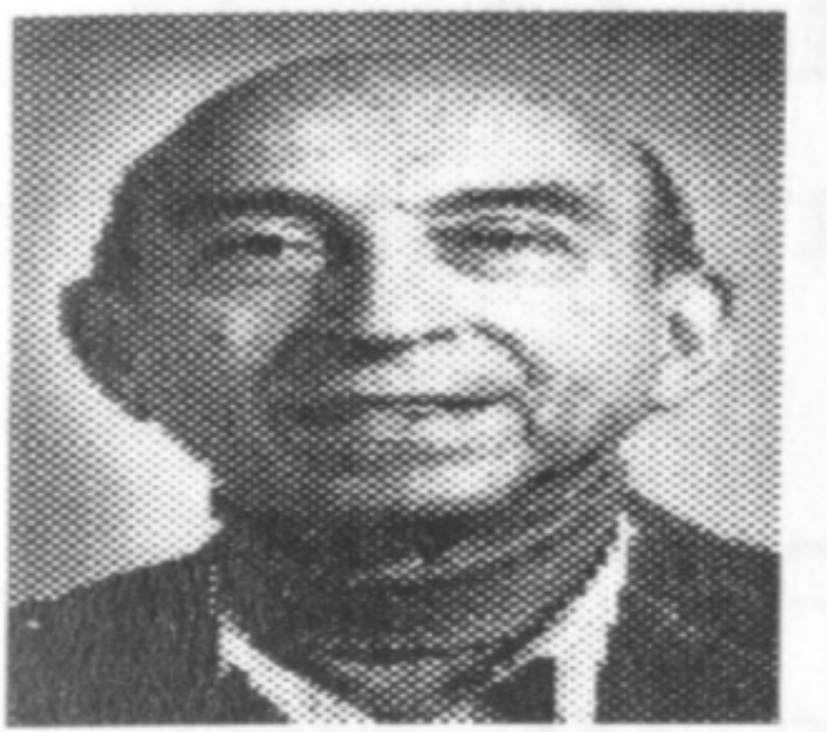
OVERVIEW

- History of Fuzzy Logic
- What is Fuzzy Logic?
- Traditional representation of Logic
- Fuzzy Logic representation
- Where is Fuzzy Logic used?
- Applications of Fuzzy Logic
- Fuzzy control
- Conclusion

HISTORY OF FUZZY LOGIC



In **1965**:"FUZZY LOGIC" by **Prof. Lotfi A. Zadeh**, Faculty in Electrical Engineering, UC Berkeley, introduced the foundation of the fuzzy sets Theory.

- In**1970**: First application in Control Engineering (Europe).

- In **1975**: Introduction of Fuzzy Logic in Japan.

- In **1980**: Empirical Verification of Fuzzy Logic in Europe.

- In **1985**: Broad application of Fuzzy Logic in Japan.

- In **1990**: Broad application of Fuzzy Logic in Europe.

- In **1995**: Broad application of Fuzzy Logic in the U.S.

- In **2000**: Fuzzy Logic becomes a Standard Technology and is also applied in Some fields.

WHAT IS FUZZY LOGIC?

- **Fuzzy**

  Fuzzy – "not clear, distinct, or precise; blurred"

- **Fuzzy logic**

  A form of knowledge representation suitable for notions that cannot be defined precisely, but which depend upon their contexts.

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

- By contrast, in Boolean logic, the truth values of variables may only be 0 or 1.

- Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false.

TRADITIONAL REPRESENTATION OF LOGIC

Slow

Speed=0

Fast

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 is Fuzzy Set?

A Fuzzy Set is defined in a pair of some closed interval [0,1].

It also splits into some sub intervals called Fuzzy subsets.

Slowest

[0.0 – 0.25]

Slow

[0.25 – 0.50]

Fast

[0.50 – 0.75]

Fastest

[0.75 – 1.00]

```
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
}
```

WHERE IS FUZZY LOGIC USED?

- Fuzzy logic is used directly in very few applications.

