An overview of *Decision Analysis*

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Aims of the lecture

● “Decision”
  ≫ Many different types
  ≫ Many different techniques for “decision aiding”
    (decision analysis)

● Give a general framework for thinking about decisions

● Put the various decision analysis techniques in perspective
Decision

- Philosophy
- Economics
- Psychology
- Sociology
- Political Science
- Computer Science
- Operational Research
- Biology?
- Theology?
Outline

- Classical view on decision
- Another view
- What can be expected?
- What should we take care of?
- What are the main types of models?
Outline

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- Another view
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Decision?

- **Classical view: Catastrophe, Bifurcation**
  - Conscious individual freely choosing between several courses of action (Reflection then commitment of resources and responsibility)

- **Culturally biased view + Philosophic difficulties**
  - Serious… but you are not interested in anthropology or philosophy

- **Practical difficulties**
  - Can we observe such decisions?
  - Empirical question (Organizational Behavior)
France (CEOs)

- 15% transports
- 5% visits
- 5% individuals interviews
- 30% internal meetings
- 10% external meetings
- 10% meals
- 15% telephone
- 5% reading / writing mail
- 2% writing
- 2% reading
- 1% solitary reflection (6 min./day)
- 0% computers

Transport 20%
Meetings 55%
Individual work 25%
UK managers

- 160 managers in the UK
  - Only 1 period every two days in which they work continuously on the same subject for 30 minutes
  - Only 1 verbal contact in 398 deals with organization/planning
  - On average 583 different activities within 8 hours
    - 0.82 min (50 sec.) per activity
Mintzberg’s Studies of Managers

● Myth #1: The manager is a reflective systematic planner
  ➤ **Fact:** Study after study shows managers work at an unrelenting pace, that their activities are characterized by brevity, variety, and discontinuity, they are strongly oriented toward action, and dislike reflective activities

● Myth #2: The effective manager has no regular duties to perform
  ➤ **Fact:** Managerial work involves performing a number of regular duties, including ritual and ceremony, negotiations, and processing of soft information that links the organization with its environment
Mintzberg’s Studies of Managers

● Myth #3: The senior manager needs aggregated information, which a formal management information system best provides
   ➔ Fact: Managers strongly favor *verbal media*, telephone calls, and meetings over documents

● Myth #4: Management is, or at least is quickly becoming, a science and a profession.
   ➔ Fact: The managers' programs (to schedule time, process information, make decisions, and so on) remain locked deep inside their brains.
Outline

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Decision

● **Provisional definition** [R. Howard]: Decision making is what you do when you do not know what to do

- Criteria: Anxiety, Fear, Hyper-vigilance
- Obvious symptoms
  - Scribbling on a sheet of paper / worksheet
  - Multiplication of meetings
  - Procrastination
  - Depression / Enthusiasm
- Origin of anxiety
  - High / complex stakes
  - Uncertainty / Time horizon / Multiples objectives
Three classical attitudes

● Recourse to an *omen* (tell me what is good)
  - Intuition / Charismatic leader / Expert / Authority

● Perform *ritual sacrifices* (tell me who is to blame)
  - René Girard: *Things hidden since the foundation of the world, The scapegoat*

● Buy a *consulting study* (tell me what to do)

Let someone else carry your anxiety

Decision analytic tools = Tools for managing anxiety
(without letting someone else carry it)
Outline

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- Another view
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- What should we take care of?
- What are the main types of models?
What Decision Analysis is not (1/2)

- A general method for taking "good decisions"
  
  *Example*
  
  - Choice 1: [Heads] 1000 € [Tails] 0 €
  - Choice 2: [Heads Heads] 5000 € [Otherwise] 0 €
  
  *Example*
  
  - Choice of new job, medical decision, etc.

- What is a "good decision"?
  
  - Good for whom, according to what criteria, at which moment in time?

- Good decision process vs. good decision
  
  - Japanese shoemaker
What Decision Analysis is not (2/2)

● A description of how “wise people” decide
  ➔ Are wise people always right?
    ● Doctors / Politicians
    ● Nuclear Industry vs. Road safety
      ➔ 5 000 000 vs. 140 000 (USD 1978)
  ➔ How do you recognize “wise people”?
    ● Luck vs. Wisdom
    ● Gurus and markets

● What can we do then?
Example: rolling a dice

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- **Natural (intuitive) but deceptive reasoning**
Decision Analysis

Definition (B. Roy): “...consists in trying to provide elements of answer to questions raised by actors involved in a decision process using a model...”

