Escola Tècnica Superior d'Enginyeria
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[DΣIM]

Approximate Reasoning

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Reasoning under Uncertainty with Probabilistic Models

MESIIA – MIA

Probability theory

- It is a branch of Mathematics, and the basis of Statistics.
- It deals with random variables (or stochastic processes), for which there is not a deterministic value.
- So, there is some uncertainty about the true value of some variable.

Probability theory in rule-based reasoning systems

- Rules: evidences $\rightarrow$ conclusion   ($e \rightarrow c$)
- The Bayes Theorem gives a method to calculate a probability "a posteriori" $p(c|e)$ from a probability "a priori" $p(c)$.
- This is a way to calculate how change the probability of $p(c)$ when new information is obtained.

$$p(c|e) = \frac{p(e|c) \cdot p(c)}{p(e)}$$

Probability Theory: assumptions

- Having rules of the form:

  evidences $\rightarrow$ conclusion (e$\rightarrow$c)

1. The elements in C must be mutually independent. We can reason about each c individually.
2. The elements in E must be conditionally independent with respect to the conclusion c.
3. A large number of input data is required (individual and conditioned probabilities), which makes it not feasible for some problems

Probability Theory: assumptions

- Conditional Independence:
  - Vi and Vj are conditionally independent with respect to W if

$$p(V_i, V_j \mid W) = p(V_i \mid W) \cdot p(V_j \mid W)$$

- Variables mutually independent if:

$$p(V_i, V_j) = p(V_i) \cdot p(V_j)$$

Probability Theory

- If temperature<10 & cloud>70% & humidity>80% => rain
- When the evidences have several variables, it is not feasible to introduce all the conditional probabilities for all the possible values.

  $$\mathrm{Prob}(t<10, c>70, h>80 \mid rain),$$

  $$\mathrm{Prob}(t>10, c>70, h>80 \mid rain) \ldots$$

- Thus, we assume conditional independence of the variables:

  $$\mathrm{Prob}(t<10, c>70, h>80 \mid rain) = \mathrm{Prob}(t<10 \mid rain)\mathrm{Prob}(c>70 \mid rain)\mathrm{Prob}(h>80 \mid rain)$$

Probability Theory

- Probability theory is the best-established technique to deal with inexact knowledge and random data.
- It works well in such areas where statistical data is usually **available** and **accurate probability statements** can be made.
- However, in many areas of possible applications of expert systems, reliable statistical information is **not available** or **we cannot assume the conditional independence of evidence.**