FUZZY LOGIC

Aditya Raj	11BIT0155
Afzal Ahmad	11BIT0038
Arun Ravindran	11BIT0035

OVERVIEW

- What is Fuzzy Logic?
- Where did it begin?
- Fuzzy Logic vs. Neural Networks
- Fuzzy Logic in Control Systems
- Fuzzy Logic in Other Fields

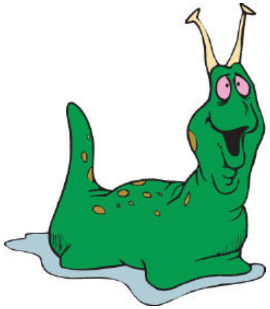
WHAT IS FUZZY LOGIC?

Definition of fuzzy

- A way to represent variation or imprecision in logic
- A way to make use of natural language in logic
- Approximate reasoning

- Humans say things like "If it is sunny and warm today, I will drive fast"

TRADITIONAL REPRESENTATION OF LOGIC



Slow

Fast

Speed = 0

Speed = 1

```
bool speed;
get the speed
if ( speed == 0) {
       //  speed is slow
}
else {
       //  speed is fast
}
```

FUZZY LOGIC REPRESENTATION

- For every problem must represent in terms of fuzzy sets.

- What are fuzzy sets?

Slowest

[0.0 – 0.25]

Slow

[0.25 – 0.50]

Fast

[0.50 – 0.75]

Fastest

[0.75 – 1.00]

FUZZY LOGIC REPRESENTATION

Slowest Slow Fast Fastest

```
float speed;
get the speed
if ((speed >= 0.0)&&(speed < 0.25)) {
        //  speed is slowest
}
else if ((speed >= 0.25)&&(speed < 0.5))
{
        //  speed is slow
}
else if ((speed >= 0.5)&&(speed < 0.75))
{
        //  speed is fast
}
else // speed >= 0.75 && speed < 1.0
{
        //  speed is fastest
}
```

ORIGINS OF FUZZY LOGIC

- Traces back to Ancient Greece
- Lotfi Asker Zadeh (1965)
  - First to publish ideas of fuzzy logic.
- Professor Toshire Terano (1972)
  - Organized the world's first working group on fuzzy systems.
- F.L. Smidth & Co. (1980)
  - First to market fuzzy expert systems.

FUZZY LOGIC VS. NEURAL NETWORKS

- How does a Neural Network work?
- Both model the human brain.
  - Fuzzy Logic
  - Neural Networks
- Both used to create behavioral systems.

