

Intelligent Systems

Fuzzy Systems

Why fuzzy systems

- Vagueness or imprecision is inherent in many real life objects or properties
What is the definition of “warm” or "tall"?
– There are many such imprecise concepts
- Application of hard boundaries for categorisation gives unsatisfactory results
- Ability to handle imprecision is an attribute of intelligence
- Fuzzy logic provides a methodology for reasoning using imprecise rules and assertions
- Intelligent control and decision support systems based on fuzzy logic have proved their superiority over conventional hard logic based systems
- [Video](#)

WHAT IS FUZZY LOGIC?

- Definition of fuzzy

- Fuzzy – “not clear, distinct, or precise; blurred”

- Definition of fuzzy logic

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

Fuzzy system applications

Fuzzy control systems

- controlling machinery

- Most renowned fuzzy control system in use - Sendai subway (since 1987)
- Japanese appliances
 - vacuum cleaners,
 - washing machines,
 - camcorders
- Fuzzy auto transmission & ABS in cars
- Fuzzy lift control system
- Fuzzy TV!



Fuzzy sets – the basis of fuzzy logic

- In classical logic, the boundary of a set is sharp:
eg, all people earning \$75,000 or higher are members of set *high-income earner*
Anyone earning less than \$75,000 is not
- Because of the sharpness of the set boundary, classical logic sets are known as *crisp sets*
- As the domain value (in this case, income) increases, the degree of membership in the set high-income earner remains zero, but jumps to 1 (true) as income reaches \$75000

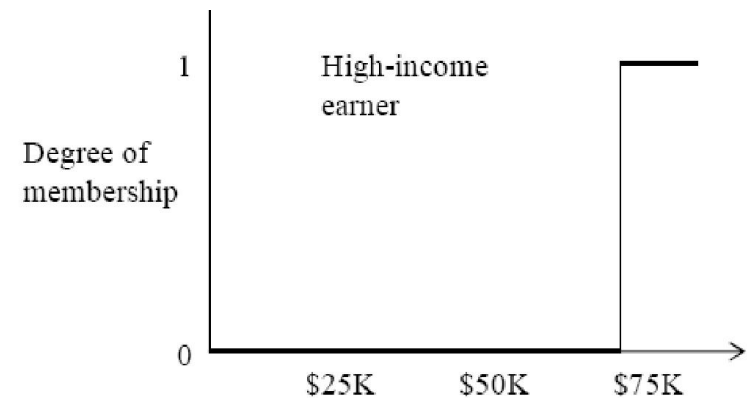
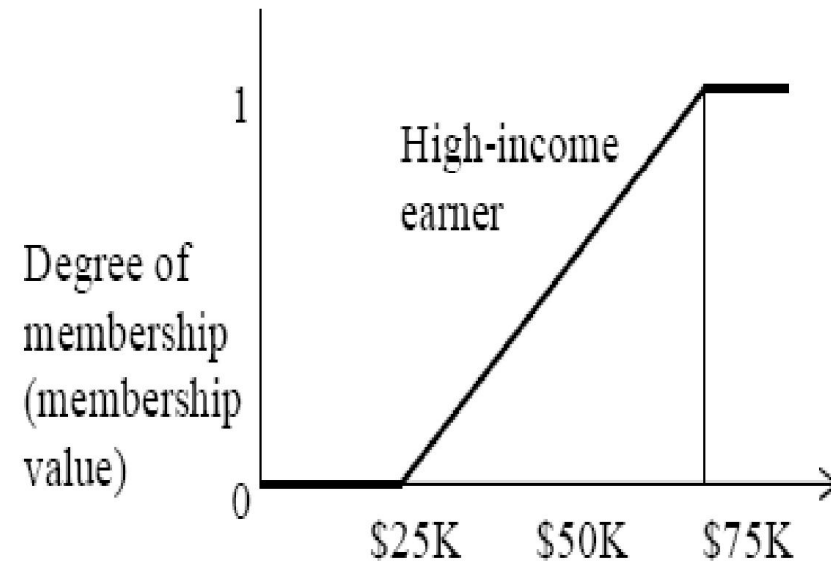


