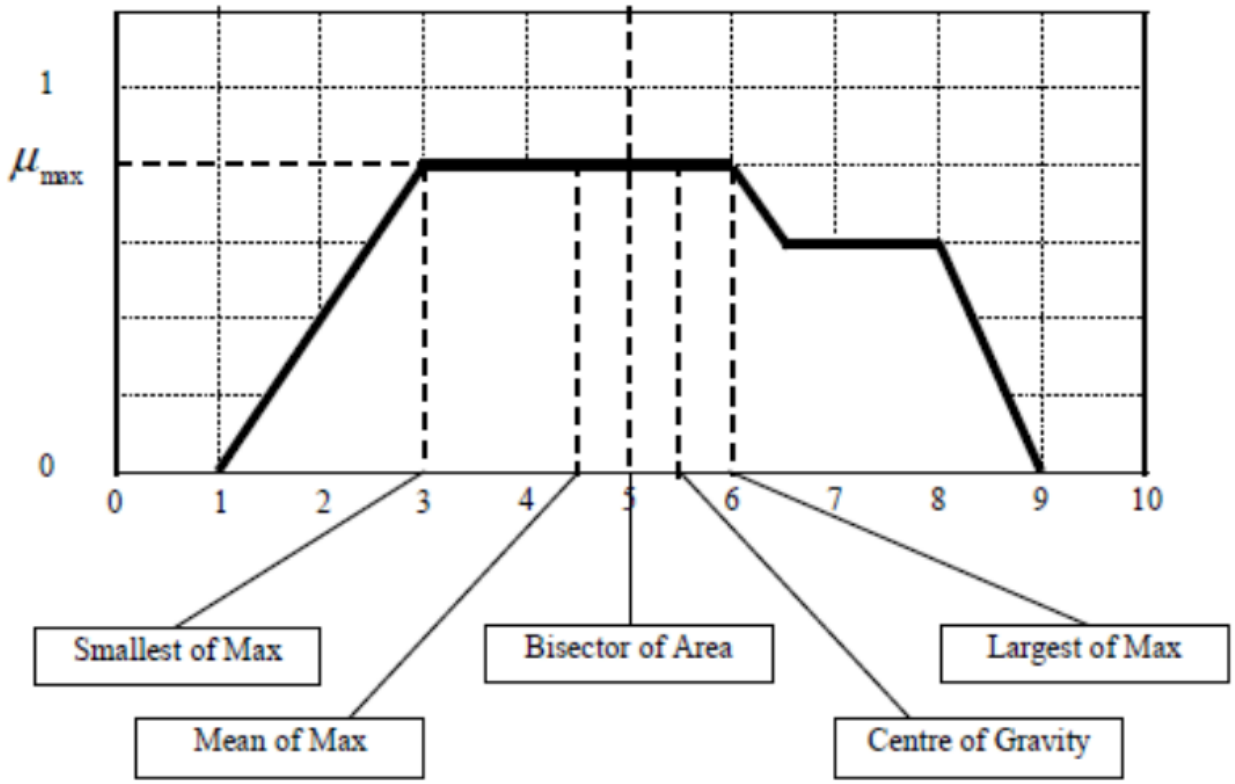
Source: https://www.slideshare.net/todkarmahesh/fuzzylogic

Fuzzy Inference



Source: https://www.slideshare.net/todkarmahesh/fuzzylogic

Defuzzification method



Source:
https://www.researchgate.net/publication/279916783_Development_of_Intelligent_Traffic_Light_System_Based_On_Congestion_Estimation_Using_Fuzzy_Logic

Fuzzy Logic Example

At Restaurants	
Wait staff	15% - 20% of the total bill before taxes (Note: some restaurants now suggest tipping after taxes because servers thenselves tip out on the after tax amount).
Wine served with dinner	The safe recommendation is to tip 15-20% of the total bill, including alcohol, even for expensive bottles of wine. However, we've seen some restaurants say it's OK to tip around 10% for expensive wines.
Bartenders	15% - 20% of the tab; or, $1 for beer or wine, $2 for mixed drinks. Ideally, pay your bar tab before leaving for your table.
Order at front	If you order at the front and food is delivered to your table, it depends. If, once you've ordered, the seating and decor compare with a standard, sit-down restaurant, tip 5%-10%. If the food is delivered to your table only as a convenience, tipping is not necessary.