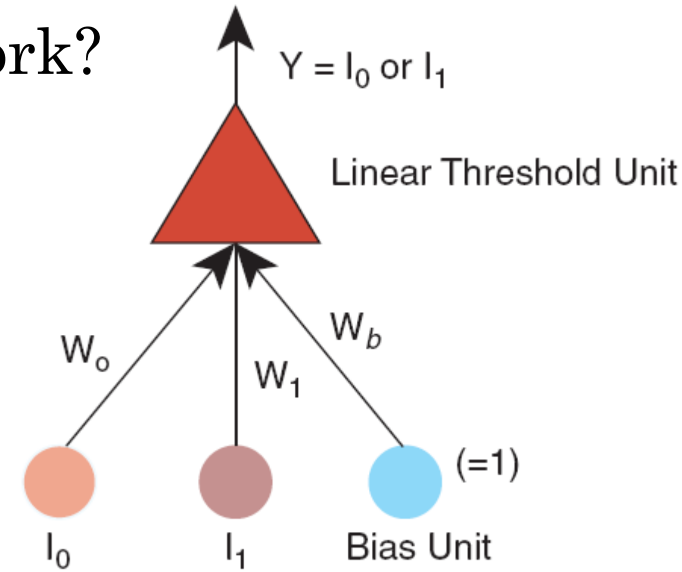


Fig. 2 A simple, single-unit adaptive network

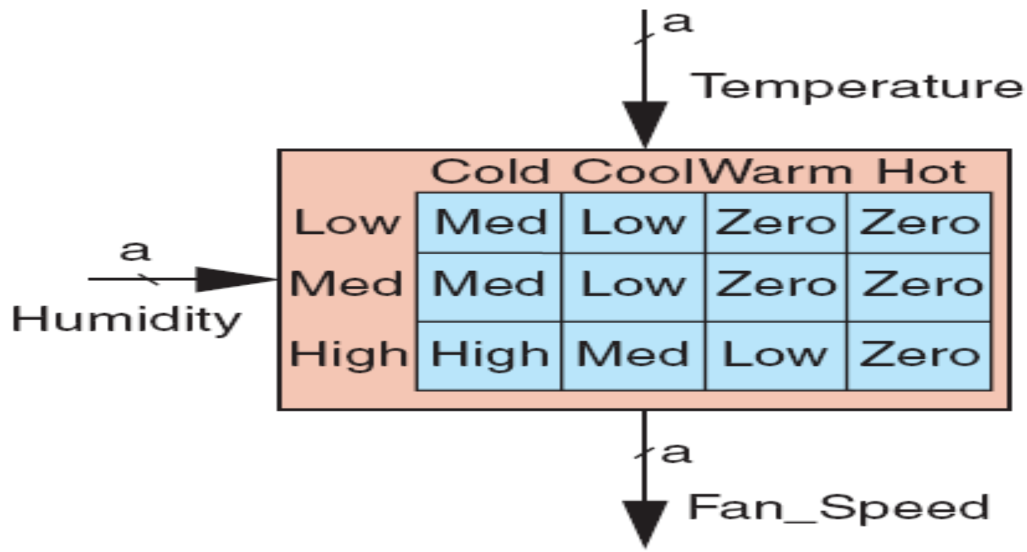
FUZZY LOGIC IN CONTROL SYSTEMS

- Fuzzy Logic provides a more efficient and resourceful way to solve Control Systems.

TEMPERATURE CONTROLLER

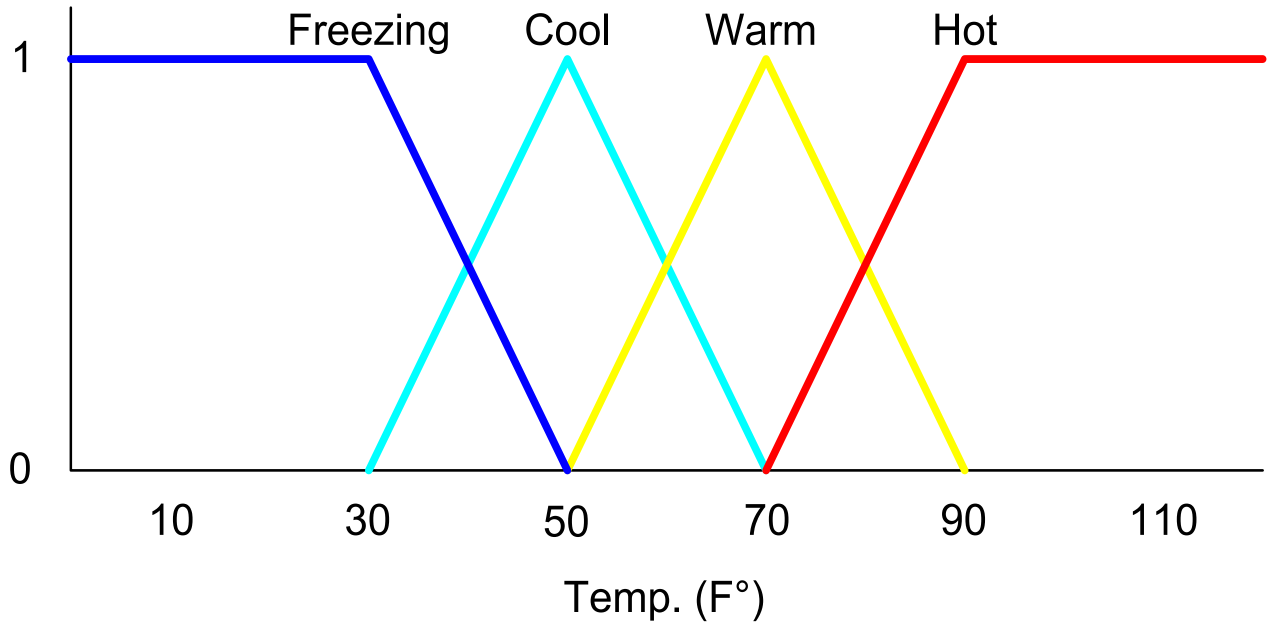
- The problem
  - Change the speed of a heater fan, based off the room temperature and humidity.
- A temperature control system has four settings
  - Cold, Cool, Warm, and Hot
- Humidity can be defined by:
  - Low, Medium, and High