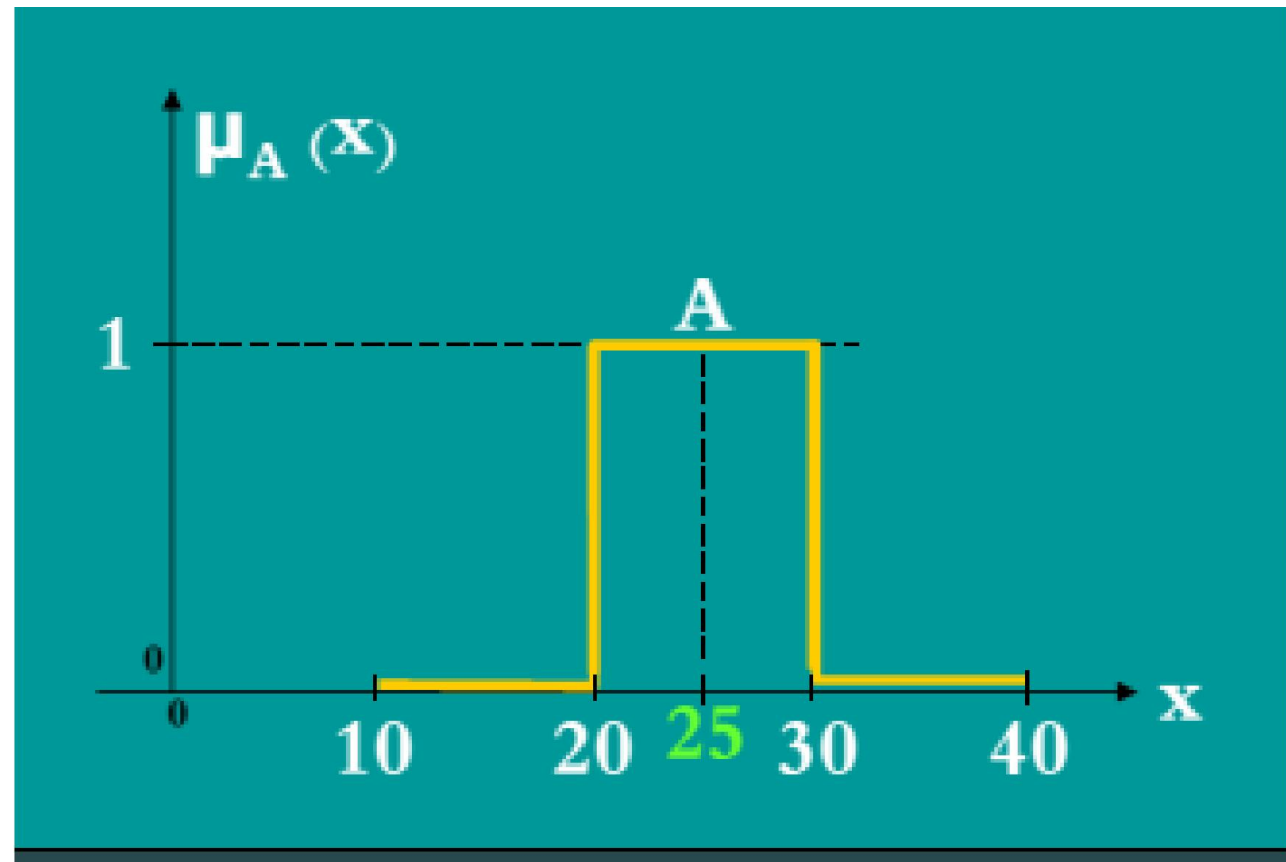
Fig. 1 membership graph for a crisp set high-income earner