At Cafes	
Tip jar	Optional. Leave 5%-10% for good service or complicated orders, especially if the staff is hired and is more dependent on tips.

At Fine Dining	
Parking Attendant	Usually $1-$3
Coatroom Attendant	Usually $1 per coat
Wait staff	15%-20% of the pre-tax bill (Note: some restaurants now suggest tipping after taxes because servers thenselves tip out on the after tax amount).
Wine steward or sommelier	For personal service from the wine steward, you may tip 10% of the wine bill.
Restroom Attendant	Usually .50-$1

Other (including delivery)	
Pizza Delivery	At least $1, 15% for normal service, more during rain, snow or other poor weather.

Source: http://www.itipping.com/tip-guide-restaurant.htm

Fuzzy Logic Example

Antecednets (Inputs)

- **Service**

  Universe (ie, crisp value range) How good was the service of the waitress, on a scale of 1 to 10?

  Fuzzy set (ie, fuzzy value range): poor, acceptable, amazing

- **Food quality**

  Universe: How tasty was the food, on a scale of 1 to 10?

  Fuzzy set: bad, decent, great

Source: https://pythonhosted.org/scikit-fuzzy/userguide/fuzzy_control_primer.html

Fuzzy Logic Example

- **Consequents (Outputs)**
  - tip
    - Universe: How much should we tip, on a scale of 0% to 25%
    - Fuzzy set: low, medium, high

- **Rules**
  - IF the service was good or the food quality was good, THEN the tip will be high.
  - IF the service was average, THEN the tip will be medium.
  - IF the service was poor and the food quality was poor THEN the tip will be low.

