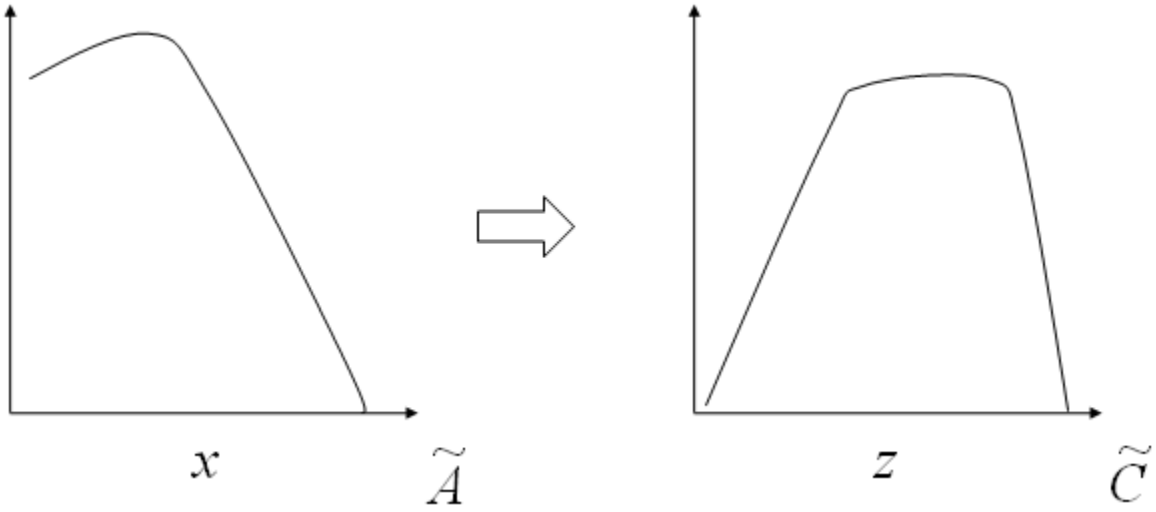
IG0029 IE Computing and Application

Introduction to Artificial Intelligence



HYUNSOO LEE

References

- Main Reference
  - John Yen and Reza Langari, “Fuzzy logic: intelligence, Control, and Information”, Prentice-Hall, 1999

Fuzzy Logic (1)

- Definition of "Hot / Mild / Cold"
  - Definition : $30^{\circ}C$
  - Case : $29.9^{\circ}C$
- Interval Theory

Fuzzy Logic (2)

- Definition of " $\mu_{Hot}(T)$ "

$$\mu_{Hot}(T) = \frac{1}{1+e^{-\alpha(T-30)}}$$

  - "Sigmoid function"

Fuzzy Logic (3)

- Fuzzy Membership Function
  - Triangular membership function : (α, β, γ)
  - Trapezoid membership function : $(\alpha, \beta, \gamma, \varepsilon)$
  - Sigmoid membership function: (α, β)
  - ……

Fuzzy Logic (4)

- Fuzzy Membership Function (1)
  - Triangular Membership Function (α, β, γ)

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & x < \alpha \\ \dfrac{x-\alpha}{\beta-\alpha} & \alpha \le x < \beta \\ \dfrac{\gamma-x}{\gamma-\beta} & \beta \le x < \gamma \\ 0 & \gamma \le x \end{cases}$$

Fuzzy Logic (5)

- Fuzzy Membership Function (2)
  - Trapezoid membership function : $(\alpha, \beta, \gamma, \varepsilon)$

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & x < \alpha \\ \dfrac{x-\alpha}{\beta-\alpha} & \alpha \le x < \beta \\ 1 & \beta \le x < \gamma \\ \dfrac{\varepsilon-x}{\varepsilon-\gamma} & \gamma \le x < \varepsilon \\ 0 & \varepsilon \le x \end{cases}$$

Fuzzy Logic (6)

- Exercise
  - Define these terms using your fuzzy membership function
    - Hungry / Full / Enough
    - Fast / Slow / Adequate
    - Early / Late
    - Good / Bad
    - …..