Fuzzy sets

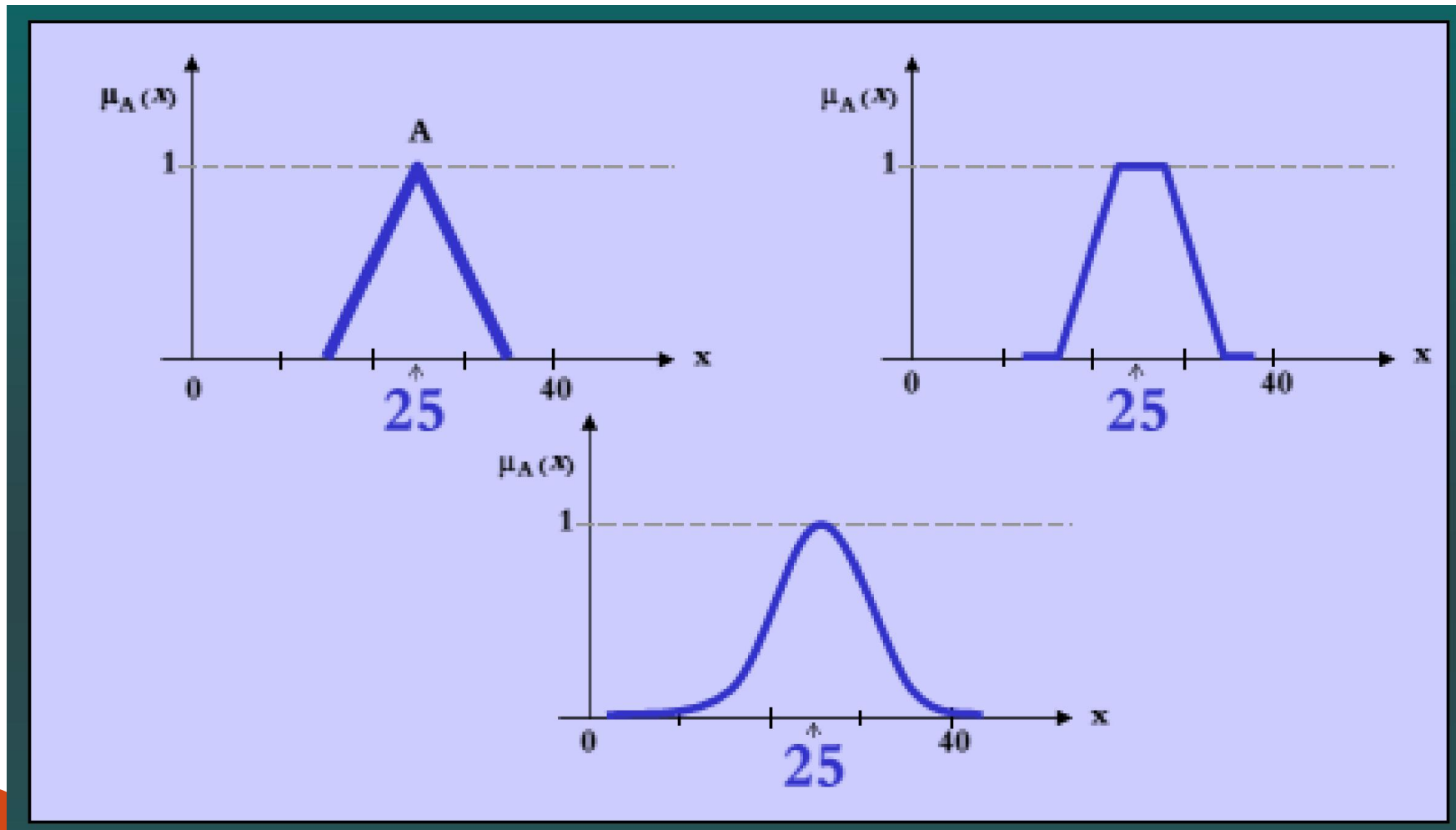
- For a *fuzzy set*, membership values lie within the range zero (no membership) to 1 (complete membership)
- eg. the membership graph of the fuzzy set *high-income earner* may have the shape shown below
- The horizontal axis of the graphs that represent these fuzzy sets is called the *universe of discourse* over a variable of interest x
- The vertical axis is a degree of membership in the set $m(x)$ and is always in the range $[0,1]$