.



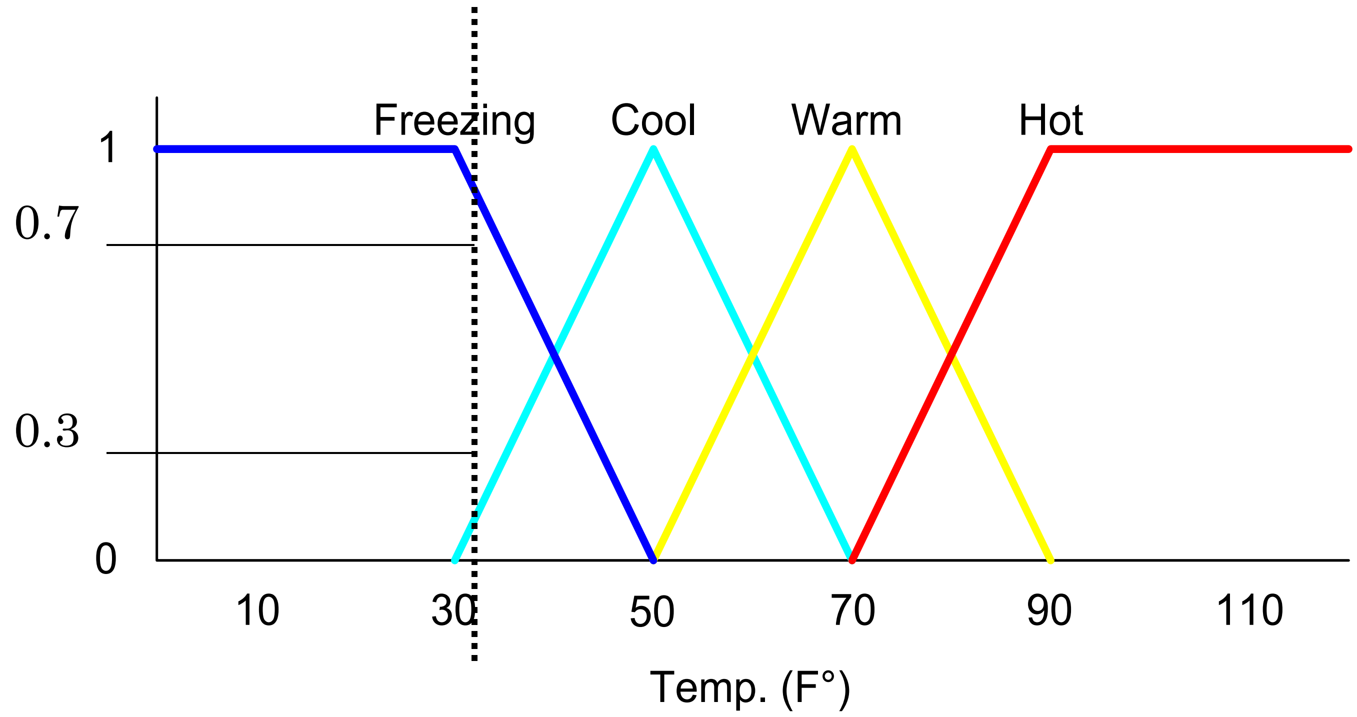
Membership Functions

- Temp: {Freezing, Cool, Warm, Hot}
- Degree of Truth or "Membership"