- Most applications of fuzzy logic use it as the underlying logic system for decision support systems.

APPLICATIONS OF FUZZY LOGIC

- **Aerospace**

  Altitude control of spacecraft, satellite altitude control, flow and mixture regulation in aircraft deicing vehicles.

- **Automotive**

  Trainable fuzzy systems for idle speed control, shift scheduling method for automatic transmission, intelligent highway systems, traffic control, improving efficiency of automatic transmissions

- **Business**

  Decision-making support systems, personnel evaluation in a large company

- **Chemical Industry**

  Control of pH, drying, chemical distillation processes, polymer extrusion production, a coke oven gas cooling plant

- **Financial**

  Banknote transfer control, fund management, stock market predictions.

- **Electronics**

  Control of automatic exposure in video cameras, air conditioning systems, washing machine timing, microwave ovens, vacuum cleaners.

- **Industries**

  Heat exchanger control, wastewater treatment process control, quantitative pattern analysis for industrial quality assurance, control of water purification plants

- **Manufacturing**

  Optimization of cheese production.

- **Medical**

  Medical diagnostic support system, control of arterial pressure during anesthesia, multivariable control of anesthesia, modeling of neuropath logical findings in Alzheimer's patients, radiology diagnoses, fuzzy inference diagnosis of diabetes and prostate cancer.

- **Mining and Metal Processing**

  Sinter plant control, decision making in metal forming.

- **Robotics**

  Fuzzy control for flexible-link manipulators, robot arm control.

- **Transportation**

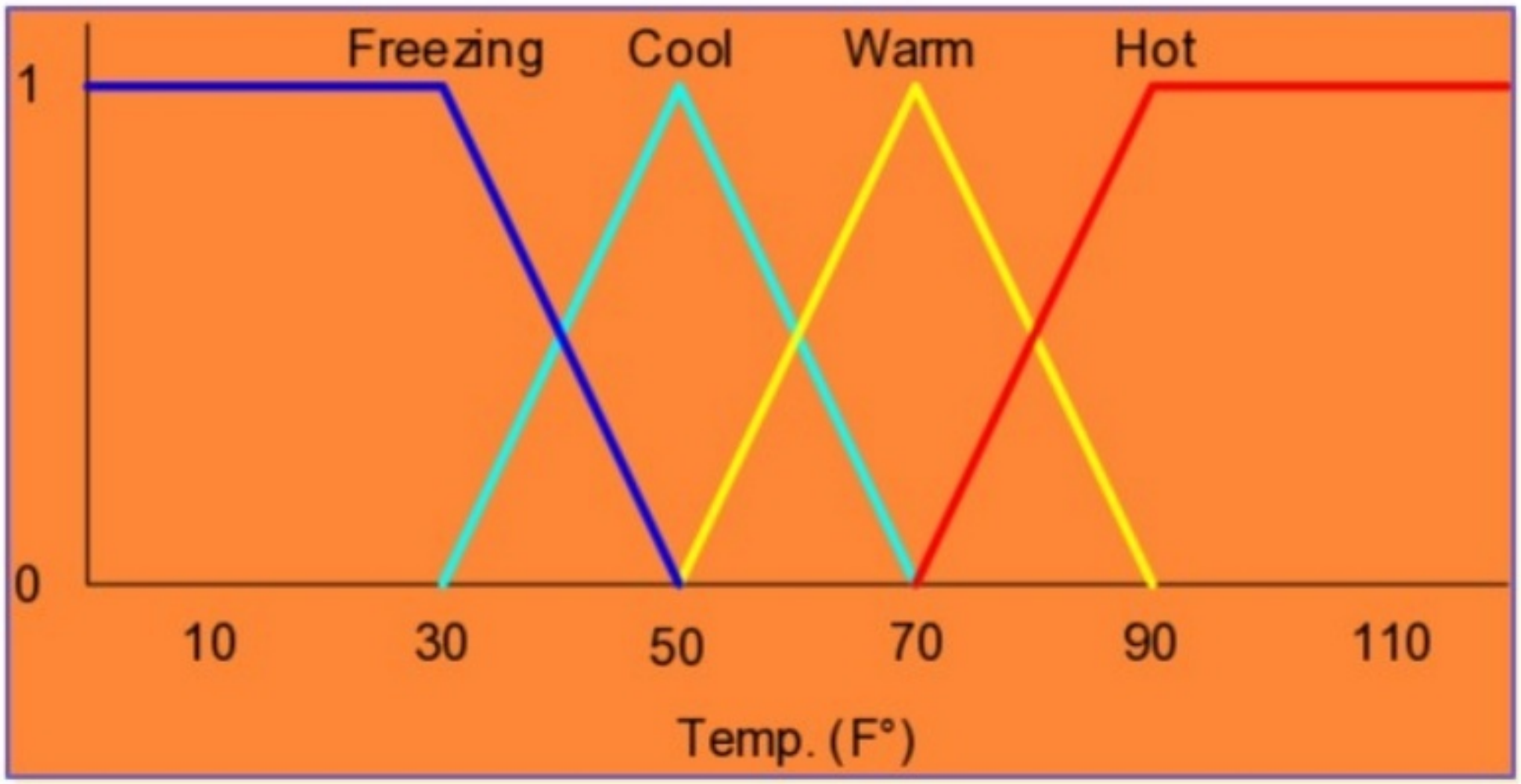
  Automatic underground train operation, train schedule control, railway acceleration, breaking and stopping

