Introduction to Decision Support

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Addressed Topics

• Decision Making and Decision Support:
  – Basic concepts and definitions
  – Overview of scientific disciplines

• Decision Support at JSI
  with examples of projects and applications

• Rationale for including this topic in this ICT programme

Symbols

Important topic:
• required understanding
• possible exam questions

Related to contents of other ICT courses
Pay attention to related slides above or below

Decision Making

Decision:
Conscious and deliberate selection of one alternative (option) from a set of possible ones in order to satisfy the goals of the decision maker(s).

Making a decision:
• involves an irrevocable allocation of resources (time, money, effort, ...)
• has consequences
• is inherently subjective (subject to individual and/or societal values)

Decision Process

Decision Making:
Is a process that involves:
• identification of the decision problem;
• collecting and verifying relevant information;
• identifying decision alternatives;
• anticipating consequences of decisions;
• making the decision;
• providing rationale for the decision;
• implementing the selected alternative;
• evaluating the consequences of the decision.

Examples of Decision Problems

• Buying everyday goods
• Buying a car
• Buying a computer
• Choosing an apartment
• Buying a house
• Choosing a job
• Selecting an employee
• Study-related decisions:
  – which profession, university, study programme, course, ...
• ...
• Investment decisions
• Medical decisions
• ...

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• ...
• Investment decisions
• Medical decisions
• ...
Example 1: Clay-Pit Location

Example 2: Electric Energy Production Strategy in Slovenia

Project OJVE 2013-2014

Aims of the study:

- Identify reliable, rational, and environmentally sound production of electric energy in Slovenia by 2050
- Consider technologies: hydro, coal, oil, gas, nuclear, biomass, photovoltaic, wind
- Assess individual technologies and technology mixtures


Example 3: Medication Change for Parkinson’s Disease Patients

Yes-No: Whether or not to change medication?

- Increase/decrease dosage/intake
- Change medication A with B
- Start/stop using medication C

Input data:
Patient’s symptoms, current therapy

Model(s): Medication Change

Decision Making: Disciplines

Who or what is making decisions?

human
computer

Decision Sciences

Descriptive

Decision Support

Decision Making: Disciplines

Decision Making

Who or what is making decisions?

human
computer

Decision Sciences

Decision Systems

Honda Asimo

Curiosity Mars Rover

Decisions Systems

- computers
- intelligent programs and systems
- robots and autonomous systems
**Decision Making: Disciplines**

- Decision Making: Who or what is making decisions?
  - Human
  - Computer

- Decision Sciences
  - Decision Systems
  - Decision Systems

- Normative
  - Descriptive
  - Decision Support

**Preference Relations**

Preference: we like/desire/prefer one thing over another.

Preference relations:
- $a \sim b$: indifference
- $a > b$: strict preference
- $a \succ b$: weak preference

Some properties:
1. Given any $a$ and $b$, then $a > b$, $a \sim b$ or $a < b$
2. If $a > b$ and $b > c$, then $a > c$
3. If $a > b$ and $b > c$, then $a > c$
4. If $a \succ b$, then $a > b$ or $a \sim b$

Preference relations are subjective!

**Utility Theory, Value Theory**

Utility functions (or value functions):
- $a \sim b \iff u(a) = u(b)$
- $a > b \iff u(a) > u(b)$

**Decision Theory**

Decision table:

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Take umbrella</th>
<th>Do not take umbrella</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status</td>
<td>Rain</td>
<td>No rain</td>
</tr>
<tr>
<td>Rain</td>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>No rain</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Types of decisions:
- Certainty: all relevant parameters have known values
- Risk: certain future events have probable outcomes
- (Strict) Uncertainty: impossible to assess the likelihood of future events

**Decision Trees**

Decision table:

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</table>

**Other Theoretical Approaches**

- Bayesian decision theory
- Multi-attribute utility theory
- Multi-stage problems
- Group decisions
- Game theory
- ...
Decision Making: Disciplines

Decision Making
- Who or what is making decisions?
  - human
  - computer

Decision Sciences
- Normative
  - rational decision making: utility theory ...
  - descriptive decision making: cognitive sciences ...

Decision Systems
- descriptive decision making: social sciences ...

Decision Support

MindMaps

What is Decision Support?

Given the principles of rational decision making, knowing that actual decision making can be difficult for people, can we help the (human) decision makers to make better decisions?

Decision Support:
Providing methods and tools for supporting people in making difficult decisions

It is not: Making decisions instead or on behalf of people

How can we support decision making?