Moderate weather in classic logic

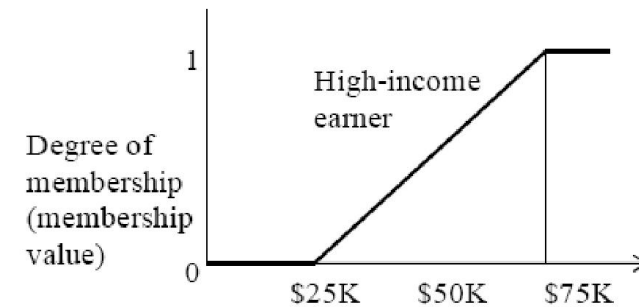


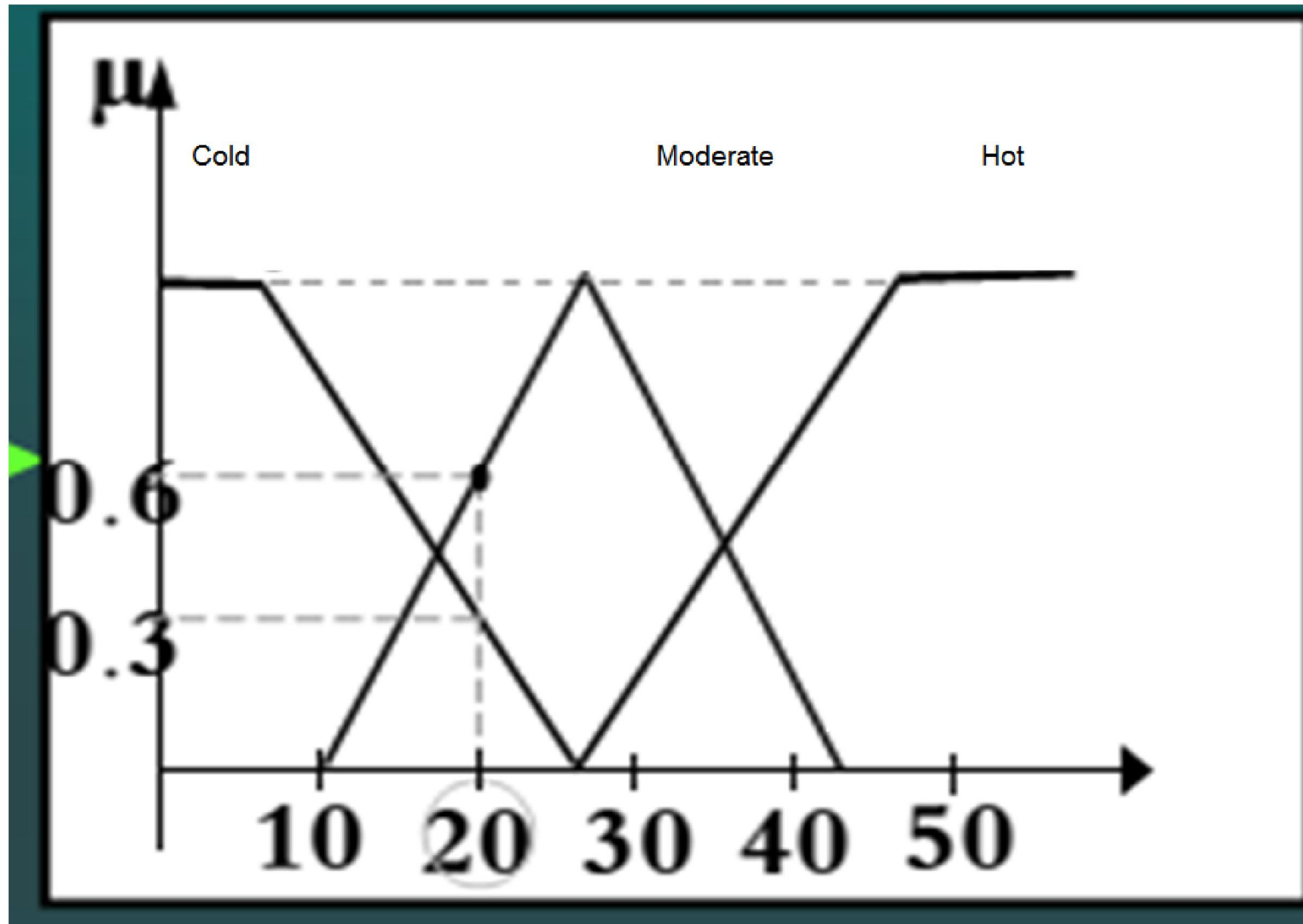
Moderate weather in Fuzzy logic



Fuzzification

- According to this *membership function*, someone earning \$30,000 will have a membership value of 0.1
- Someone earning \$74,900 will have a membership value of 0.998
- This is called *fuzzification*
- All incomes at or below \$25,000 have membership value 0
- All those at or above \$75,000 have membership value 1





