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Introduction to Intelligent Systems

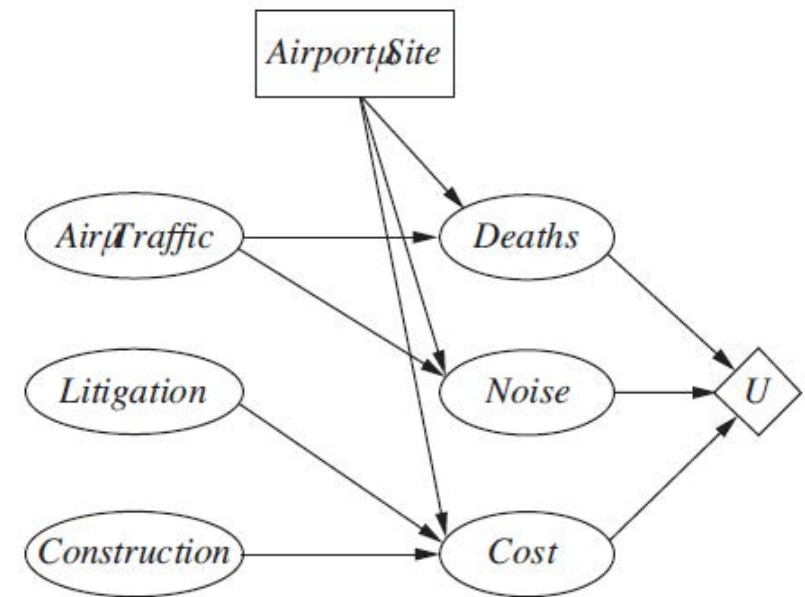
Prof. Songhwai Oh
ECE, SNU

DECISION NETWORKS

Decision Networks

Decision network: represents information about the agents current state, its possible actions, the state that will result from the agents action, and the utility of that state.

- **Chance nodes** (ovals): represent random variables similar to Bayesian networks. The parent nodes can include decision nodes as well as chance nodes.
- **Decision nodes** (rectangles): represent points where the decision maker has a choice of actions.
- **Utility nodes** (diamonds): represent the agents utility function (a.k.a. value nodes). The utility node has as parents all variables describing the outcome that directly affect utility.



Evaluating Decision Networks

1. Set the evidence variables for the current state.
2. For each possible value of the decision node:
 - (a) Set the decision node to that value.
 - (b) Calculate the posterior probabilities for the parent nodes of the utility node, using a standard probabilistic inference algorithm.
 - (c) Calculate the resulting utility for the action.
3. Return the action with the highest utility.

Value of Information

Example:

- An oil company is hoping to buy one of n indistinguishable blocks of ocean-drilling rights. Exactly one of the blocks contains oil worth C dollars, while the others are worthless. The asking price of each block is C/n dollars.
- Now suppose that a seismologist offers the company the results of a survey of block number 3, which indicates definitively whether the block contains oil.
- How much should the company be willing to pay for the information?

There are two possible outcomes:

- With probability $1/n$, the survey will indicate oil in block 3. In this case, the company will buy block 3 for C/n dollars and make a profit of $C - C/n = (n-1)C/n$ dollars.
- With probability $(n-1)/n$, the survey will show that the block contains no oil, in which case the company will buy a different block. Now the probability of finding oil in one of the other blocks changes from $1/n$ to $1/(n-1)$, so the company makes an expected profit of $C/(n-1) - C/n = C/n(n-1)$ dollars.

The expected profit given the survey information is

$$\frac{1}{n} \times \frac{(n-1)C}{n} + \frac{n-1}{n} \times \frac{C}{n(n-1)} = C/n .$$

Value of Perfect Information (VPI)

- Given initial evidence $\mathbf{e}$, the value of the best action α is

$$EU(\alpha|\mathbf{e}) = \max_a \sum_{s'} P(Result(a) = s' | a, \mathbf{e}) U(s').$$

- The value of the new best action after observing the new evidence $E_j = e_j$ is

$$EU(\alpha_{e_j} | \mathbf{e}, e_j) = \max_a \sum_{s'} P(Result(a) = s' | a, \mathbf{e}, e_j) U(s').$$

- Value of perfect information** for E_j given $\mathbf{e}$ is

$$VPI_{\mathbf{e}}(E_j) = \sum_k P(E_j = e_{jk} | \mathbf{e}) EU(\alpha_{e_{jk}} | \mathbf{e}, E_j = e_{jk}) - EU(\alpha | \mathbf{e}).$$

- Properties:

- Nonnegative: $VPI_{\mathbf{e}}(E_j) \geq 0$ for all $\mathbf{e}, E_j$.
- Not additive: $VPI_{\mathbf{e}}(E_j, E_k) \neq VPI_{\mathbf{e}}(E_j) + VPI_{\mathbf{e}}(E_k)$ in general.
- Order independent: $VPI_{\mathbf{e}}(E_j, E_k) = VPI_{\mathbf{e}}(E_j) + VPI_{\mathbf{e}, e_j}(E_k) = VPI_{\mathbf{e}}(E_k) + VPI_{\mathbf{e}, e_k}(E_j)$.

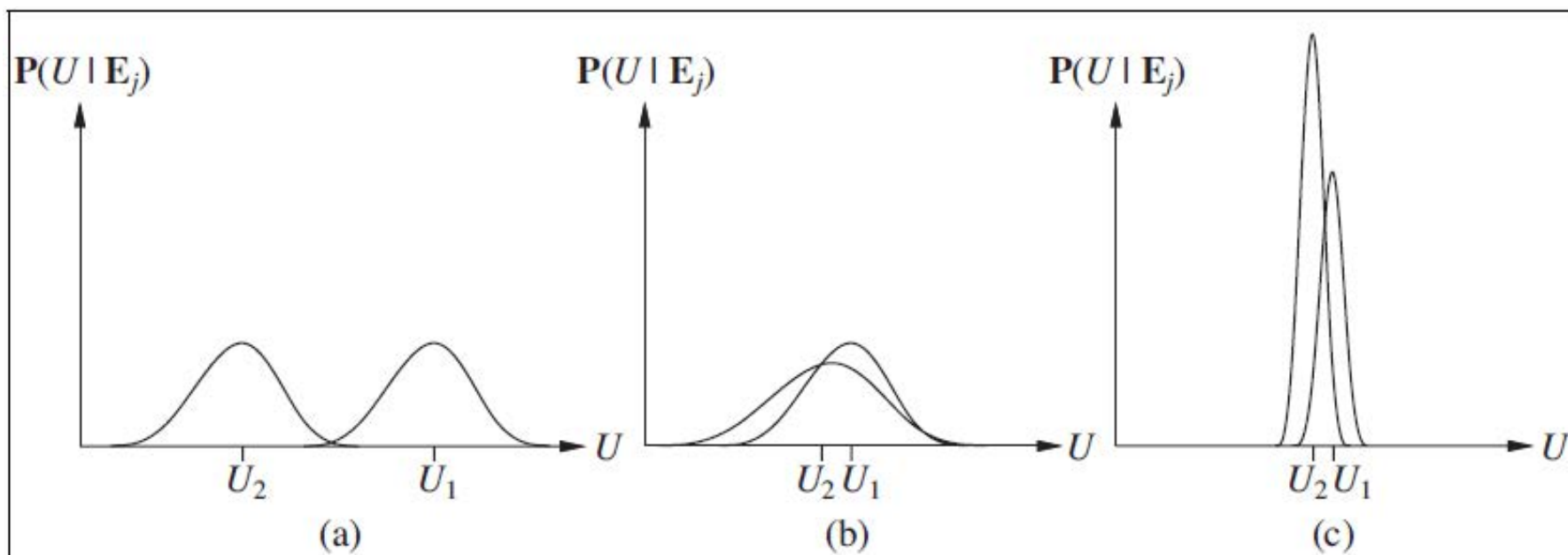


Figure 16.8 Three generic cases for the value of information. In (a), a_1 will almost certainly remain superior to a_2 , so the information is not needed. In (b), the choice is unclear and the information is crucial. In (c), the choice is unclear, but because it makes little difference, the information is less valuable. (Note: The fact that U_2 has a high peak in (c) means that its expected value is known with higher certainty than U_1 .)