FUZZY CONTROL

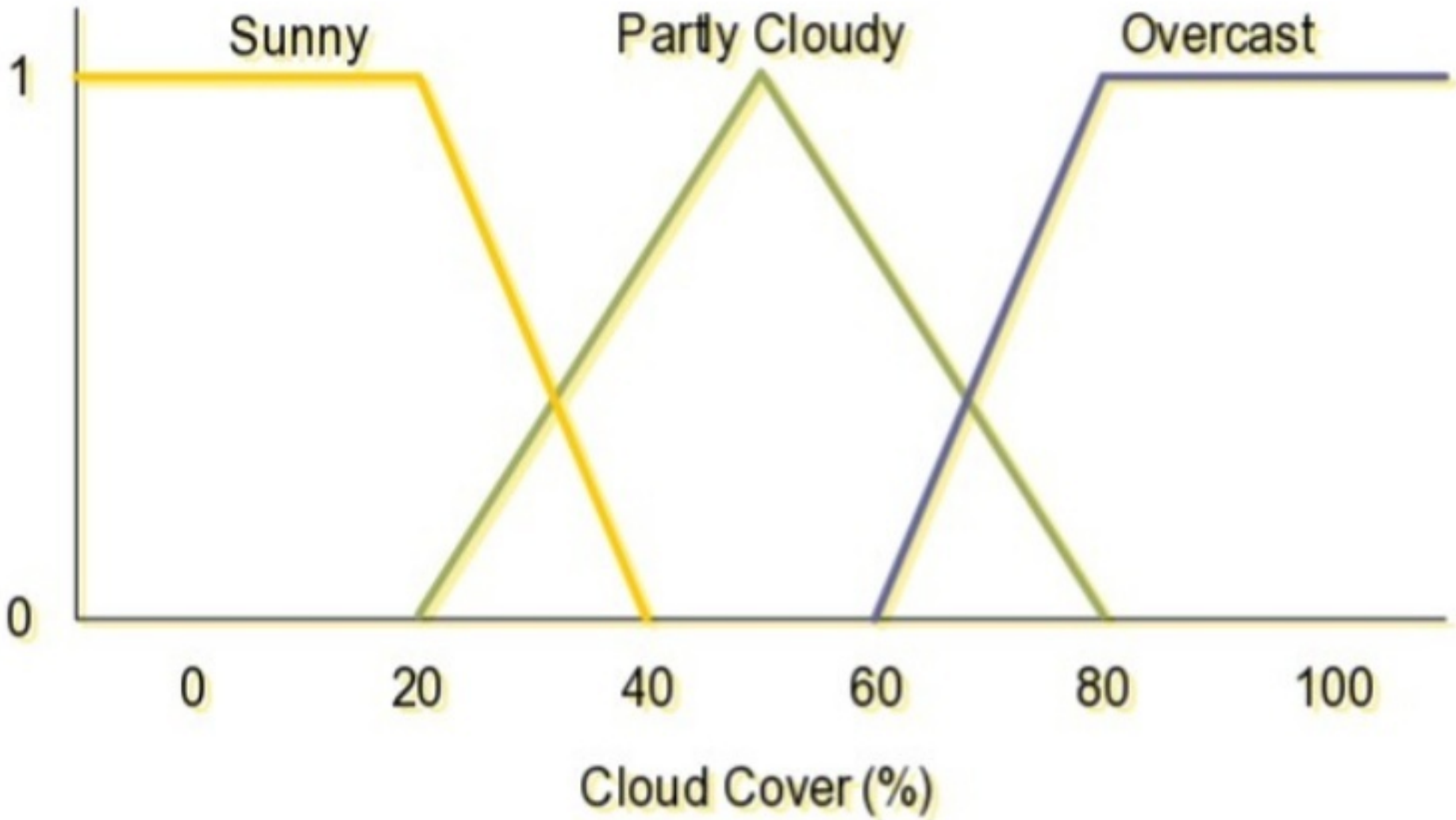
- Fuzzy Control combines the use of fuzzy linguistic variables with fuzzy logic.
- Example: **Speed Control**
- How fast am I going to drive today?
- Linguistic variables:
  - Temp: {freezing, cool, warm, hot}
  - Cloud Cover: {overcast, partly cloudy, sunny}
  - Speed: {slow, fast}