- decision process
- elements of answer
- model
Decision Process

● Time

● Multiple actors

● Organization
  ➡ links with other processes
  ➡ power

● Milestones vs. final result
  ➡ alternatives created / rejected
  ➡ fragments of decisions
  ➡ feedback
Decision Making and Decision Processes

● Decision Making ≠ “solving” a well-defined problem

● Intervention in a decision process
  ➢ imagine compromises
  ➢ communicate
  ➢ coordinate
  ➢ control
  ➢ motivate
  ➢ conduct change

● Final choice
  ➢ only part of the job

● Strategy of intervention
  ➢ Many different (good) ways to provide decision-aid
Several uses of Decision Analysis

● *Ex ante* use
  ➥ trying to reach a conclusion

● *Ex post* use
  ➥ insurance policy
  ➥ convince others
  ➥ kill another project
  ➥ delay the decision
  ➥ ...

Coimbra – January 2006 – 22
Elements of answer

● No mention is made of:
  ➔ Optimal solutions
  or even
  ➔ Good decisions

● Consistent with our view on decision...

● ...but raises the question of judging the quality of decision analysis
Models

● Variety of models
  ➔ explicit or not
  ➔ formalized or non-formalized
  ➔ abstract (domain independent) or not

● Examples of models
  ➔ Astrology, Graphology, Psycho-analysis
    ● the astrologer “provide answers to questions raised by his/her client using a model”

● Decision analysis mainly makes use of explicit, abstract and formalized models
Formalized Models

● Drawbacks
  ➔ Complex
  ➔ Opaque
  ➔ Costly

● Advantages
  ➔ Provide a clear language (reducing ambiguity)
    ● communication tools
  ➔ Capture the essence of a situation
    ● structuration tools
  ➔ Answers what-if questions (sensitivity, robustness)
    ● Exploration tools

● Example: choosing a bottle of wine
Possible Objections to the study of such tools

- *We* do not need such tools because *we* know how to decide
- *Intuition* is often enough
- Let’s organize a high-level *meeting* to discuss it
I do not need it

- OK but:
  - What makes you so sure?
  - How will you convince your Boss?
  - How will you avoid being a scapegoat?
Intuition?

- Doctors

- New England Journal of Medicine
  - Tonsillectomy
  - Experts (3 groups) + Clinical Tableaus

389 child

- 45% Yes
- 55% No

- 46% Yes
- 54% No

- 44% Yes
- 56% No
Do-it-yourself example

You are confronted with the *double* decision problem:

**Problem 1.** Choose between

- Option A = sure gain of 1200 €
- Option B = gain of 5000 € with probability 25%, no gain with probability 75%

**Problem 2.** Choose between:

- Option C = sure loss of 3750 €
- Option D = loss of 5000 € with probability 75 %, no loss with probability 25%

● Make your own choices!
Results (D. Kahneman / A. Tversky)

 Modal choice = A & D (73%)
Trap # 6

Shooting from the hip

● “Believing that you can keep straight in your head all the information you’ve discovered, and therefore “winging it” rather than following a systematic procedure when making the final choice”

Russo & Shoemaker
Meetings?

- **Asch experiment**

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<tr>
<th>Test</th>
<th>A</th>
<th>B</th>
<th>C</th>
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- **99% correct answers**
  - 1 person says A  error rate = 3%
  - 2 person say A  error rate = 13%
  - 3 person say A  error rate = 33%
  - Bonus for correct consensus  error rate = 47%
Trap # 7

Group failure

- “Assuming that with many smart people involved, good choices will follow automatically, and therefore failing to manage the group decision-making process”

Russo & Shoemaker
Optical Illusions

- Why illusions should only be limited to vision?
- Besides we use “vision” far more often than “decision”
What can be expected?

Criteria for good decision processes

- Separate “facts” and “values”
- Separate “robust” from “fragile” conclusions
- Improve communication
- Foster consistent reasoning
- Draw attention to counter-intuitive and perverse effects
- Promote open debate and discussion
- Promote partial agreements
- Promote reflection on objectives
Outline

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Simple Model of Decision Process

Herbert A. Simon (NP 1978)

Intelligence

Design

Choice
Trap # 1

Plunging In

● “Beginning to gather information and reach conclusions without taking first a few minutes to think about the crux of the issue you’re facing or to think how you believe decisions like this one should be made”

Russo & Shoemaker
Trap # 10

Failure to audit your decision process

● “Failing to create an organized approach to understanding your own decision-making, so you remain constantly exposed to all other nine decision traps”