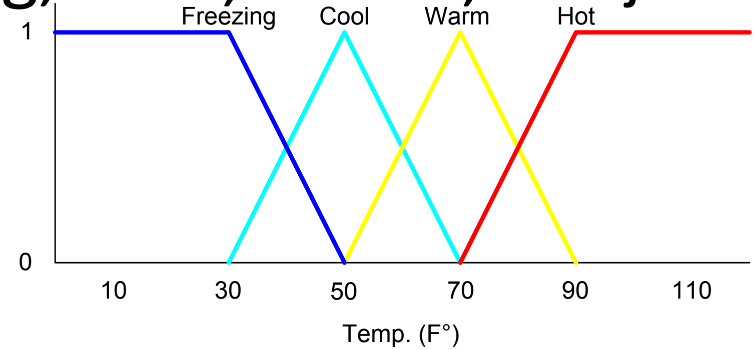
Membership Functions

- How cool is 36 F° ?
- It is 30% Cool and 70% Freezing

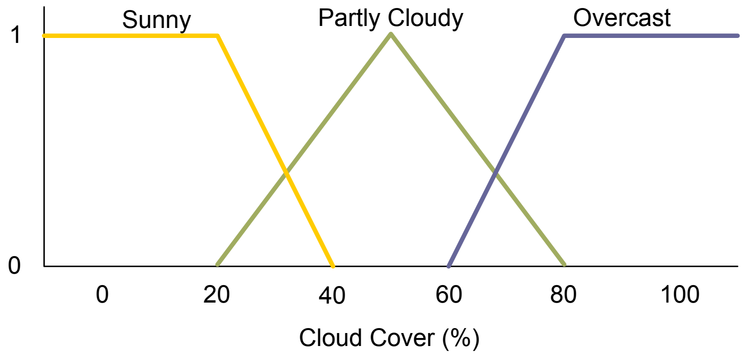


Inputs: Temperature, Cloud Cover

- Temp: {Freezing, Cool, Warm, Hot}



- Cover: {Sunny, Partly, Overcast}



Example Speed Calculation

- How fast will I go if it is
  - 65 F°
  - 25 % Cloud Cover ?