INPUTS : TEMPERATURE, CLOUD COVER

Temp : {Freezing, Cool, Warm, Hot}



Cloud Cover : {Sunny, Partly cloudy, Overcast}



Example Speed Calculation

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

Rules

- If it's Sunny and Warm then drive Fast.

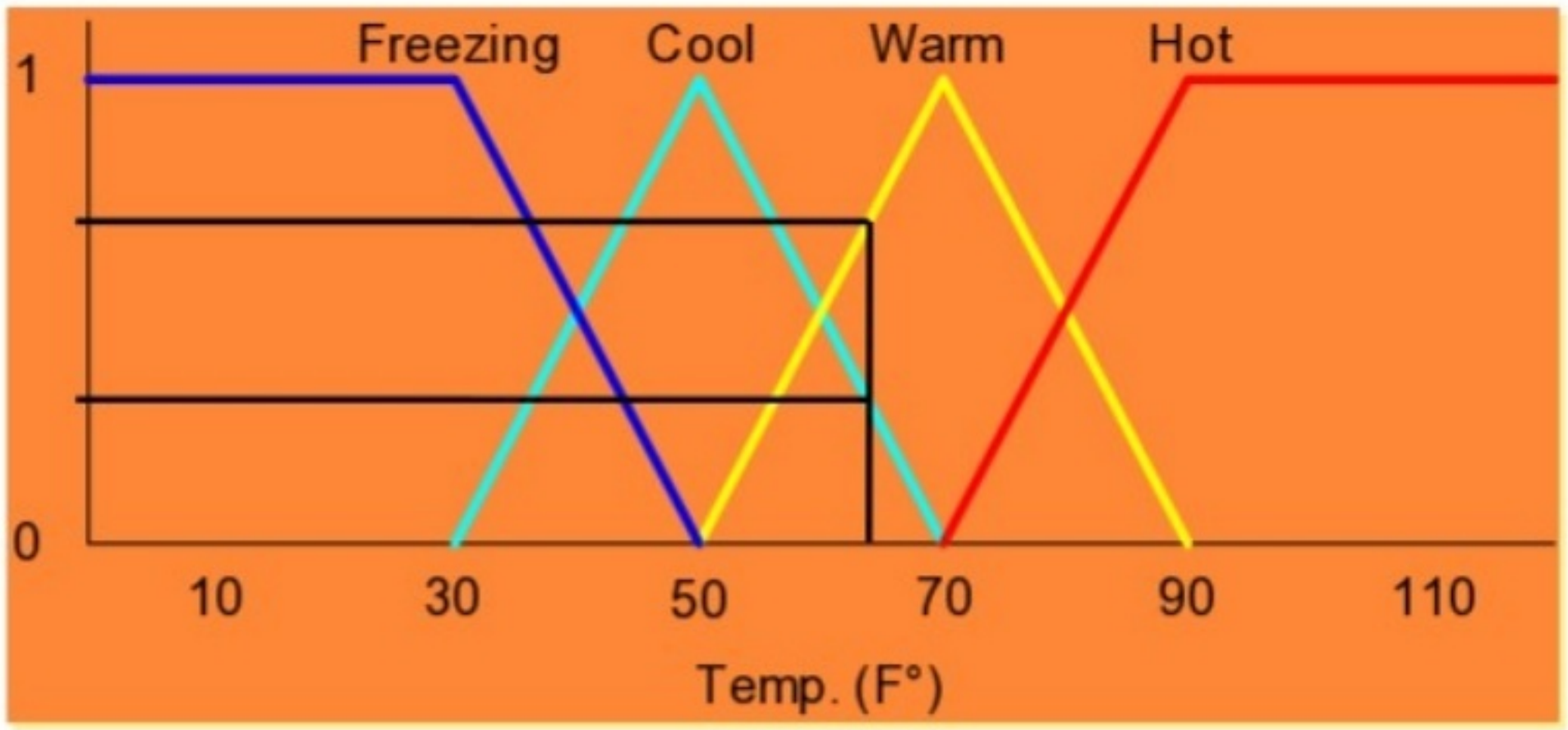
$$Sunny(Cover) \wedge Warm(Temp) \Rightarrow Fast(Speed)$$

- If it's Cloudy and Cool then drive Slow.