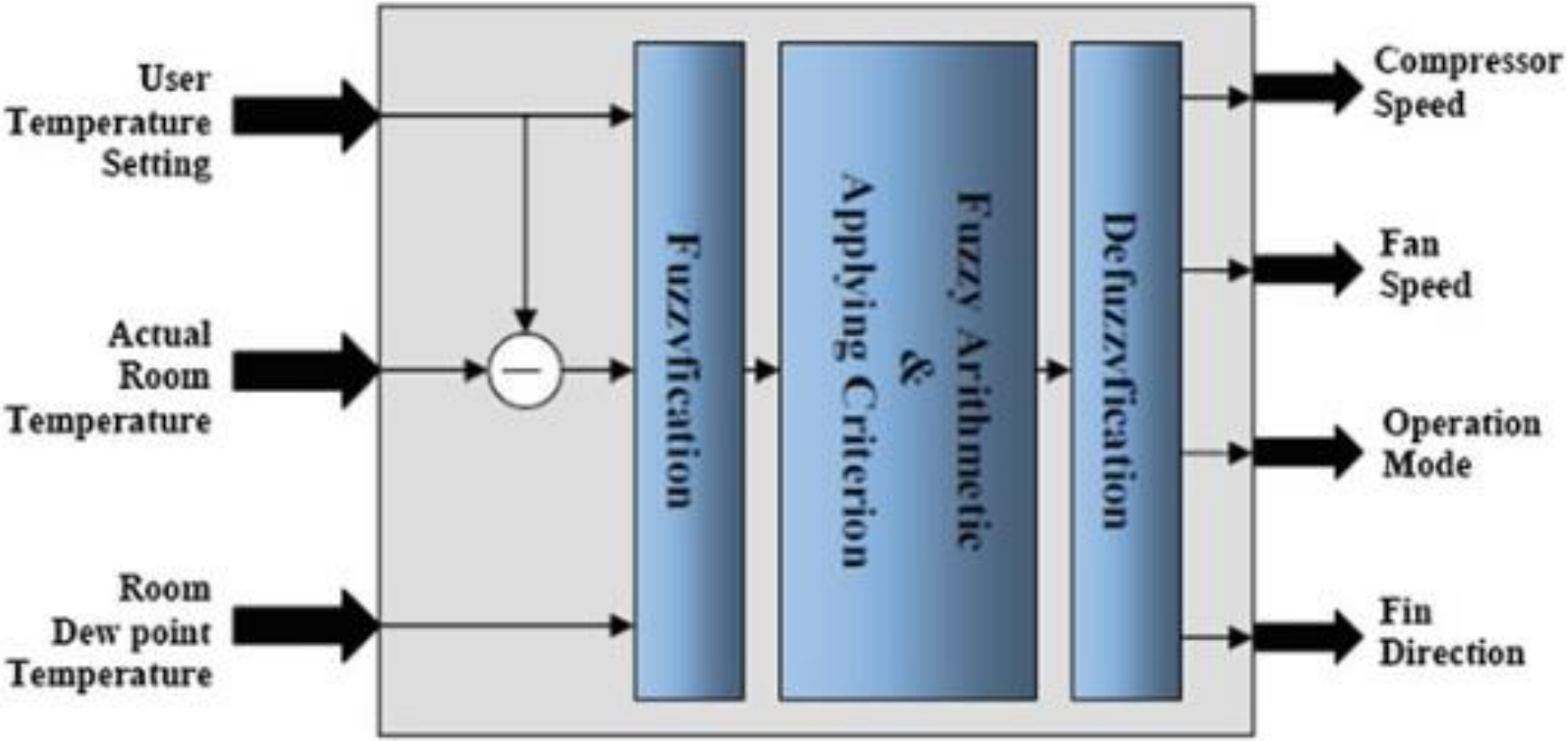
- **Usage**

If I tell this controller that I rated:
the service as 9.8, and the quality as 6.5,

it would recommend I leave:
a 20.2% tip.

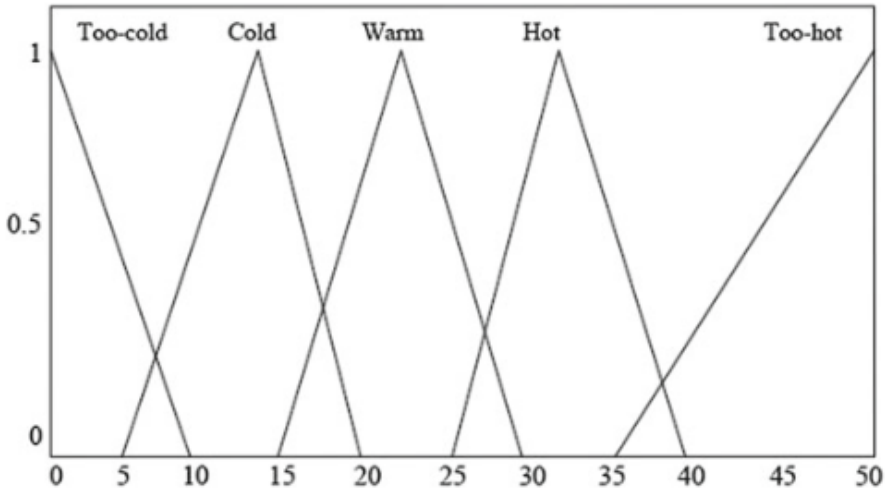