Russo & Shoemaker
Intelligence

● Four main activities
  ➤ Entering a “decision process”
  ➤ Reflecting on values (objectives)
  ➤ Isolating a system
  ➤ Imagining possible actions on the system
Triggers: Information Systems

● You cannot always be deciding…
● …something has to trigger the start of a decision process
  ➢ MIS / EIS / Accounting / Inventory management
  ➢ Watch
  ➢ Prospective

● Information
  ➢ of adequate nature and volume
  ➢ in a timely manner
Values

● “Decision-Making is what you do to satisfy objectives” (R.L. Keeney)

● Objectives
  ➡ guide the collection of information
  ➡ facilitate communication
  ➡ allow audits and evaluation
  ➡ avoid endless debates

● Examples
  ➡ Should we legalize cannabis?
  ➡ What should be the objective of a public policy towards the control of psychotropic substances?
THINKING ABOUT VALUES

- uncovering hidden objectives
- creating alternatives
- identifying decision opportunities
- guiding strategic thinking
- interconnecting decisions
- guiding information collection
- facilitating involvement in multiple-stakeholder decisions
- evaluating alternatives
- improving communication

Adapted from Keeney, 1992
Values

● **Ends objectives**
  ➔ *Why* is this important to me?
  ➔ Evaluation

● **Means objectives**
  ➔ *How* to reach my goals?
  ➔ Alternatives

● **Means Objective**: an objective whose importance stems from its contributions to achieving another objective

● **Ends Objective**: objective that defines a basic reason for caring about a decision
  ➔ Means Objective: arrive home from work early
  ➔ Ends Objective: make my spouse happy
Techniques to Identify Objectives

- Use a wish list
- Think about alternatives
- Imagine possible consequences
- Describe problems and shortcomings
- Identify goals, constraints and guidelines
- Use different perspectives
- Think about strategic objectives
- Ask ‘why’ for each objective
- Do individual thinking first
Fundamental Objectives Hierarchy
CO Air Quality Standards

Health impacts
- heart attacks
- angina attacks
- peripheral vascular attacks

Costs
- regulation cost
- enforcement cost
- health cost

Health impacts
- fatal
- nonfatal

Costs
- capital equipment
- operations
- direct (e.g., treatment)
- indirect (e.g., lost opportunity)

Adapted from Keeney, 1992
Means-Ends Objectives Network
CO Air Quality Standards

Adapted from Keeney, 1992
Frontiers

● A model *has to* simplify (map / territory)
  ➤ Isolating a “system”

● Frontiers
  ➤ Time
  ➤ Space
  ➤ Persons
  ➤ Linked decisions

● Example
  ➤ Elevator
Frontiers

- Key points?
- Neglected points?
- Traps
  - metaphors, language
  - firm stereotypes
  - trigger
  - obvious constraints
Metaphors

● Sports / war / health, etc.
  ➡ “winning team”
  ➡ “price war”
  ➡ “terminal phase”
  ➡ “strategic movement”
  ➡ “general mobilization”
  ➡ “win the battle of quality”
  ➡ etc.

● Is it always appropriate to think of decisions in terms of winning a battle?
Trap # 2

Frame Blindness

“Setting out to solve the wrong problem because you have created a mental framework for your decision with little thought that causes you to overlook the best options or lose sight of important objectives”

Russo & Shoemaker
Trap # 3

Lack of Frame Control

● “Failing to consciously define the problem in more than one way or being unduly influenced by the frames of others”

Russo & Shoemaker
Example (Kahneman/Tversky)

- You have decided to go to see a play and bought a ticket for 30 €

As you enter the theater, you discover that you have lost the ticket. The seat was not marked and the ticket cannot be recovered.

Would you pay 30 € for another ticket to see the play (assuming you have enough cash)?

- 38% of subjects do not buy
Example (Kahneman/Tversky)

You have decided to go to see a play where admission is 30 € per ticket, but you have not yet purchased the ticket. As you enter the theater, you discover that you have lost 30 € from your wallet. Would you still pay 30 € for a ticket to see the play (assuming you have enough cash)?

- 17% do not buy (vs. 38%)
- Lost cash is “out-of-boundary”
Imagining alternatives

● “Let $A$ be a an exhaustive set of mutually exclusive alternatives”

● Creativity
  ➢ No really standard techniques
  ➢ Test: is there at least one satisfactory alternatives?