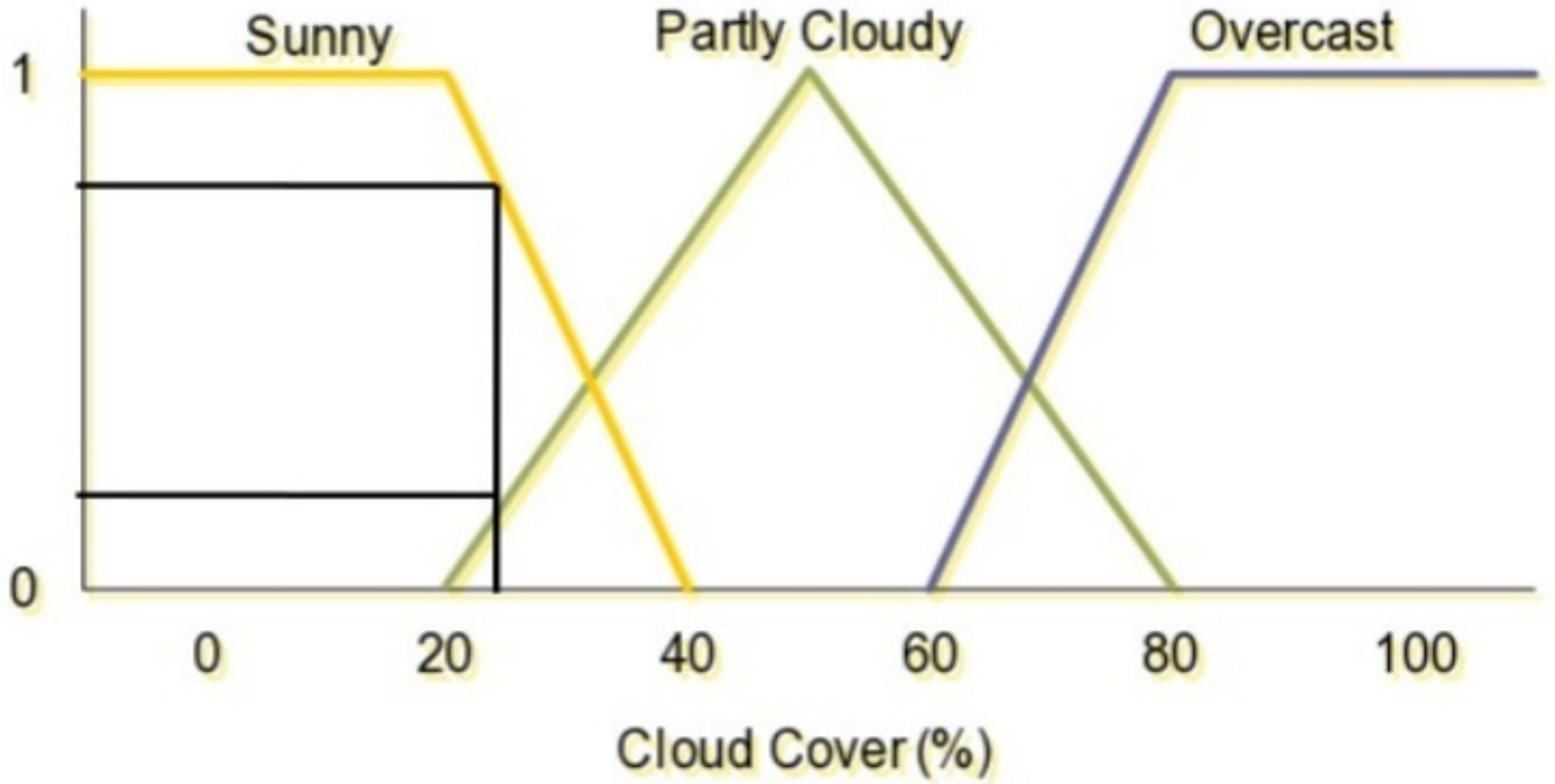
$$Cloudy(Cover) \wedge Cool(Temp) \Rightarrow Slow(Speed)$$

FUZZIFICATION
CALCULATE INPUT MEMBERSHIP LEVELS

$$65\ F^{\circ} \Rightarrow \text{Cool} = 0.4, \text{Warm} = 0.7$$



$$25\%\ \text{Cover} \Rightarrow \text{Sunny} = 0.8,\ \text{Cloudy} = 0.2$$



...CALCULATING...