Rules

- If it's Sunny and Warm, drive Fast

  $\text{Sunny(Cover)} \wedge \text{Warm(Temp)} \Rightarrow \text{Fast(Speed)}$

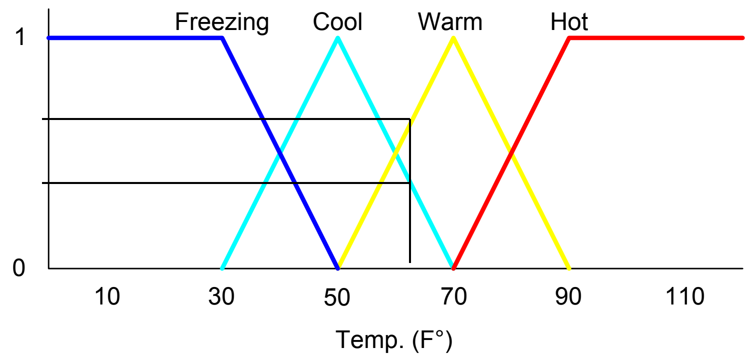
- If it's Cloudy and Cool, drive Slow

  $\text{Cloudy(Cover)} \wedge \text{Cool(Temp)} \Rightarrow \text{Slow(Speed)}$

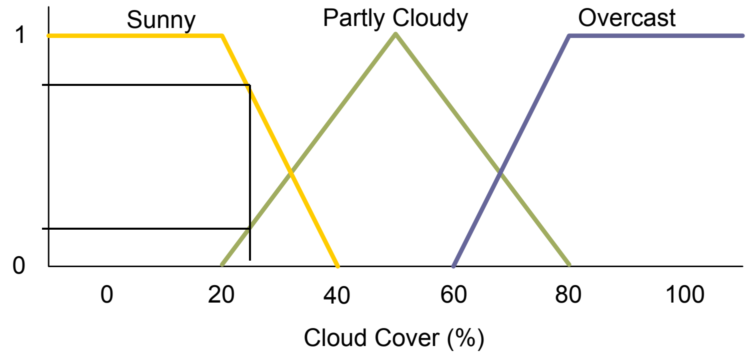
- Driving Speed is the combination of output of these rules...

Fuzzification: Calculate Input Membership Levels

- 65 F° ⇒ Cool = 0.4, Warm= 0.7



- 25% Cover ⇒Sunny = 0.8, Cloudy = 0.2



...Calculating...

- If it's Sunny and Warm, drive Fast

  $Sunny(Cover) \wedge Warm(Temp) \Rightarrow Fast(Speed)$

  $0.8 \wedge 0.7 = 0.7$

  $\Rightarrow$ **Fast = 0.7**

- If it's Cloudy and Cool, drive Slow

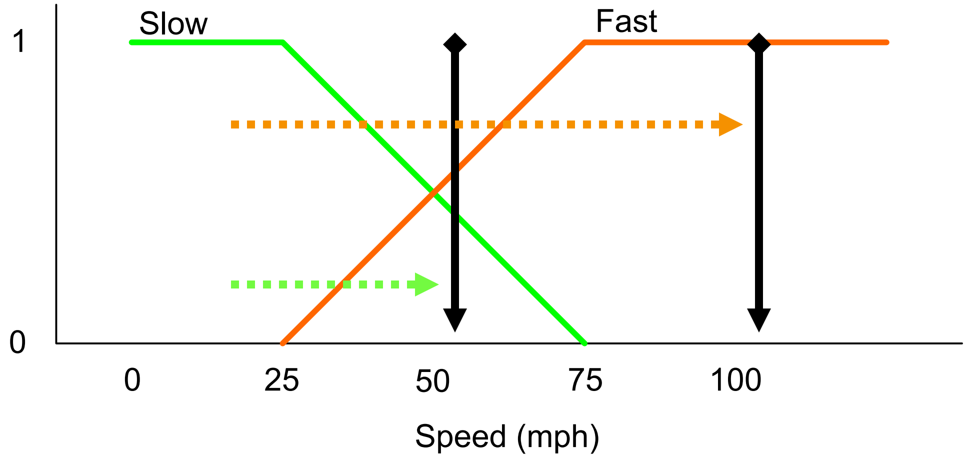
  $Cloudy(Cover) \wedge Cool(Temp) \Rightarrow Slow(Speed)$

  $0.2 \wedge 0.4 = 0.2$

  $\Rightarrow$ **Slow = 0.2**

Defuzzification: Constructing the Output

- Speed is 20% Slow and 70% Fast



- Speed = weighted mean

  = (2*25+7*75)/(9)

  = 63.8 mph

Similarity Degree

- A = B if and only if that every element of the union A ∪ B also belongs to the intersection A ∩ B.

- So, it is reasonable to define the degree of similarity as d=(A, B) =P(A ∩ B)/P(A ∪ B).

- The smaller the ratio, the more there are elements from one of the sets which do not belong to the other.