● R.L. Keeney
  ➢ “your decision cannot be better than your best alternative”
  ➢ “you can never choose an alternative you haven’t considered”
Problem

- Join these 9 points by 4 lines without lifting the pencil from the paper
“Creativity Killers”

● “Business as usual”: budgets
● Status-quo bias
● No action: letting time/others decide for me
● Fear of being ridiculous
  ➢ “brainstorming sessions”
  ➢ US army
Remedies

● Use your objectives and ask: how do I achieve them?
● Increase aspiration levels
● Beware of (implicit) constraints
● Sleep on it
● Modify / improve what is “given”: nothing is “given”

● Test: Is there anything really satisfactory?
Intelligence Phase

Objectives

Alternatives

"Decision situation"

IS

S
Design

● Describe/forecast the “state of the system” if you apply some alternative

● Examples: most management techniques
  ➔ sales forecasts, financial plans, accounting

● Choosing a job
  ➔ salary
  ➔ learning
  ➔ transportation time
  ➔ social security
  ➔ nights out
  ➔ interest
  ➔ chances of keeping the job
Traps

● Not having objectives
● Not using your objectives
● Fetish “hard data”
● Not taking uncertainty into account
● Mixing up “knowledge” of experts with their “values”
  ◦ doctors

● Design: crucial points
  ◦ What do I know?
  ◦ What should I know?
More traps

- Reference points
- Units
  - nature of the measure
  - absolute/relative
Example (Kahneman/Tversky)

- Experiment with 167 doctors
- Choice of a treatment for (own) lung cancer
  - Surgery
  - Radiotherapy
- Information on survival “chances”
  - 2 groups
<table>
<thead>
<tr>
<th>Group</th>
<th>Outcomes</th>
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<tr>
<td>100 patients Surgery</td>
<td>10 die during operation</td>
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<tr>
<td></td>
<td>32 are dead after 1 year</td>
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<td>66 are dead after 5 years</td>
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<tr>
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<td>0 die during operation</td>
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<td>78 are dead after 5 years</td>
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50 % in Group 1 prefer Surgery
84% in Group 2 prefer Surgery

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Measurement units

- Public Health decisions
  - Number of fatalities
  - Number of years of life lost
  - Number of years of “good quality” life lost
    - QUALY, HYE
Absolute/Relative measurement

● Situation A
  Watch = 70 €
  You are told by a friend that, five blocks away, you can buy the same watch (same service and guarantee) at 30 €
  Question: Are you going to buy the watch in the distant shop?
  (90% Yes)

● Situation B
  Video camera = 800 €
  Five blocks away, you can buy the same video (same service and guarantee) at 770 €
  Question: Are you going to buy the video in the distant shop?
  (50% Yes)
Absolute/Relative measurement

● Budget: 100 000 €

● Expenditures: 90 000 €
  ➔ “I saved 10 000 € to the firm”

● Expenditures: 110 000 €
  ➔ “I stayed with 10% of the budget”
Design Phase

Alternatives $a \in A$

Description of the system if you apply alternative $a \in A$
Choice Phase

● Choose alternative giving to system the “most desirable” state

● Complexity depends on:
  ➢ $A$ (set of alternatives)
  ➢ $S$ (system)
  ➢ $E_x$ (description of system) / objectives
    ● precision/imprecision
    ● certainty/uncertainty
    ● Time horizon
    ● 1 opinion / multiple opinions
    ● 1 criterion / several criteria
Objectives

Alternatives

"Decision situation"

\[ E_a \]

Description of system if \( a \in A \) is implemented

Choice
Example: Optimization

● $A$ is stable; alternatives are exclusive

● System and objectives allow to summarize $E_a$ by a unique performance measure

● Examples
  ◦ Profit, Sales, Quality, Jobs, Pollution level, etc.

● $a \in A \rightarrow E_a \rightarrow f(a)$

$E_a$ preferred to $E_b$ $\iff f(a) > f(b)$

$E_a$ indifferent to $E_b$ $\iff f(a) = f(b)$
Optimization

- Choose an alternative \( a \in A \) making
  \{Maximum or Minimum\}
  the performance measure \( f(a) \)

\[
\begin{align*}
  \text{Max} & \quad f(a) \quad & \text{or} \quad \text{Min} & \quad f(a) \\
  a \in A & & a \in A
\end{align*}
\]

- Optimize = Maximize or Minimize
  depending on the nature of \( f(a) \)
"Optimal decision" contingent to:

- Objectives
- $S$: System
- $A$: set of alternatives
- $E_a$: Description of consequences

- Optimization model is an *aid* to decision
  - discuss/modify the optimal solution
  - integrate neglected aspects
  - Redefine $S$, $A$, or $E_a$

