Decision Analysis
Part 3:
Influence Diagrams

Motivation for Influence Diagrams
Decision trees:
• sometimes too detailed.
• grow exponentially.
• contain repeated information.

Influence Diagram
Influence diagrams are:
• high-level (compact),
• visual representation,
• displaying relationships between essential elements that
  affect the decision.

Two levels of detail:
• higher: only elements and relations
• lower: detailed information defined with each element

Elements of Influence Diagrams
Decision node:
represents alternatives

Chance node:
represents events (states of nature)

Value node:
represents consequences, objectives, or calculations

Working Example
Decision tree:

Working Example
Equivalent Influence diagram:
Arcs in Influence Diagrams

- Decision A affects the probabilities of event B; Decision A is relevant for event B.
- The outcome of event A affects the probabilities of event B; Event A is relevant for event B.
- Decision A occurs before decision B; Decisions A and B are sequential.
- Decision B occurs after event A; The outcome of A is known when deciding about B.

Developing Influence Diagrams

Two basic strategies:
- Start with outcomes and model towards decisions and events
- Gradually add more and more detail

Common Mistakes

1. An influence diagram is not a flowchart.
2. An arc from a chance node into a decision node means that the decision-maker knows the outcome of the chance node when making the decision.
3. There can be no cycles:

Decision Trees: Influence Diagrams

- DT display more information, the details of a problem, but they may become "messy".
- ID show a general structure of a problem and hide details.
- ID are particularly valuable for the structuring phase of problem solving and for representing large problems.
- Solving algorithms: DT straightforward, ID difficult.
- Any properly built ID can be converted into a DT, and vice versa.
- Bayesian networks are ID’s containing only event nodes

Solving Influence Diagrams

A. Convert ID to DT; solve DT or
B. Solve directly by node reduction:
   1. Clean up: one can assume no C; no cycles, transform calculation nodes to one-event chance nodes...
   2. Repeat until ID solved:
      1. Reduce (cancel out) all chance nodes that directly precede C and do not provide any other nodes.
      2. Reduce (cancel out) the decision node that directly precedes C and has as predecessors all of the other direct predecessors of C.
      3. Arc reversal where there are no nodes corresponding to 2,2

Influence Diagram Software

Add-ins for Microsoft Excel:
- PrecisionTree: http://www.palisade-europe.com/presc/ontree/

Influence-Diagram Development Programs
- GeNe: http://gene.es.pitt.edu/
- TreeAge Pro (DATA): http://www.treeage.com/
- DRL: http://www.drlsoftware.com/
- Analytica: http://www.sional.com/andwhatsana.htm
- HUGIN: http://www.hugin.com/
- Netica: http://www.noibel.com/

•2
Sequential Decision
Introduce product, set price
do not introduce

introduce
no competitor (.2)
high 500
medium 300
low 100

competitor (.8)
high (.3) 150
medium (.5) 0
low (.2) -200

medium
high (.1) 250
medium (.6) 100
low (.3) -50

low
high (.1) 100
medium (.2) 50
low (.7) -100

EMV: 0
EMV: 500
EMV: 5
EMV: 70
EMV: 70
EMV: 156

Introduce Product?
Profit

Revenue
Cost

Example 1: Gradual Development (1/3)
Influence diagram of a new product decision

Example 1: Gradual Development (2/3)
Influence diagram with additional detail

Several decisions and outcomes are shown, including the introduction of a product with different possible outcomes for revenue, cost, and profit. The outcomes are categorized into high, medium, and low, with associated probabilities and EMV calculations.
Exercise 4
Create influence diagrams representing the decision trees encountered so far:
1. Oilco
2. Take an umbrella
3. Service station

Exercise 5: Tractor Buying (1/3)
- Your uncle is going to buy a tractor. He has two alternatives:
  1. A new tractor (17,000 €)
  2. An old tractor (14,000 €)
- The engine of the old tractor may be defective, which is hard to ascertain. Your uncle estimates a 15% probability for the defect.
- If the engine is defect, he has to buy a new tractor and gets 2000 € for the old one.
- Before buying, your uncle can take the old tractor to a garage for an evaluation, which costs 1500 €:
  - If the engine is OK, the garage can confirm it with an exception.
  - If the engine is defective, there is a 70% chance that the garage does not notice it.

Exercise 5: Tractor Buying (2/3)

Exercise 5: Tractor Buying (3/3)
Do the following:
1. Solve the decision tree
2. Develop equivalent influence diagram:
   1. structure of nodes
   2. detailed node data (names, values, probabilities)