Source: https://pythonhosted.org/scikit-fuzzy/userguide/fuzzy_control_primer.html

Air Conditioning System with Fuzzy Logic

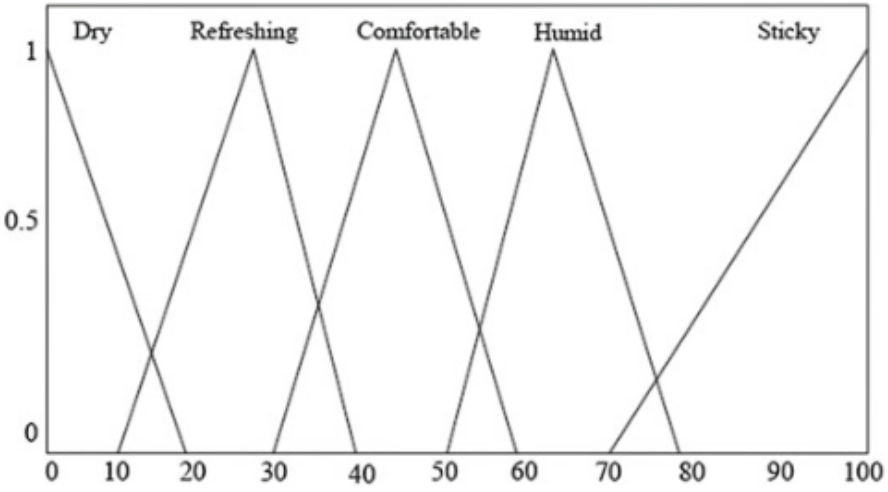


Source: https://www.researchgate.net/publication/236157468_Air_Conditioning_System_with_Fuzzy_Logic_and_Neuro-Fuzzy_Algorithm

