Reasoning under Uncertainty: Issues and Other Approaches

Course: CS40022
Instructor: Dr. Pallab Dasgupta

Department of Computer Science & Engineering
Indian Institute of Technology Kharagpur

Default reasoning

- Some conclusions are made by default unless a counter-evidence is obtained
  - Non-monotonic reasoning
- Points to ponder
  - Whats the semantic status of default rules?
  - What happens when the evidence matches the premises of two default rules with conflicting conclusions?
  - If a belief is retracted later, how can a system keep track of which conclusions need to be retracted as a consequence?

Issues in Rule-based methods for Uncertain Reasoning

- Locality
  - In logical reasoning systems, if we have A $\Rightarrow$ B, then we can conclude B given evidence A, *without worrying about any other rules*. In probabilistic systems, we need to consider *all* available evidence.

Issues in Rule-based methods for Uncertain Reasoning

- Detachment
  - Once a logical proof is found for proposition B, we can use it regardless of how it was derived (*it can be detached from its justification*). In probabilistic reasoning, the source of the evidence is important for subsequent reasoning.

Issues in Rule-based methods for Uncertain Reasoning

- Truth functionality
  - In logic, the truth of complex sentences can be computed from the truth of the components. Probability combination does not work this way, except under strong independence assumptions.

A famous example of a truth functional system for uncertain reasoning is the *certainty factors model*, developed for the Mycin medical diagnostic program

Dempster-Shafer Theory

- Designed to deal with the distinction between *uncertainty* and *ignorance*.
- We use a belief function *Bel(X)* – probability that the evidence supports the proposition
- When we do not have any evidence about X, we assign Bel(X) = 0 as well as Bel($\neg$X) = 0

Dempster-Shafer Theory

For example, if we do not know whether a coin is fair, then:

Bel(Heads) = Bel(¬Heads) = 0

If we are given that the coin is fair with 90% certainty, then:

Bel(Heads) = 0.9 X 0.5 = 0.45

Bel(¬Heads) = 0.9 X 0.5 = 0.45

Note that we still have a gap of 0.1 *that is not accounted for by the evidence*

Fuzzy Logic

- Fuzzy set theory is a means of specifying how well an object satisfies a vague description
  - Truth is a value between 0 and 1
  - Uncertainty stems from lack of evidence, but given the dimensions of a man concluding whether he is fat has no uncertainty involved

Fuzzy Logic

- The rules for evaluating the fuzzy truth, T, of a complex sentence are

$$T(A \wedge B) = \min(T(A), T(B))$$
$$T(A \vee B) = \max(T(A), T(B))$$
$$T(\neg A) = 1 - T(A)$$