Continuous / Discrete Fuzzy Set

- Continuous Case

$$\mu_{Hot}(T) = \frac{1}{1+e^{-\alpha(T-30)}} \quad \Rightarrow \quad \tilde{A} = \int_x \mu_A(x)dx \ / \ x$$

- Discrete Case

$$\tilde{A} = \{0/1, 0.2/2, 0.5/3, 0.7/4, 1/5, 1/6, 0.7/7, 0.5/8, 0.2/9, 0/10\}$$

$$\Rightarrow \quad \tilde{A} = \Sigma\mu_A(x) \ / \ x$$

Fuzzy Operation (1)

- " $\cup$ " – Fuzzy Set Vs. Crisp Set
  - Crisp Set (A)

$$\mu_{\neg A} = 1 - \mu_A$$

$$\mu_A \cup \mu_{\neg A} = 1$$

  - Fuzzy Set ($\tilde{A}$)

$$\mu_{\neg \tilde{A}} = 1 - \mu_{\tilde{A}}$$

$$\mu_{\tilde{A}} \cup \mu_{\neg \tilde{A}} \neq 1$$

Fuzzy Operation (2)

- Max / Min operation
  - "Max" operation

$$\tilde{A} \cup \tilde{B} = \max(\mu_{\tilde{A}}(x), \mu_{\tilde{B}}(x))$$

  - "Min" operation

$$\tilde{A} \cap \tilde{B} = \min(\mu_{\tilde{A}}(x), \mu_{\tilde{B}}(x))$$

Fuzzy Operation (3)

- "S-norm" & "t-norm"
  - S-norm : generalization of "Min"

$$s(0,0)=0 \qquad s(x,y)=s(y,x)$$

$$s(x,1)=t(1,x)=1 \qquad s(x,t(y,z))=s(t(x,y),z)$$

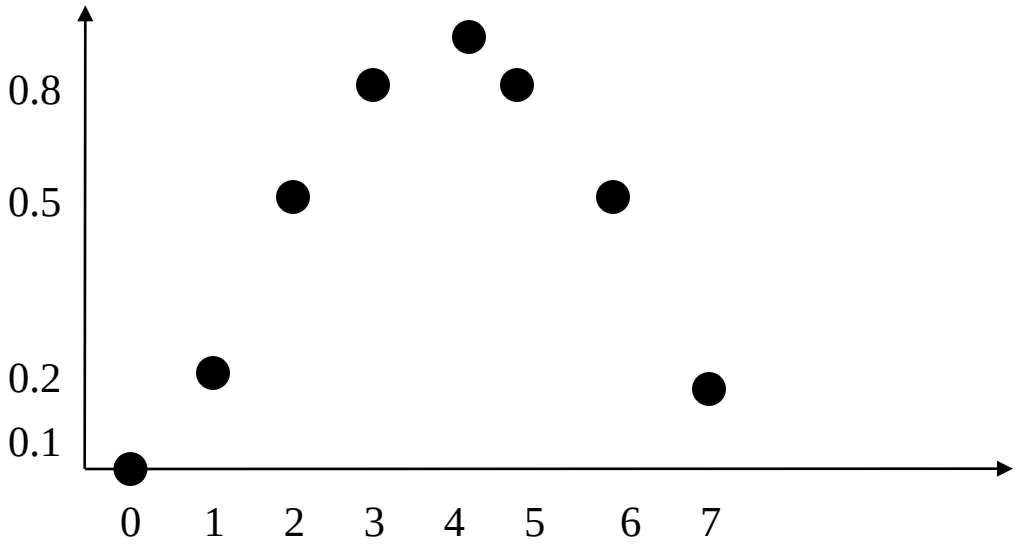
  - T-norm : generalization of "Max"

$$t(0,0)=0 \qquad t(x,y)=t(y,x)$$

$$t(x,1)=t(1,x)=x \qquad t(x,t(y,z))=t(t(x,y),z)$$

Fuzzy Operation (3)