- Apply Fuzzy AND (conjunction) ⇒

$$\mathbf{A \wedge B = \min(A, B)}$$

- If it's Sunny and Warm, drive Fast

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

$0.8 \wedge 0.7 = 0.7$

$\Rightarrow$ **Fast = 0.7**

- If it's Cloudy and Cool, drive Slow

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

$0.2 \wedge 0.4 = 0.2$

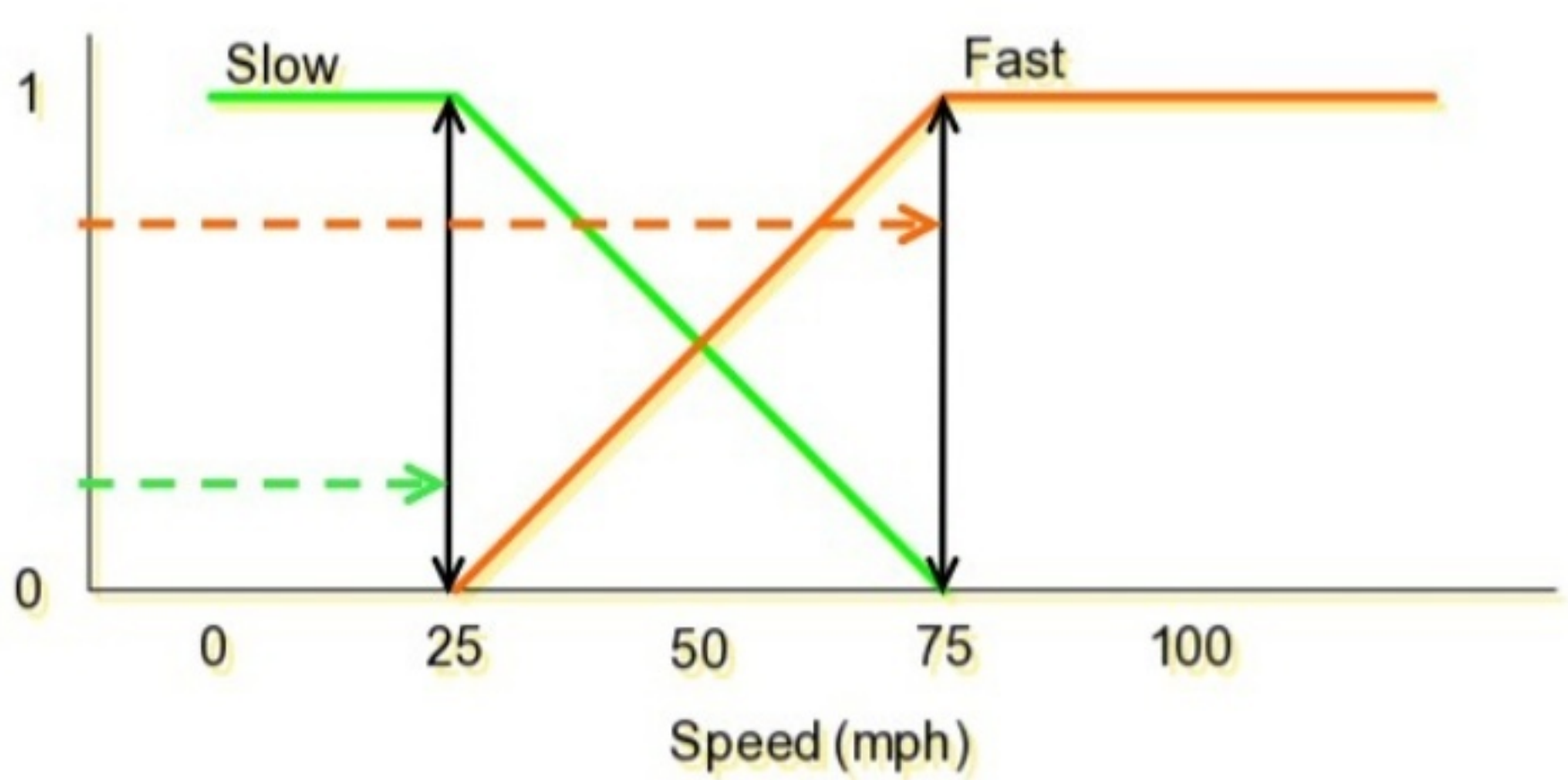
$\Rightarrow$ **Slow = 0.2**

OUTPUT : SPEED

Speed : {Slow, Fast}

DEFUZZIFICATION
CONSTRUCTING THE OUTPUT

Speed is 20% Slow and 70% Fast



CALCULATING SPEED

Speed = weighted mean

= (20*25+70*75)/(90)

