Algorithms and Networking for Computer Games

Chapter 7: Modelling Uncertainty

http://www.wiley.com/go/smed

Types of uncertainty

- probabilistic uncertainty
  - probability of an outcome
  - dice, shuffled cards
  - statistical reasoning
    - Bayesian networks, Dempster-Shafer theory
- possibilistic uncertainty
  - possibility of classifying object
  - *sorites* paradoxes
  - fuzzy sets

Bayes' theorem

- hypothesis H
- evidence E
- probability of the hypothesis $P(H)$
- probability of the evidence $P(E)$
- probability of the hypothesis based on the evidence
  $P(H \mid E) = (P(E \mid H) \cdot P(H)) \,/\, P(E)$

Example

- H — there is a bug in the code
- E — a bug is detected in the test
- $E | H$ — a bug is detected in the test given that there is a bug in the code
- $H | E$ — there is a bug in the code given that a bug is detected in the test

Example (cont'd)

- $P(H) = 0.10$
- $P(E \mid H) = 0.90$
- $P(E \mid \neg H) = 0.10$
- $P(E) = P(E \mid H) \cdot P(H) + P(E \mid \neg H) \cdot P(\neg H)$
  $= 0.18$
- from Bayes' theorem:
  $P(H \mid E) = 0.5$
- conclusion: a detected bug has fifty-fifty chance that it is not in the actual code

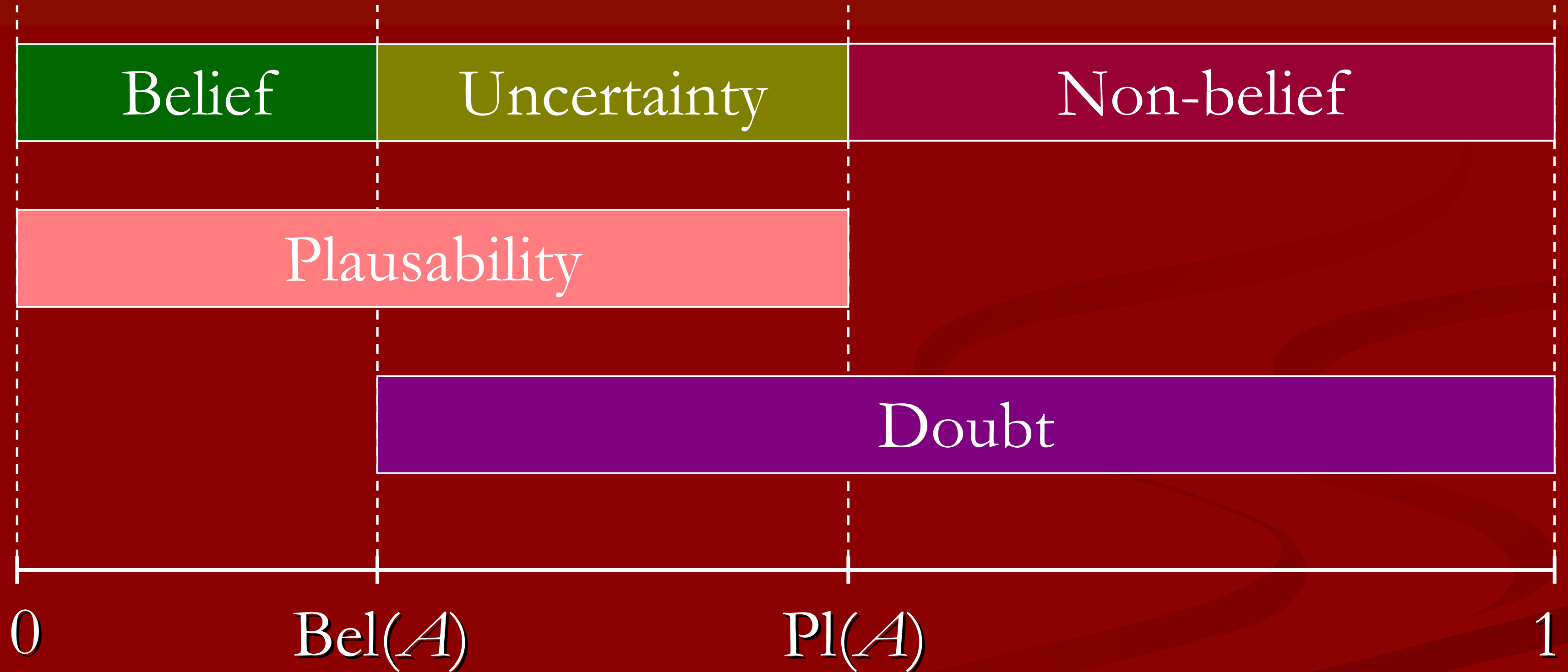
Bayesian networks

- describe cause-and-effect relationships with a directed graph
  - vertices = propositions or variables
  - edges = dependencies as probabilities
- propagation of the probabilities
- problems:
  - relationships between the evidence and hypotheses are known
  - establishing and updating the probabilities