- " α -cut" $\tilde{A}_\alpha = \{x \mid \mu_{\tilde{A}}(x) \geq \alpha\}$



- " α -strict" $\tilde{A}_\alpha = \{x \mid \mu_{\tilde{A}}(x) > \alpha\}$

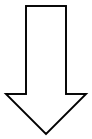
Linguistic Hedge (1)

- Definition of "Linguistic Term"
  - Hungry / Full / Enough
  - Fast / Slow / Adequate
  - Early / Late
  - Good / Bad
  - …..
- Linguistic Hedge
  - Very, More, Less
  - Example

$$\mu_{very\ hot}(T) = (\mu_{hot}(T))^2$$

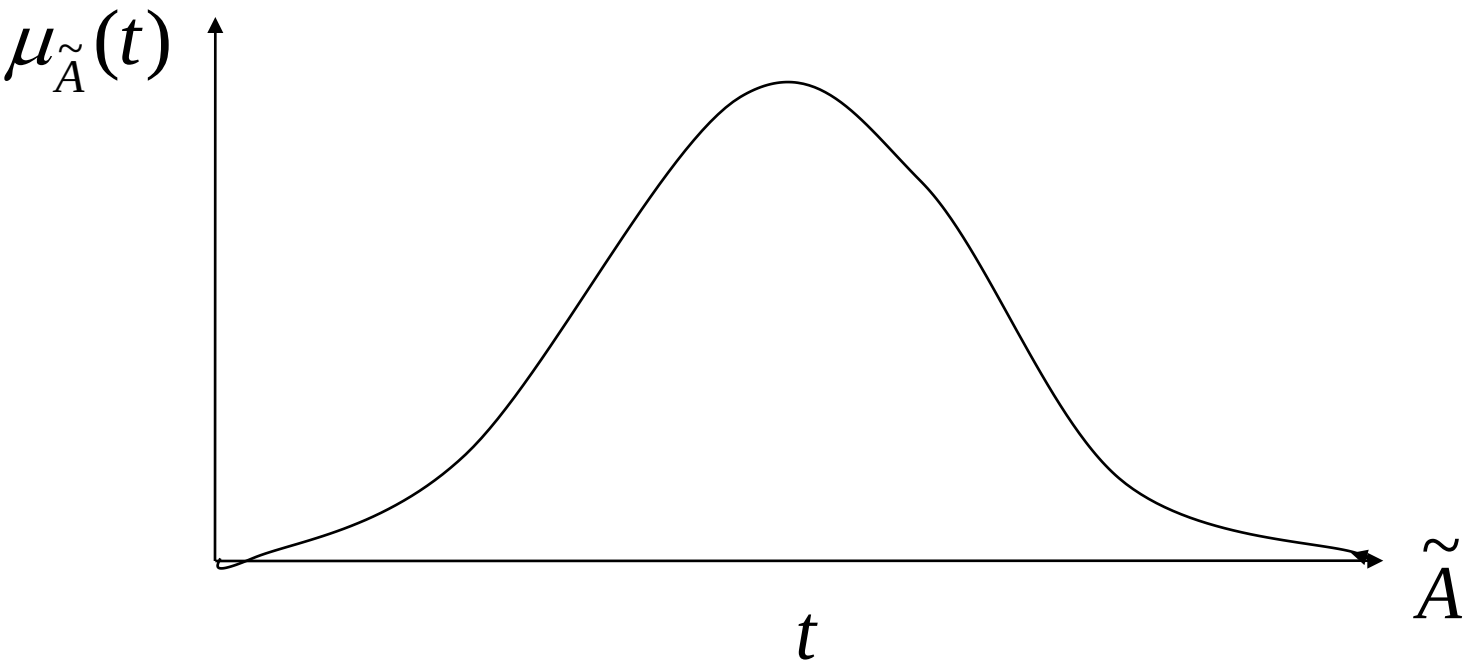
Linguistic Hedge (2)