- So, the sets A and B are equal if, d=1. and P(A ∩ B)/P(A ∪ B) =

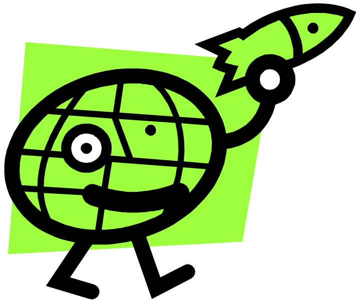
$$\frac{c \cdot \sum_{x} \mu_{A \cap B}(x)}{c \cdot \sum_{x} \mu_{A \cup B}(x)} = \frac{\sum_{i=1}^{n} \min(a_i, b_i)}{\sum_{i=1}^{n} \max(a_i, b_i)}$$

Intuitionistic Triangular Fuzzy Number

- *Let* A={(x , t(x), s(x))/x∈X} be an IFS, then **(**t(x), s(x)**)** be an intuitionistic number for better understanding we take no. such as , A={(a,b,c)(l,m,n)} where (a,b,c) ∈F(I) and (l,n,m) ∈F(I)

For two intuitionistic fuzzy path length :

- L1 = ((a1,b1, c1) (l1,m1,n1)) *and* L2 = ((a2, b2, c2) (l2,m2,n2)),
- For membership function Lmin = (a b c)
  - a = min(a1,a2)
- b= {
  min(b1,b2) if min(b1,b2)<=max(a1,a2);
  (b1*b2)-(a1*a2)/(b1+b2)-(a1+a2)
  if min(b1,b2)>max(a1,a2);
  }
- c = min[min(c1, c2),max(b1, b2)]



For non membership function

- Lmax = (l m n)

- l = min(l1,l2)

- m={ min(m1,m2)

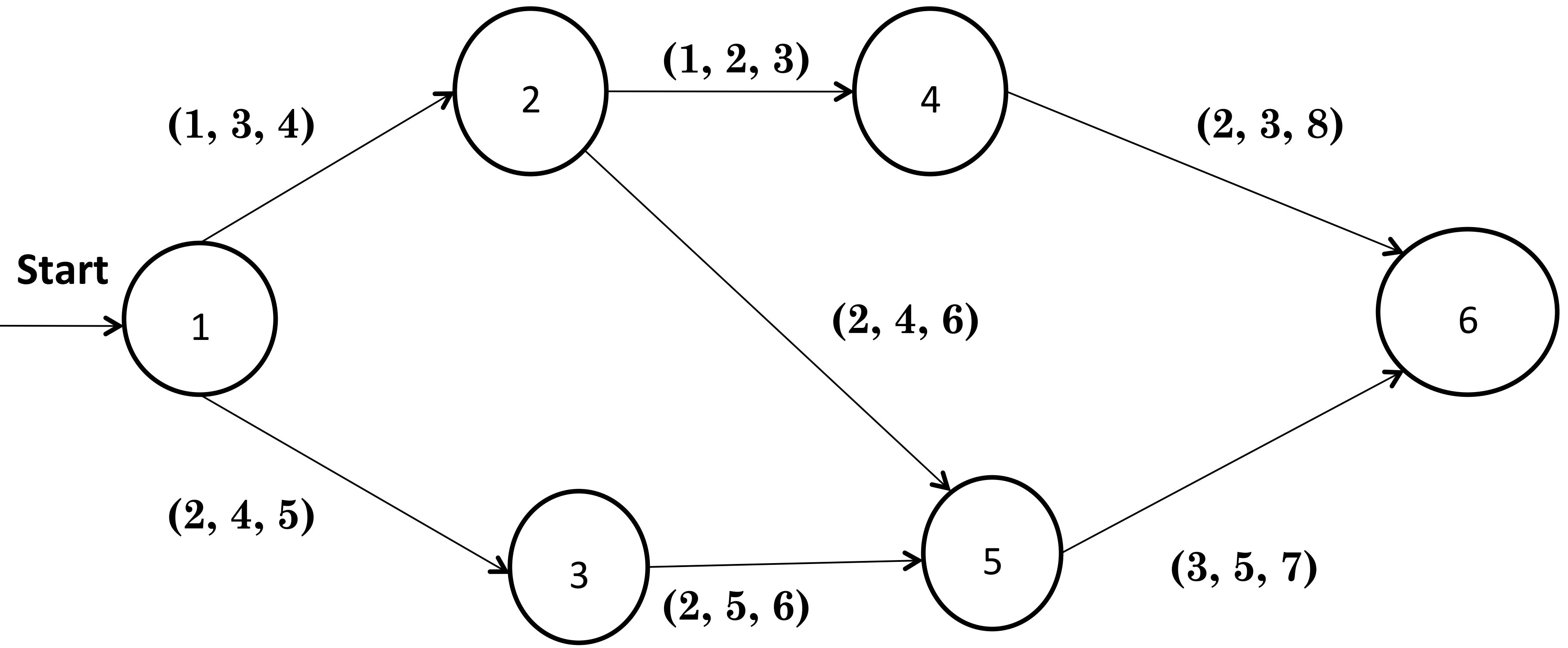
  if max(m1,m2)>min(l1,l2)

