Introduction to Decision Modeling

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Chapter 0

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Outline

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Current definitions of a model

- a standard or example for imitation or comparison.
- a representation, generally in miniature, to show the construction or appearance of something.
- an image in clay, wax, or the like, to be reproduced in more durable material.
- a person or thing that serves as a subject for an artist, sculptor, writer, etc.
- a person whose profession is posing for artists or photographers.
- a person employed to wear clothing or pose with a product for purposes of display and advertising.
- a style or design of a particular product: His car is last year's model.
- a pattern or mode of structure or formation.
- a typical form or style.
- a simplified representation of a system or phenomenon, as in the sciences or economics, with any hypotheses required to describe the system or explain the phenomenon, often mathematically.
- *Zoology:* an animal that is mimicked in form or color by another.

What is a model?

- $\Rightarrow$ Representation of reality
- More Precisely: A model refers to some form of symbolic representation of our assumptions about reality

Why do we use models?

- Enhance our understanding of the world to improve our decision making
- Elaborate a scientific method to solve a problem
  - Duplicable (repeatable)
  - Reduce bias

Types of models

1. Deterministic models
   - outcomes are precisely determined through known relationships among states and events
   - in such models, a given input will always produce the same output
     Ex: Resources to make a PC are the same every time
   - Domains: Multi-Attribute Decision Making; Linear programing; ...
2. Probabilistic (stochastic) models
   - Not all data is known with certainty
   - Ex: College acceptance, being above average increases likelihood of acceptance but does not make it certain
   - Domains: Queuing; Simulation; ...

Models are fed by data

1. Qualitative data
   - measured by quality
   - Expert opinions
   - