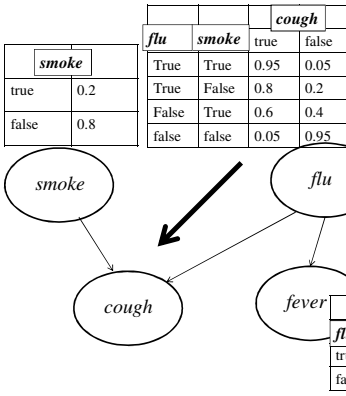
Reasoning under uncertainty 2



smoke	
true	0.2
false	0.8

flu	smoke	cough: true	cough: false
True	True	0.95	0.05
True	False	0.8	0.2
False	True	0.6	0.4
false	false	0.05	0.95

flu	
true	0.01
false	0.99

flu	fever: true	fever: false
true	0.9	0.1
false	0.2	0.8

Conditional probability tables for each node

Semantics of Bayesian networks

- If network is correct, can calculate full joint probability distribution from network.

$$P(X_1 = x_1 \wedge \ldots \wedge X_n = x_n)$$

$$= \prod_{i=1}^{n} P(X_i = x_i \mid parents(X_i))$$

where parents(X_i) denotes specific values of parents of X_i.

1. What is unconditional (marginal) probability that *fever* is true?

$$P(fever) = P(fever \mid flu)\,p(flu) + p(fever \mid \neg flu)\,p(\neg flu)$$
$$= (.9)(.01) + (.2)(.99) = .207$$

2. Now, instantiate evidence *flu* = *true*. What is $P(fever \mid flu)$?

$P(fever \mid flu) = .9$ (up from .207) **Causal inference**

3. Now, instantiate evidence *fever* = true. What is $P(flu \mid fever)$?

$$P(flu \mid fever) = \frac{P(fever \mid flu)P(flu)}{P(fever)} = \frac{(.9)(.01)}{.207} = .043 \text{ (up from .01)}$$

Diagnostic inference

4. What is the unconditional (marginal) probability that cough is true?

$$P(cough) = P(cough \mid flu, smoke)\,p(flu)\,p(smoke)$$
$$+ P(cough \mid flu, \neg smoke)\,p(flu)\,p(\neg smoke)$$
$$+ P(cough \mid \neg flu, smoke)\,p(\neg flu)\,p(smoke)$$
$$+ P(cough \mid \neg flu, \neg smoke)\,p(\neg flu)\,p(\neg smoke)$$
$$= (.95)(.01)(.2) + (.8)(.01)(.8)$$
$$+ (.6)(.99)(.2) + (.05)(.99)(.8) = .167$$

5. What is P(*flu*|*cough*)?

$$P(flu \mid cough) = \frac{P(cough \mid flu)P(flu)}{P(cough)} =$$
$$\frac{[P(cough \mid flu, smoke)\,p(smoke) + P(cough \mid flu, \neg smoke)\,p(\neg smoke)]P(flu)}{p(cough)}$$
$$= \frac{[(.95)(.2) + (.8)(.8)](.01)}{.167} = .0497$$

Diagnostic inference

5. What is P(*flu*|*cough*,*smoke*)?

$$P(flu \mid cough, smoke) = \frac{p(flu \wedge cough \wedge smoke)}{p(cough \wedge smoke)}$$

$$= \frac{p(cough \mid flu, smoke)\, p(flu)\, p(smoke)}{p(cough \mid flu, smoke)\, p(flu)\, p(smoke) + p(cough \mid smoke, \neg flu)\, p(smoke)\, p(\neg flu)}$$

$$= (.95)(.01)(.2) / [(.95)(.01)(.2) + (.6)(.2)(.99)]$$

$$= 0.016$$

causal inference (or "explaining away")

Why is P(*flu*|*cough*,*smoke*) < P(*flu*|*cough*)?

Types of inference

- Diagnostic inference
  - Evidence is effect, inference is probability of cause
    - Example
- Causal inference
  - Evidence is cause, inference is probability of effect
    - Example
- Inter-causal inference
  - Explain away different possible causes of effect
    - Example

Real-World Example 1: The Lumière Project at Microsoft Research

- Bayesian network approach to answering user queries about Microsoft Office.
- *"At the time we initiated our project in Bayesian information retrieval, managers in the Office division were finding that users were having difficulty finding assistance efficiently."*
- *"As an example, users working with the Excel spreadsheet might have required assistance with formatting "a graph". Unfortunately, Excel has no knowledge about the common term, "graph," and only considered in its keyword indexing the term "chart".*

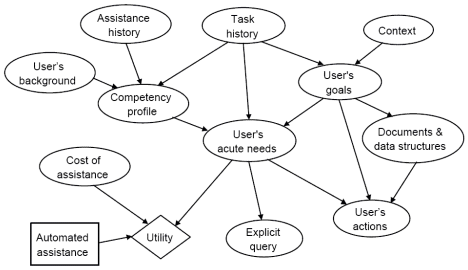


Figure 1: An influence diagram for providing intelligent assistance given uncertainty in a user's background, goals, and competency in working with a software application.

- Networks were developed by experts from user modeling studies.

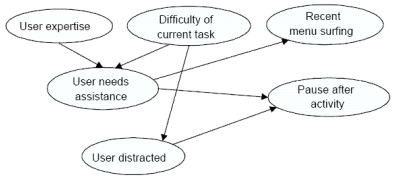


Figure 2: A portion of a Bayesian user model for inferring the likelihood that a user needs assistance, considering profile information as well as observations of recent activity.

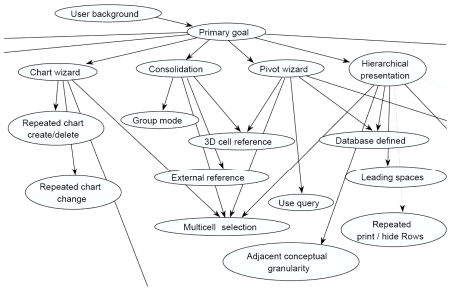


Figure 3: Partial structure of an early formulation of a Bayesian user model for inferring a user's needs for the Excel spreadsheet application.

- Offspring of project was *Office Assistant* in Office 97.
- Video