Defuzzification

- step to convert fuzzification to numeric values used by computer
- Convert linguistic values to numeric values

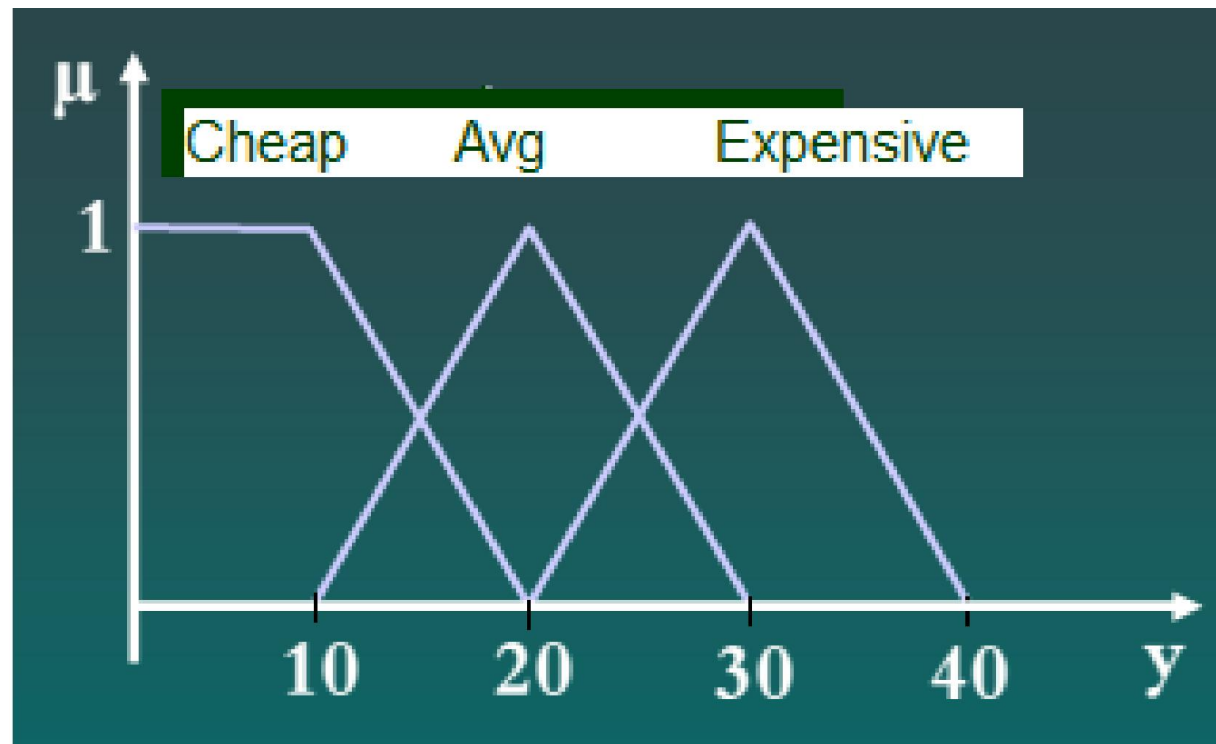
- By using Center of area

$$y_0 = \frac{y_1 \mu_Y(y_1) + y_2 \mu_Y(y_2)}{\mu_Y(y_1) + \mu_Y(y_2)}$$

- Y = Fuzzification
- y_1 = First possibility
- y_2 = Second possibility
- u = membership
- Y_0 = Final Decision

Defuzzification (cont'd)