- Interpretation
  - "Temperature is hot ,**but not** very hot"



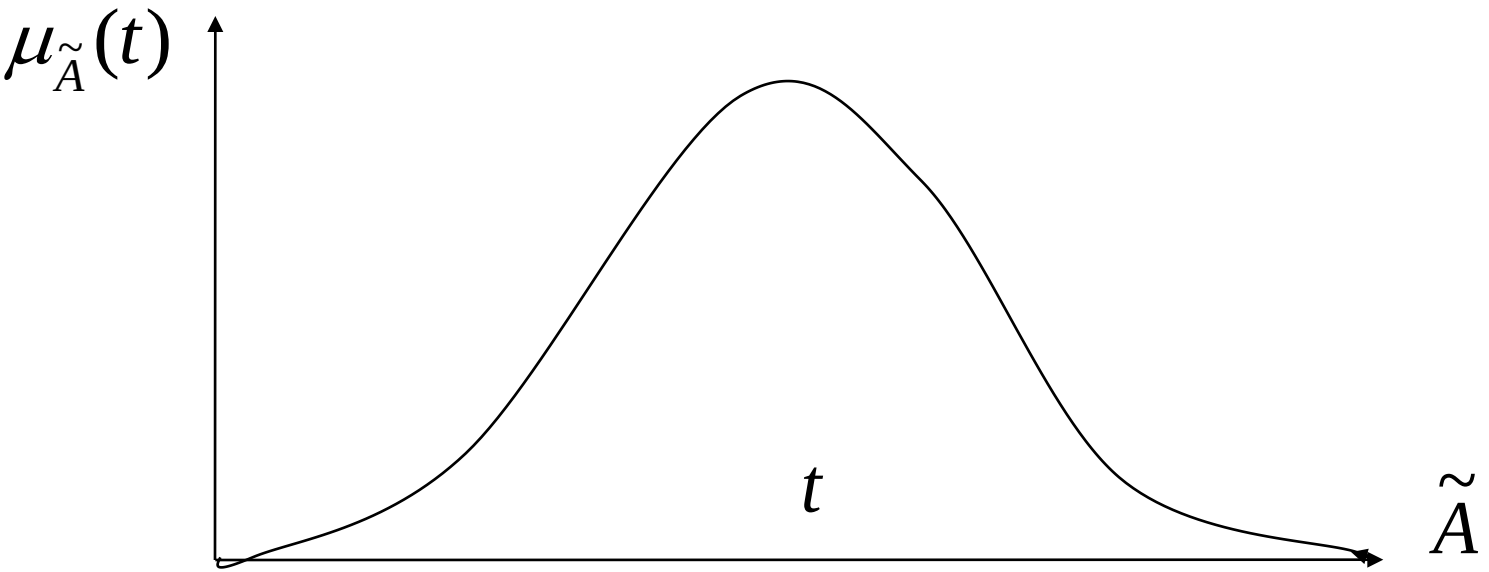
Defuzzification (1)