- In many cases the very idea of an "optimal solution" is meaningless
Meta Decision

- How much time to allocate to each phase?
- Design: 80% of time (crunching numbers not to think hard)

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<td>Int.</td>
<td>5%</td>
<td>20%</td>
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<tr>
<td>Design</td>
<td>45%</td>
<td>35%</td>
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Russo & Shoemaker
Trap # 9

Not keeping track

● “Assuming that experience will make its lessons automatically, and therefore failing to keep systematic records to track the results of your decisions and failing to analyze these results in ways that reveal their key lessons”

Russo & Shoemaker
Generic problems in the Choice phase

- Very high number of alternatives
- Interdependent decision
  - resources
  - time
- Uncertainty
- Time Horizon
- Multiple Criteria
- System with retro-action
- Group Decision
In Practice

- All difficulties are more or less present
- Design phase will put more emphasis on one or two depending on context
- Sometimes “Intelligence + Design” are enough to give sufficient insights into the situation
  - Solving vs. dissolving “problems”
Outline

● Classical view on decision
● Another view
● What can be expected?
● What should we take care of?
● What are the main types of models?
Decision analysis tools
(Classical techniques for generic problems)

- Very high number of alternatives
- Interdependent decision

*Mathematical Programming*
*Combinatorial Optimization*

- Uncertainty

*Bayesian Decision Theory*
*Fuzzy sets*
Mathematical Programming and Combinatorial optimization
Decision trees
### Pascal’s Wager

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<tr>
<th></th>
<th>Jesus' claims false</th>
<th>Jesus' claims true</th>
</tr>
</thead>
<tbody>
<tr>
<td>I accept</td>
<td>some disappointment</td>
<td>infinite reward</td>
</tr>
<tr>
<td>I reject</td>
<td>no big deal</td>
<td>consider carefully!! don’t let it happen</td>
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Classical techniques

- Time
  Dynamic Programming - Optimal Control -
  [Sustainable Development]
- Retroactions
  Game Theory
- Group Decisions
  Social Choice Theory – Negotiation analysis
- Multiple Criteria
  MCDM / MCDA
Game trees
A final trap

- Confuse Decision Analysis with the application of generic techniques
  - Decision Analysis consists in an *intervention* in a decision process
  - Tools are more or less restricted to the Choice phase
  - Sophisticated tools in the Choice phase cannot compensate for weaknesses in the Intelligence and Design phases
Example: retroaction
"Competition" on a network

Road network: point A to point B

- 10 K users
- 2 routes
- Travel time ("cost") = \( f(\text{# of users on route}) \)

\[ \text{3w + 5} \]

\[ \text{2z} \]
Liberal Regulation

- Informed users choose the route according to travel times

- Equilibrium if cost of two routes is equal
  - $3w + 5 = 2(10 - w) \Rightarrow w = 3$
  - 3 Kusers on upper route (cost = 14)
  - $10 - 3 = 7$ Kusers on lower route (cost = 14)

- Each user “pays” 14

- Social “cost” = 140 (time lost in the network)
Bureaucratic Regulation

● A bureaucrat located at point A makes the choices for the users. S/he wishes to minimize total social cost

$$CT(w) = w(3w + 5) + 2(10 - w)^2 = 5w^2 - 35w + 200$$

● Minimization

$$CT'(w) = 10w - 35 = 0 \Rightarrow w = 3,5$$

◇ 3,5 Kuser on upper route each paying:

$$3 \times 3,5 + 5 = 15,5$$

◇ 6,5 Kusers on lower route each paying:

$$2 \times 6,5 = 13$$

● Social cost = 3,5(3 × 3,5 + 5) + 2(10 – 3,5)2 = 138,75

● Efficiency vs. Justice??
Outline

● Classical view on decision
● Another view
● What can be expected?
● What should we take care of?
● What are the main types of models?
● Conclusions
What to remember?

● Inadequacy of the classical view of decision
● Decision as a process generating anxiety
● Decision analysis as a methodology to get along in spite of this anxiety
● Deciding is not solving a well-defined problem
● Three main phases: Intelligence, Design, Choice
● Formal techniques for generic problems in the choice phase
● Informal hints for the other phases
● Decision aiding means intervening in a decision process
Research / Questions / Problems

● Integration of decision analysis tools
● Validation
  ➢ rationality?
  ➢ checking the profession?
  ➢ training novices?
● Organizing the decision aiding process
  ➢ consistency and meaningfulness?
  ➢ legitimating?