Air Conditioning System with Fuzzy Logic



Temperature membership functions



Humidity membership functions

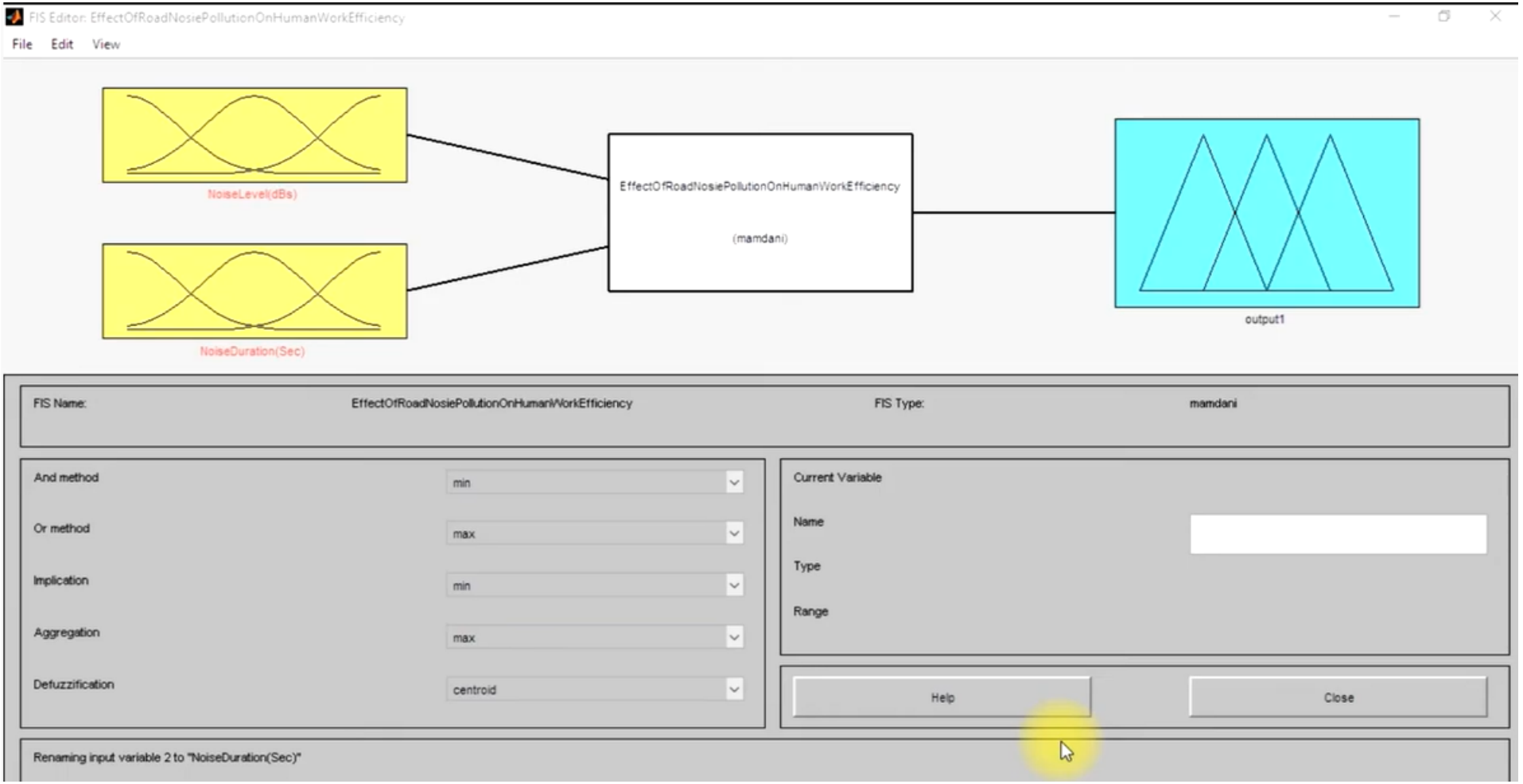
Source: https://www.guru99.com/what-is-fuzzy-logic.html#10