  (m1*m2)-(l1*l2)/(m1+m2)-(l1+l2)

  if max(m1,m2)<=min(l1,l2)

  }

- n = max[max(n1, n2),min(m1,m2)]


Start
1
2
3
4
5
6
(1, 3, 4)
(2, 4, 5)
(1, 2, 3)
(2, 4, 6)
(2, 5, 6)
(2, 3, 8)
(3, 5, 7)

Step1: P1: 1-2-4-6 $\rightarrow$ L1 = (4, 8, 15)

P2: 1-2-5-6 $\rightarrow$ L2 = (6, 12, 17)

P3: 1-3-5-6 $\rightarrow$ L3 = (7, 14, 18)

Step 2: $L_{\min}$ = (a, b, c) = L1= (4, 8, 15)

Step 3: Compute (a, b, c) :

$$b = (12 * 8) - (6 * 4)/(12 + 8) - (6 + 4) = 7.2$$

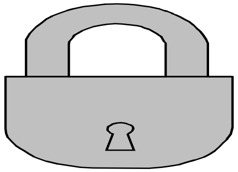
$$a = \min(4, 6) = 4;$$

$$c = \min(15, 12) = 12;$$

Step 5:

Set $L_{min} = (4, 7.2, 12)$

$$S(L_i, L_{min}) = \begin{cases} 0 & L_i \cap L_{min} = \emptyset \\ \dfrac{100(c-a)^2}{2(c_i - a_i)[(c-b)(b_i - a_i)]} & L_i \cap L_{min} = \emptyset \end{cases}$$

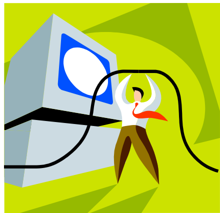


And put the values in this formula for all path i.e. p_1,p_2,p_3 and get the value of that path

path	member function
P1: 1-2-4-6	L1 = (4, 8, 15)
P2: 1-2-5-6	L2=(6, 12, 17)
P3: 1-3-5-6	L3=(7, 14, 18)

Table 1 represents the only member function for the given path and it's length L_{min}=(4,8,15)

I	Path	$S(L_{i,} L_{min})$	RANK
1	P1: 1-2-4-6	3.12	1^{st}
2	P2: 1-2-5-6	7.2	2^{nd}
3	P3: 1-3-5-6	9.5	3^{rd}



Drawbacks to Fuzzy logic

- Requires tuning of membership functions
- Fuzzy Logic control may not scale well to large or complex problems
- Deals with imprecision, and vagueness, but not uncertainty

CONCLUSION

- Fuzzy logic provides an alternative way to represent linguistic and subjective attributes of the real world in computing.
- It is able to be applied to control systems and other applications in order to improve the efficiency and simplicity of the design process.