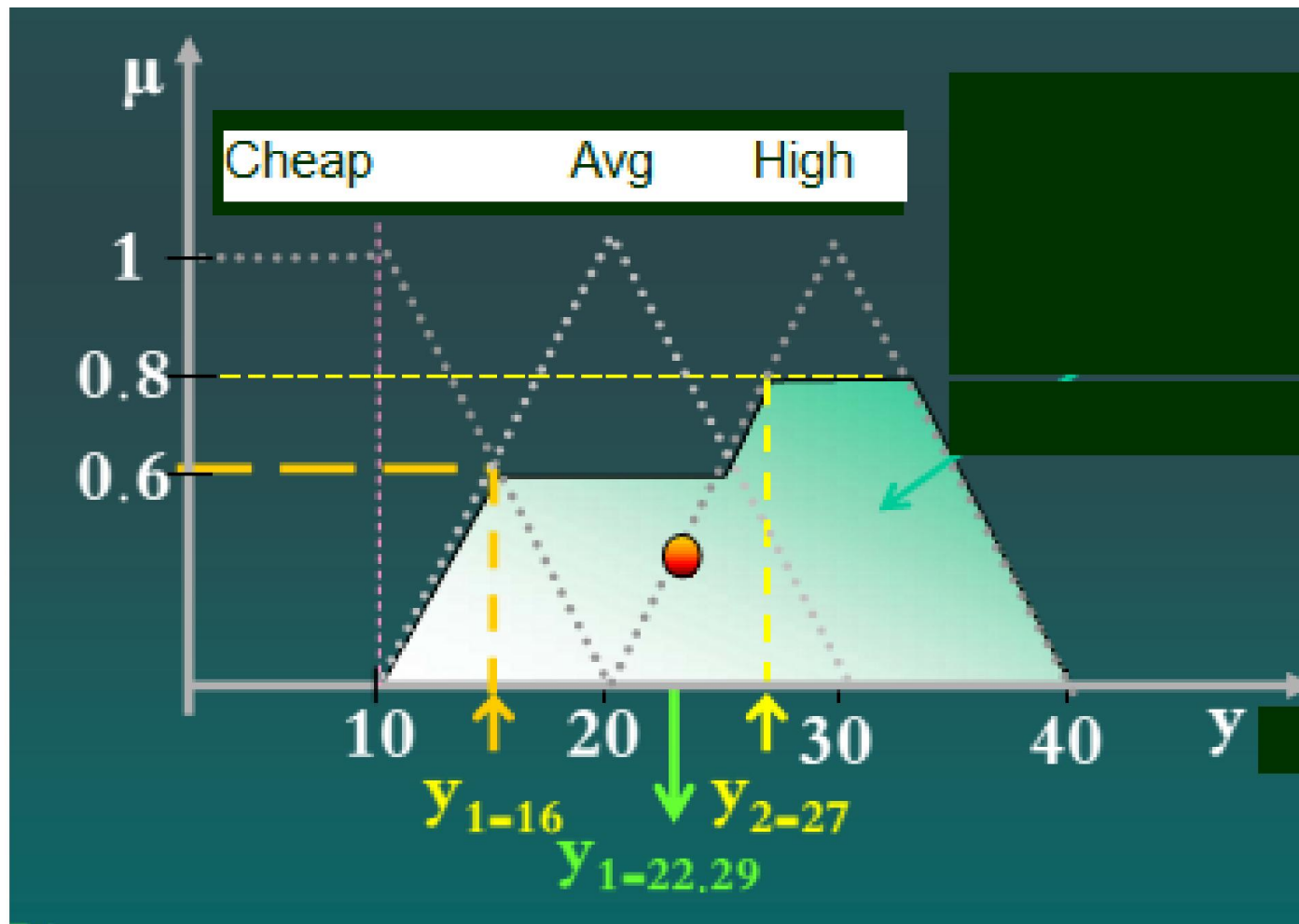
- Product price divide to 3 fuzz set:
 - Cheap
 - Average
 - Expensive



Defuzzification (cont'd)