Decision Making: Disciplines

Decision Making
- Who or what is making decisions?
  - human
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- Normative
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Decision Systems
- descriptive decision making: social sciences ...

Decision Support

Dan Ariely: Predictably Irrational

- Decision Making: Disciplines
  - human
  - computer

Decision Sciences
- Normative
- Descriptive

Decision Support

MindMaps
Data Storage, Search and Retrieval

Data Cube
Pivot Table

Data Analysis and Data Mining

Central Decision Support Disciplines

Decision Support

- Decision Analysis
- Operational Research
- Decision Support Systems

Operational Research

- mathematical formulation of the decision problem
- searching for optimal solutions

Decision Analysis

- decision process, stages
- modeling
- evaluation and analysis
- finding 'sufficiently good' solutions

Evaluation Models

Alternatives
Performance variables
Evaluation model

Decision Analysis

**Decision Analysis: Applied Decision Theory**

Provides a framework for analyzing decision problems by:

- structuring and breaking them down into more manageable parts,
- explicitly considering the:
  - possible alternatives,
  - available information
  - uncertainties involved, and
  - relevant preferences
- developing models for the evaluation and analysis of alternatives
- following a systematic procedure (stages)
- with the aim to arrive at "sufficiently good" decisions ("satisficing")
Types of Models in Decision Analysis

- **Decision Trees**
- **Influence Diagrams**
- **Multi-Attribute Utility Models**

Examples of Decision Models

<table>
<thead>
<tr>
<th>pairwise comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

Decision Support Systems (DSS)

**Decision Support Systems:**
- interactive computer-based information systems
- that support decision-making activities

**Characteristics:**
- DSS incorporate both data and models;
- they are designed to assist managers in their decision processes in semi-structured (or unstructured) tasks;
- they support, rather than replace, managerial judgment;
- their objective is to improve the quality and effectiveness (rather than efficiency) of decisions.

Example: Traffic Control DSS

DEXi:

http://kt.ijs.si/MarkoBohanec/dexi.html

- model structure
- interactive computer-based informations systems
- decision tables
- acquisition and evaluation of alternatives
- analysis of alternatives: "what-if", "t1 analysis", comparison of alternatives, selective explanation
- tabular and graphical reports
1. Decision Analysis and Decision Modelling

- Decision Analysis
  - Decision Makers
  - Experts
  - Decision Analysts

- Evaluation
- Analysis

- Decision alternatives
  - A
  - B
  - C
  - D
  - E

2. Data Mining and Decision Modelling

- Data Mining
- Decision Analysis
- Decision model

3. Decision Support Systems

- Data Mining
- Decision Analysis
- Decision Support System

Clay-Pit Location Model

- SITE SUITAB
- ENVIRONMENT
- FEASIBILITY
- ATTRACT
- VULNERAB
- SOC-PSYCH
- TECHN
- ECONOM

Model for Electric Prod. Technologies

- Data
- Decision Analysis
- Decision model

DSS for Electric Prod. Technologies

http://sepo.ijs.si/naloge/OVJE/energetic_scenario_comparative_model/
Overview of Disciplines

- Decision Making
  - Decision Sciences
    - Normative: concerned with rational (ideal, theoretical) decision making
    - Descriptive: concerned with actual (human, practical) decision making
    - Decision Support: combining the two in order to help people in making decisions (and not to make decisions on behalf of them)
  - Decision Systems
  - Operational Research
  - Decision Analysis
  - Decision Support Systems

Take-Home Messages

- Decision is an act, decision-making is a process
- Decision Sciences vs. Decision Systems = human vs. machine decision making
- Main disciplines in Decision Sciences:
  - Normative: concerned with rational (ideal, theoretical) decision making
  - Descriptive: concerned with actual (human, practical) decision making
  - Decision Support: combining the two in order to help people in making decisions (and not to make decisions on behalf of them)
- Decision Support:
  - Very wide area, involving everything from “pen-and-pencil” to advanced AI systems
  - Central disciplines: Operational research, Decision analysis, Decision Support Systems
- Decision Analysis:
  - A systematic approach: structuring the decision problem and identifying its key elements
  - Developing and using models: decision trees, influence diagrams, multi-attribute models, ...
- Decision Support Systems: Information systems "aimed at decision support"
- Decision Support at JSI:
  - Key tasks and projects: developing decision models and DSSs for solving complex decision problems
  - Key approaches: expert modelling, possibly combined with data mining and optimization
  - Key tool: DEXi, software for developing qualitative multi-attribute models