Air Conditioning System with Fuzzy Logic

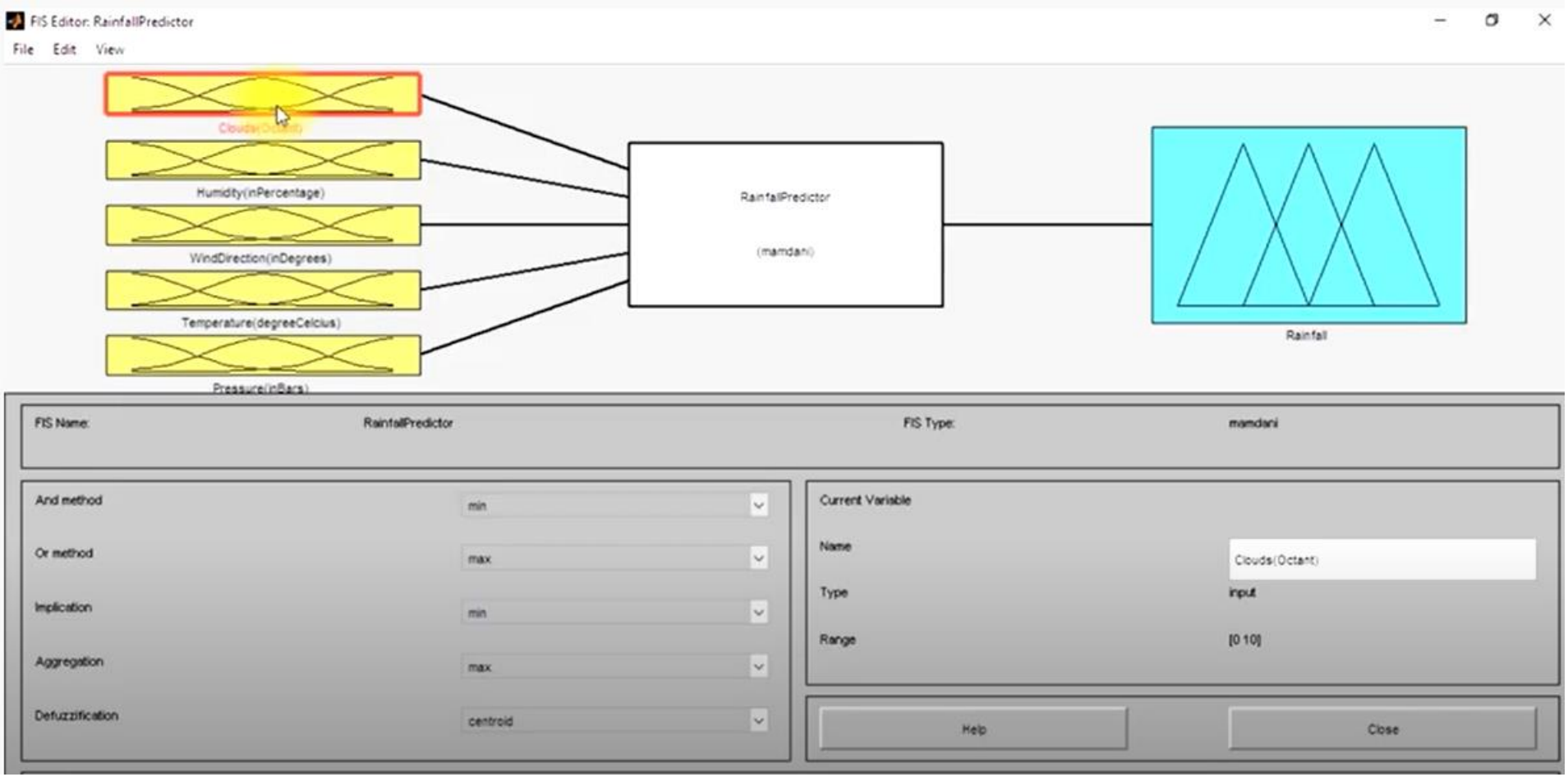
Rules	Input		Output			
	Temperature	Humidity	Compressor speed	Fin direction	Fan speed	Operation mode
1	Too cold	Dry	Off	Away	Off	AC
2	Too cold	Refreshing	Off	Away	Off	AC
3	Too cold	Comfortable	Off	Away	Off	AC
4	Too cold	Humid	Off	Away	Very low	AC
5	Too cold	Sticky	Very low	Towards	Low	Dehumidifier
6	Cold	Dry	Off	Away	Off	AC
7	Cold	Refreshing	Off	Away	Off	AC
8	Cold	Comfortable	Very low	Away	Very low	AC
9	Cold	Humid	Very low	Towards	Low	AC
10	Cold	Sticky	Low	Towards	Low	Dehumidifier
11	Warm	Dry	Very low	Away	Very low	AC
12	Warm	Refreshing	Very low	Away	Very low	AC
13	Warm	Comfortable	Low	Away	Low	AC
14	Warm	Humid	Medium	Towards	Medium	Dehumidifier
15	Warm	Sticky	Medium	Towards	Medium	Dehumidifier
16	Hot	Dry	Low	Away	Low	AC
17	Hot	Refreshing	Medium	Away	Medium	AC
18	Hot	Comfortable	Medium	Towards	Medium	AC
19	Hot	Humid	Fast	Towards	Fast	Dehumidifier
20	Hot	Sticky	Fast	Towards	Fast	Dehumidifier
21	Too hot	Dry	Medium	Away	Medium	AC
22	Too hot	Refreshing	Medium	Towards	Medium	AC
23	Too hot	Comfortable	Fast	Towards	Fast	Dehumidifier
24	Too hot	Humid	Fast	Towards	Fast	Dehumidifier
25	Too hot	Sticky	Fast	Towards	Fast	Dehumidifier