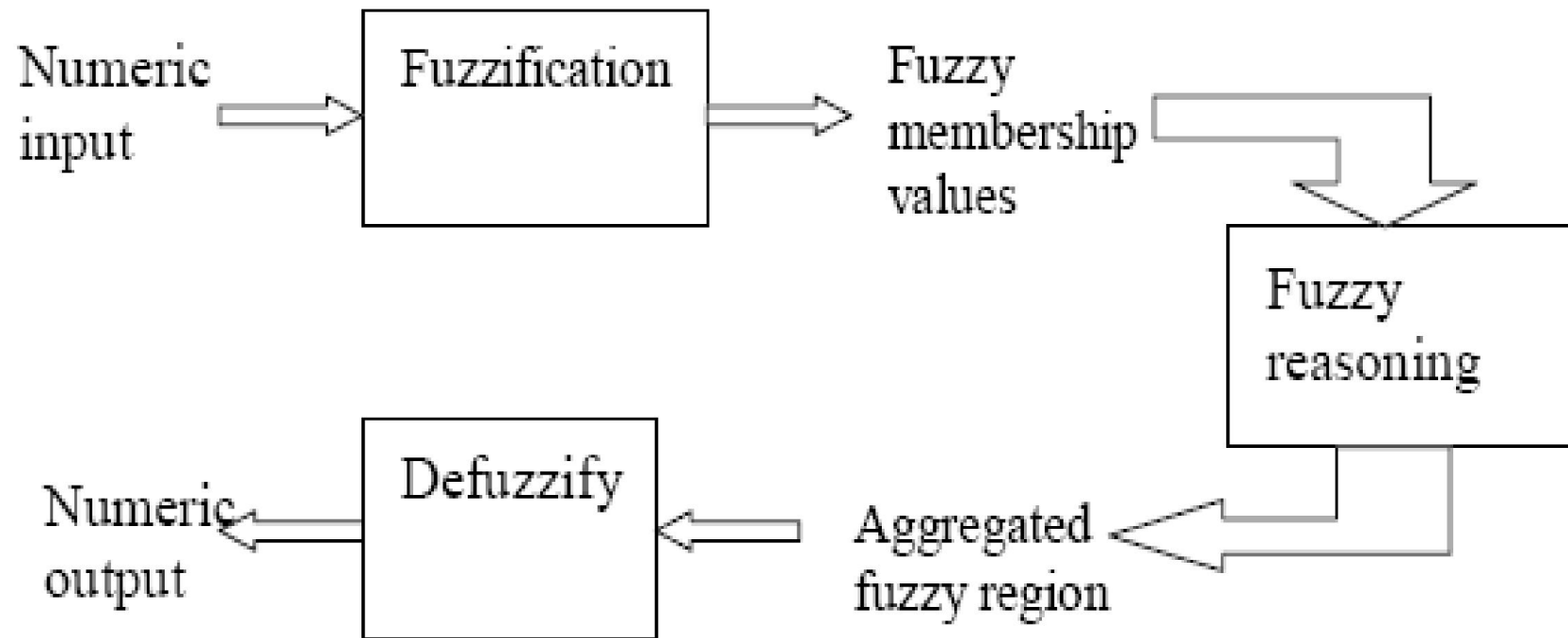
- When we put product price for new product
- After insert all fuzzy set in Fuzzication the final decision about average membership start from 0.6 and expensive membership start from 0.8
- NOW we need to Defuzzification by using Center of Area

- First possibility = 16
- Second possibility = 27
- Price = $(27)(0.8) + (16)(0.6) / (0.8) + (0.6) = 21.6 + 9.6 / 1.4 = 22.29$