Dempster-Shafer theory

- belief about a proposition as an interval
  [belief, plausability] $\subseteq$ [0, 1]
- belief supporting A: Bel(A)
- plausability of A: Pl(A) = 1 − Bel($\neg A$)
- Bel(intruder) = 0.3, Pl(intruder) = 0.8
  - Bel(no intruder) = 0.2
  - 0.5 of the probability range is indeterminate

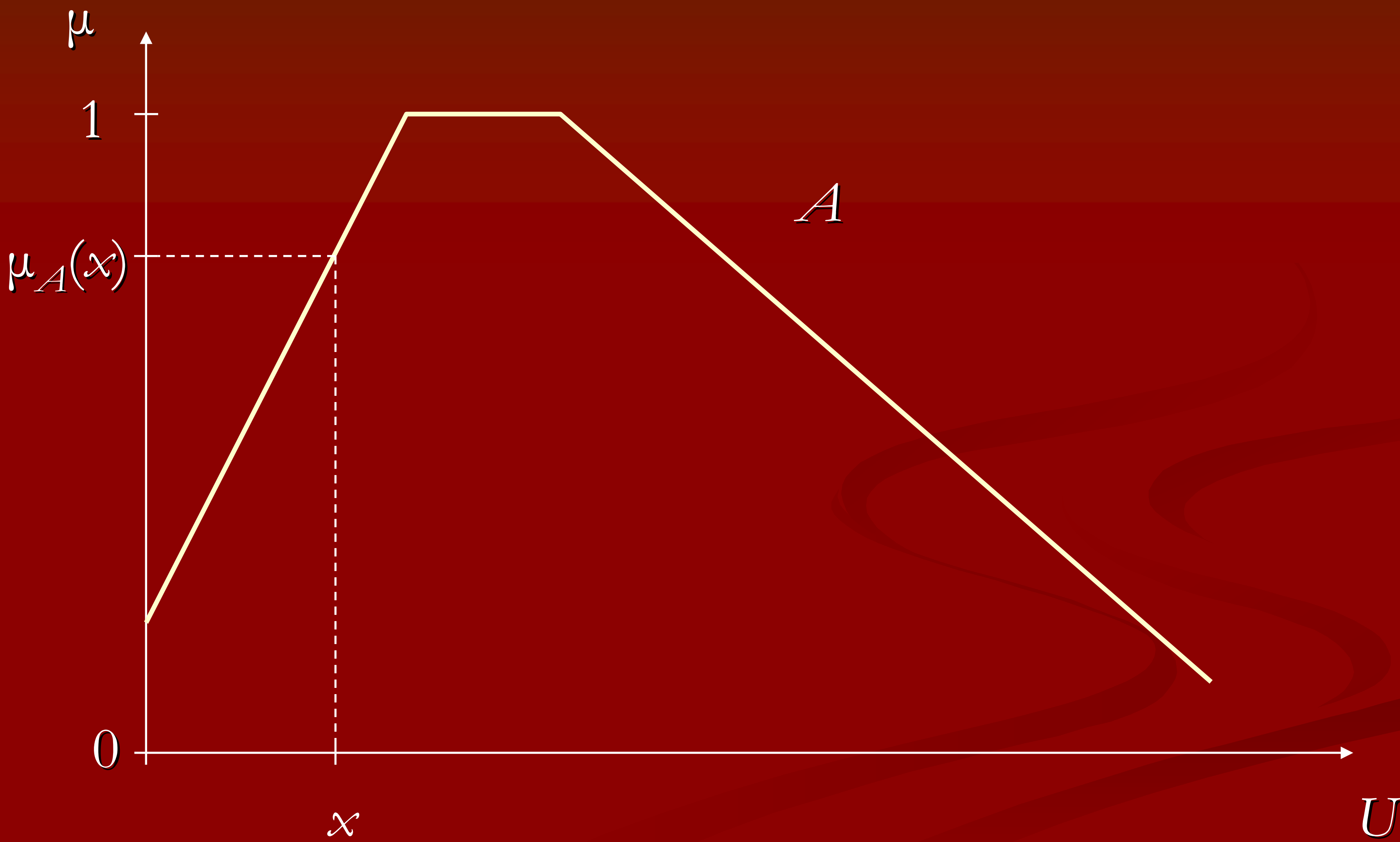
Belief interval



Fuzzy sets

- element x has a membership in the set A defined by a membership function $\mu_A(x)$
  - not in the set: $\mu_A(x) = 0$
  - fully in the set: $\mu_A(x) = 1$
  - partially in the set: $0 < \mu_A(x) < 1$

