Informatics 2D: Reasoning and Agents

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Lecture 20a: Quantifying Uncertainty

Where are we?

Last time ...

- Previous part of course discussed planning as an efficient way of determining actions that will achieve goals
- Used more elaborate representations than in search, but avoided full complexity of logical reasoning
- Allowed uncertainty to some extent (e.g. conditional planning, replanning)
- However the approaches seen so far don't allow for a *quantification* of uncertainty

Today ...

- **Acting under uncertainty**

Handling uncertain knowledge

- So far we have always assumed that propositions are assumed to be true, false, or unknown
- But in reality, we have hunches rather than complete ignorance or absolute knowledge
- Approaches like conditional planning and replanning handle things that might go wrong
- But they don't tell us how likely it is that something might go wrong...
- And **rational decisions** (i.e. 'the right thing to do') depend on the relative importance of various goals and the **likelihood** that (and degree to which) they will be achieved

Handling uncertain knowledge

- To develop theories of uncertain reasoning we must look at the nature of uncertain knowledge
- Example: rules for dental diagnosis
  - A rule like $\forall p\ Symptom(p, Toothache) \Rightarrow Disease(p, Cavity)$ is clearly wrong
  - Disjunctive conclusions require long lists of potential diagnoses:

$$\forall p\ Symptom(p, Toothache) \Rightarrow$$
$$Disease(p, Cavity) \vee Disease(p, GumDisease) \vee Disease(p, Abscess) \ldots$$

  - Causal rules like $\forall p\ Disease(p, Cavity) \Rightarrow Symptom(p, Toothache)$ can also cause problems
  - Even if we know all possible causes, what if the cavity and the toothache are not connected?

Uncertain knowledge, logic, and probabilities

- Clearly, using (classical) logic is not very useful to capture uncertainty, because of ...
  - complexity (can be impractical to include all antecedents and consequents in rules, and/or too hard to use them)
  - theoretical ignorance (don't know a rule completely)
  - practical ignorance (don't know the current state)
  - How *likely* an unknown factor is influences how we reason and act
- One possible approach: express **degrees of belief** in propositions using **probability theory**

  Probability can **summarise** *the uncertainty that comes from our 'laziness' and ignorance*
- Probabilities between 0 and 1 express the degree to which we believe a proposition to be true

Degrees of belief and probabilities

- In probability theory, propositions themselves are actually true or false!
- **Degrees of truth** are the subject of other methods (like **fuzzy logic**) not dealt with here
- Degrees of belief depend on **evidence** and should change with new evidence
- Don't confuse this with change in the world that might make the proposition itself true or false!
- Before evidence is obtained we speak of **prior/unconditional probability**, after evidence of **posterior probability**

Summary

- We are rarely completely uncertain about things we don't know.
- We can use probabilities to express our confidence in whether a proposition is true, or false.
- Quantifying uncertainty is critical for intelligent decision making, because it contributes to quantifying **risk**.