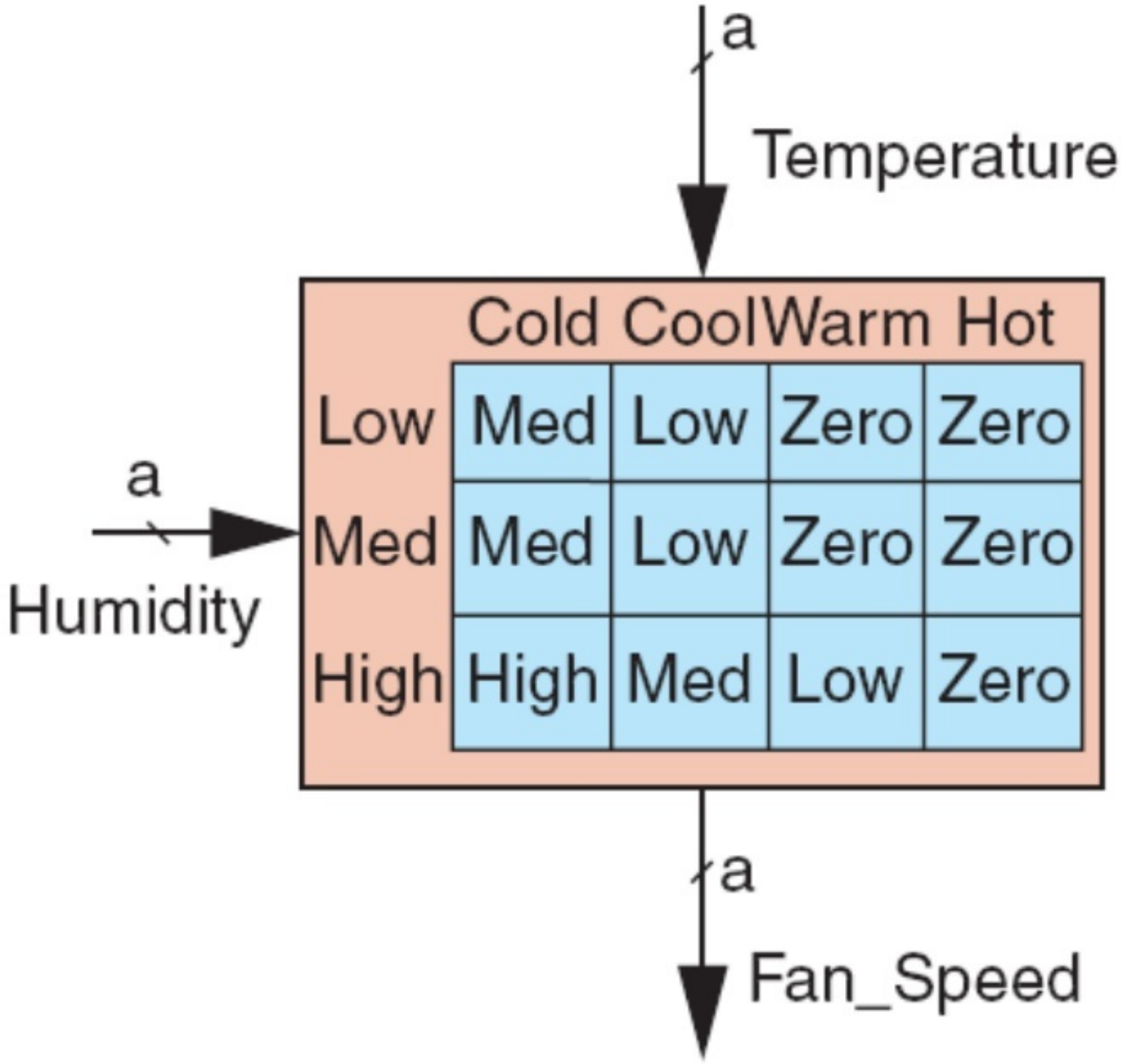
=(500+5,250)/(90)

=(5,750)/(90)

Speed = 63.8888888889

Speed is approximately **63.8 mph.**

FUZZY CONTROL IN AIR CONDITIONER


a
Temperature
Cold Cool Warm Hot
Low
Med
High
Med Low Zero Zero
Med Low Zero Zero
High Med Low Zero
a
Humidity
a
Fan_Speed

FUZZY CONTROL IN WASHING MACHINE

Quantity / Softness	Small	Medium	Large
Soft	Delicate	Light	Normal
Normal Soft	Light	Normal	Normal
Normal Hard	Light	Normal	Strong
Hard	Light	Normal	Strong

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.