Membership function

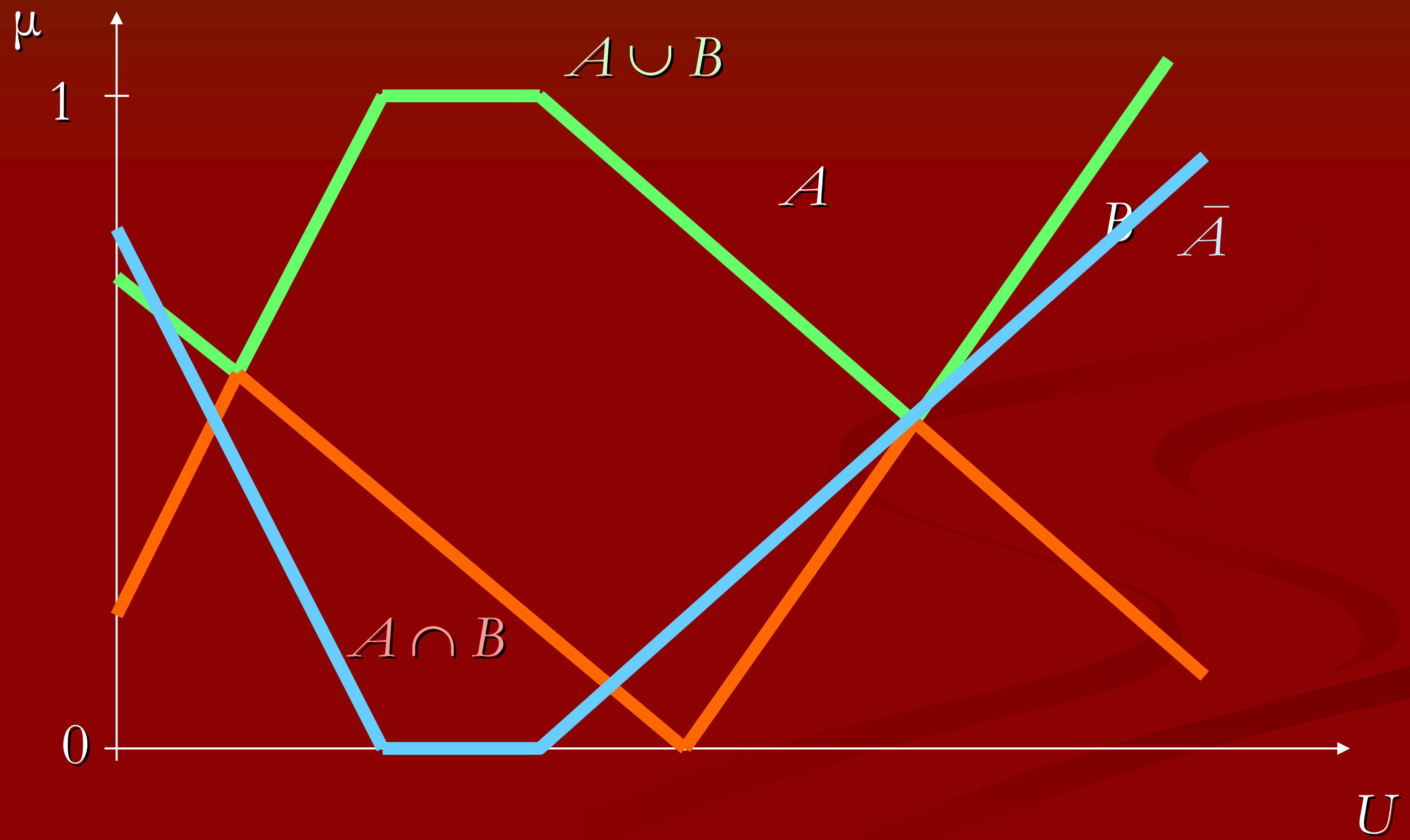


Fuzzy operations

- union: $\mu_C(x) = \max\{\mu_A(x), \mu_B(x)\}$
- intersection: $\mu_C(x) = \min\{\mu_A(x), \mu_B(x)\}$
- complement: $\mu_C(x) = 1 - \mu_A(x)$

- note: operations can be defined differently

Fuzzy operations (cont'd)



Uses for fuzzy sets

- approximate reasoning
- fuzzy constraint satisfaction problem
- fuzzy numbers
- almost any ‘crisp’ method can be fuzzified!