Source: https://www.guru99.com/what-is-fuzzy-logic.html#10

Road Noise Pollution Estimation

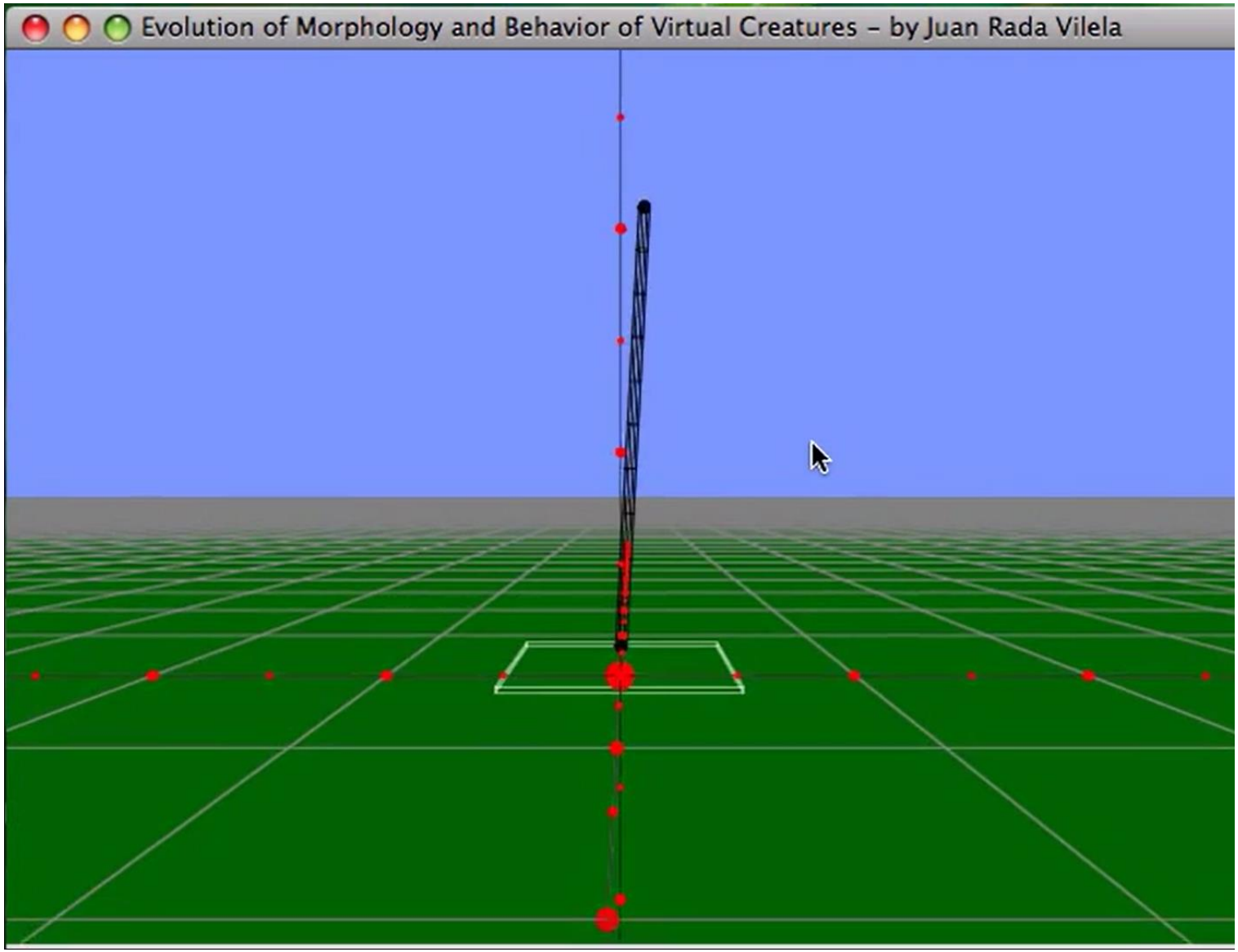


Rainfall prediction



Source: https://www.youtube.com/watch?v=h-PekWwPR-k

Fuzzy Logic Controller of 3D Pole Balancing



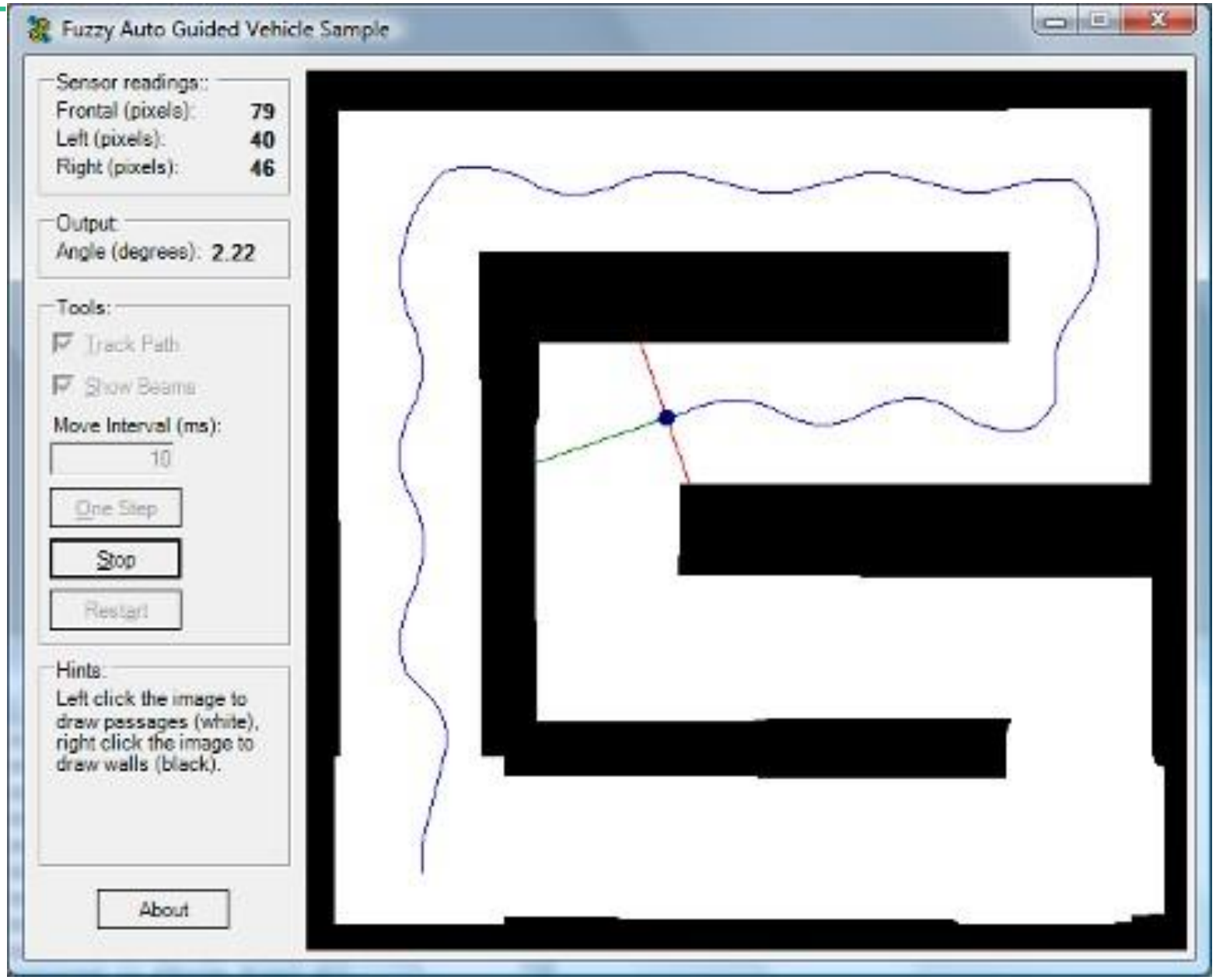
Source: http://www.fuzzylite.com/

Fuzzy Logic Example

Fuzzy Logic 4-Stage Inverted Pendulum

Source: https://www.youtube.com/watch?v=zoWsFyhRnE8

Fuzzy Logic Demo



Source: http://www.aforgenet.com/framework/samples/fuzzy_sets.html

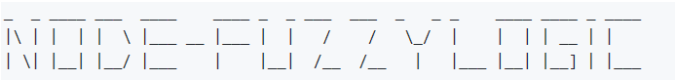
Fuzzy Logic Example Library

Python
https://github.com/scikit-fuzzy/scikit-fuzzy

Java
http://jfuzzylogic.sourceforge.net/html/fcl.html

jFuzzyLogic

JavaScript:
https://github.com/sebs/node-fuzzylogic



C++
https://fuzzylite.com/cpp/

C#
http://www.aforgenet.com/framework/samples/fuzzy_sets.html

AForge.NET
FRAMEWORK

Advantages of Fuzzy Logic System

- The structure of Fuzzy Logic Systems is **easy** and **understandable**
- Fuzzy logic **is widely used** for commercial and practical purposes
- It helps you to **control machines** and consumer products
- It may not offer **accurate reasoning**, but the only **acceptable reasoning**
- It helps you to deal with the **uncertainty** in engineering
- Mostly **robust** as **no precise inputs required**