- Defuzzification process



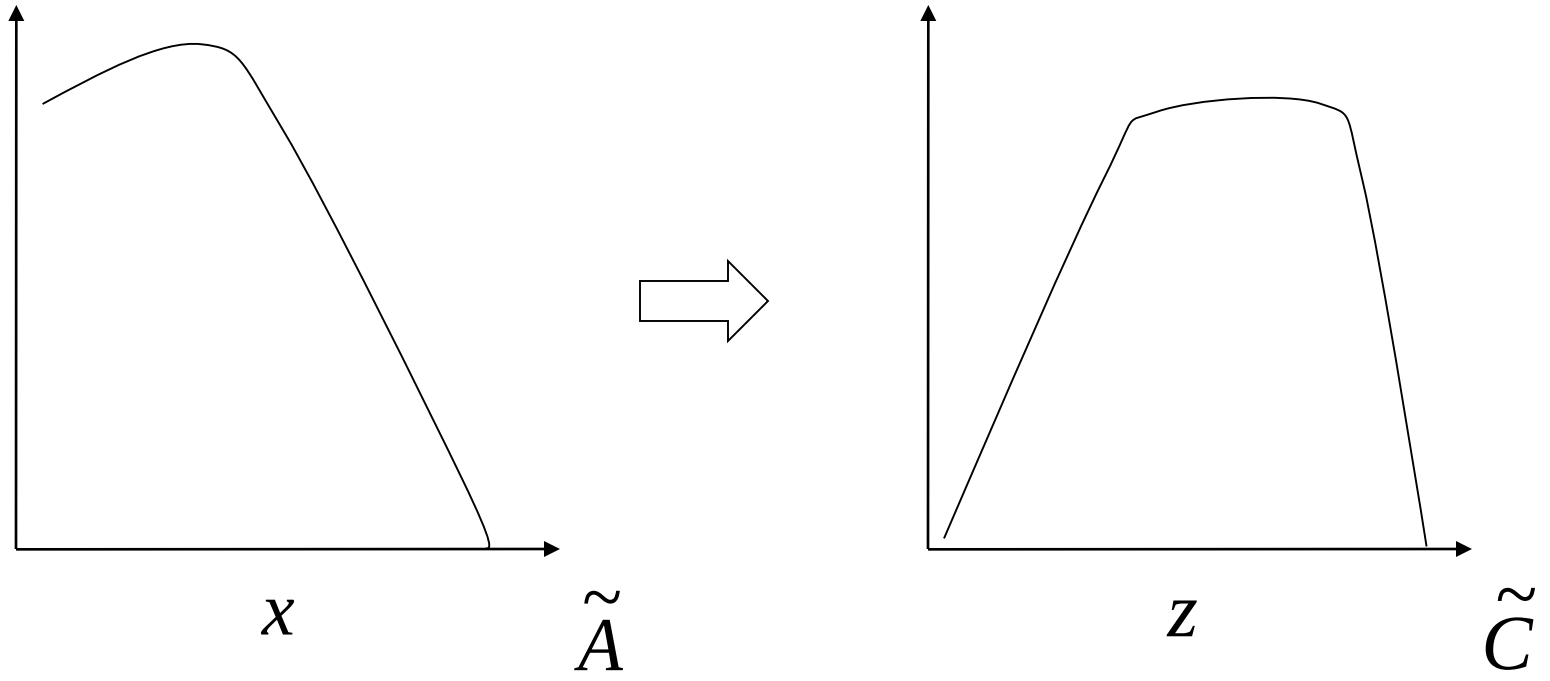
Defuzzification (2)

- Defuzzification type
  - MOM (Mean of Maximum)
  - COA (Center of Area)
  - CLA (Center of Largest Area)



Fuzzy Logic (1)

- "if x is $\tilde{A}$, then z is $\tilde{C}$ "



Fuzzy Logic (2)

- "if x is $\tilde{A}$ and y is $\tilde{B}$, then z is $\tilde{C}$"

Homework (1)

- Due : May 31st (Friday) – 100 Pts
  - No Late submission, due to the Mid-term
  - 4 Problems – each 25 points
- Problem 1) Find 2 examples of the use of fuzzy concepts in newspaper or magazine
- Problem 2) Suggest two good applications of fuzzy logics, which may or may not yet exist but could make effective use of fuzzy logic. Explain at some detail why you think these are good applications

Homework (2)

- Problem 3 : How would you define the following concepts as fuzzy sets
  - Healthy person
  - Beautiful day
  - Easy class
  - Hard class
  - Average class
  - Moderately wealthy person
  - Not so easy task

Homework (3)

- Problem 4
  - Consider one of the examples you gave in Problem #2 and create a set of fuzzy rules that might e used to introduce fuzzy logic in that problem.