Decision Analysis
Part 3: Influence Diagrams

Working Example

Decision tree:

- Alternatives: status quo, extend, build, cooperate
- Events (states): decreased sales (0.25), increased sales (0.75)
- Expected profit:
  - Decreased sales (0.25): 28, 30
  - Increased sales (0.75): 24, 24, 42, 16, 44, 30, 34

Motivation for Influence Diagrams

Decision trees:
- Sometimes too detailed,
- Grow exponentially,
- Contain repeated information.
Working Example

Equivalent Influence Diagram

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
### Arcs in Influence Diagrams

- **A** → **B**: Decision A affects the probabilities of event B; Decision A is relevant for event B.
- **A** ← **B**: The outcome of event A affects the probabilities of event B; Event A is relevant for event B.
- **A** ← **B**: Decision A occurs before decision B; Decisions A and B are sequential.
- **A** → **B**: 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. Cleanup: one do no sequence C, no cycles, transform calculation nodes to one-event chance nodes—
   2. Repeat until ID solved:
      1. Reduce calculate Z(Y) all chance nodes that directly proceed C and do not proceed any other node.
      2. Repeat calculate Z(Y) the final set of net that directly proceed C and has as pre-precursors all of the other pre-precursors of C + any remain where the re are no nodes correspond to 2.2

Influence Diagram Software

Add-ins for Microsoft Excel:
- PrecisionTree: http://www.palisade-software.com/presiciontree/

Influence Diagram Development Programs:
- Genie: http://gen.eas.asu.edu/
- TreeAge Pro (DATA): http://www.treeage.com/
- HUGIN: http://www.hugin.com/
- Netica: http://www.norisys.com/
Exercises

Exercise 1: DATA

Exercise 2: GeNle
Example 1: Gradual Development (3/3)

Example 2: Multiple Objectives (1/2)
Influence diagram of a venture capitalist’s decision

Example 2: Multiple Objectives (2/2)
Example 3: Intermediate Calculations

Example 4: Evacuation Decision (1/2)

Example 4: Evacuation Decision (2/2)
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 used tractor (14 000 €)
- The engine of the old tractor may be defected, which is hard to ascertain. Your uncle estimates a 15% probability for the defected.
- If the engine is defected, 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 1 500 €.
  - If the engine is OK, the garage can confirm it with 95% exception.
  - If the engine is defective, there is a 20% chance that the garage does not notice it.

Exercise 5: Tractor Buying (2/3)

[Diagram showing decision tree with nodes for evaluation, new tractor, old tractor, defect, no defect, and monetary outcomes.]
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)