- It can be programmed to in the situation when **feedback sensor stops working**
- It can easily be **modified** to improve or **alter** system performance
- **Inexpensive sensors** can be used which helps you to keep the overall system cost and complexity low
- It provides a most effective solution to **complex issues**

Source: https://www.guru99.com/what-is-fuzzy-logic.html#10

Advantages of Fuzzy Logic System

- Fuzzy logic **is not always accurate**, so he results are perceived based on assumption, so it may not be widely accepted.
- Fuzzy systems **don't have the capability of machine learning** as-well-as neural network **type pattern recognition**
- **Validation and verification** of a fuzzy knowledge-based system needs extensive testing with hardware
- Setting exact, fuzzy rules and, membership functions is a **difficult task**
- Some fuzzy time logic is **confused with probability theory** and the terms

Source: https://www.guru99.com/what-is-fuzzy-logic.html#10

Reading materials

- https://web.archive.org/web/20061205114153/http://blog.peltarion.com/2006/10/25/fuzzy-math-part-1-the-theory
- https://www.researchgate.net/publication/278031775_The_Basics_of_Fuzzy_Logic_A_Tutorial_Review
- https://www.researchgate.net/publication/236157468_Air_Conditioning_System_with_Fuzzy_Logic_and_Neuro-Fuzzy_Algorithm