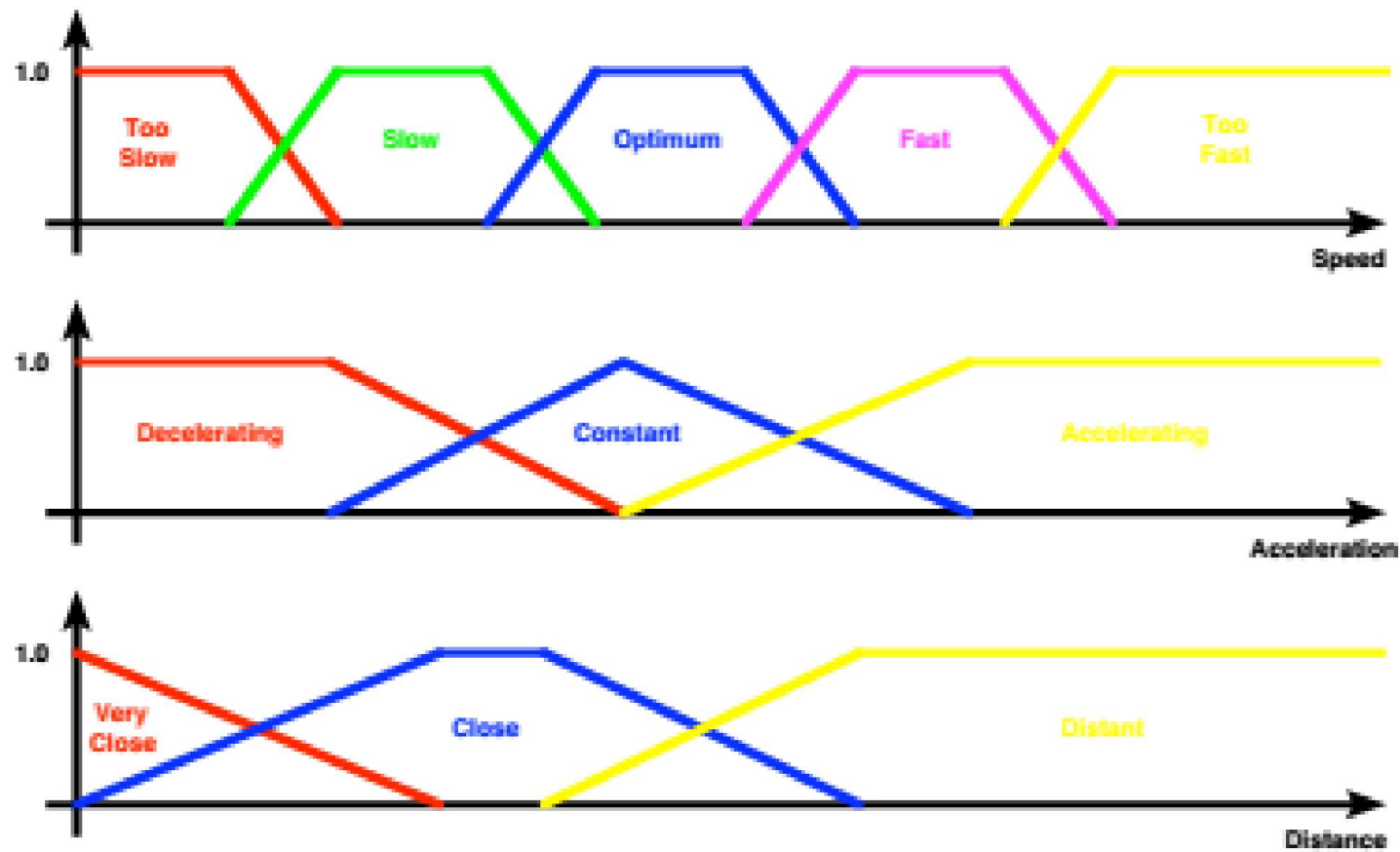
Fuzzy system operation - an overall view

The operation of a fuzzy system is shown in the schematic diagram below.



Example of Fuzzy Logic

- Automotive Speed Controller
- 3 inputs:
 - speed (5 levels)
 - acceleration (3 levels)
 - distance to destination (3 levels)
- 1 output:
 - power (fuel flow to engine)
- Set of rules to determine output based on input values



Example Rules

- IF speed is TOO SLOW and accelerations DECELERATING,
THEN INCREASE POWER GREATLY
- IF speed is SLOW and acceleration is DECREASING,
THEN INCREASE POWER SLIGHTLY
- IF distance is CLOSE,
THEN DECREASE POWER SLIGHTLY

- Output Determination
- Degree of membership in an output fuzzy set now
- represents each fuzzy action.
- Fuzzy actions are combined to form a system output.

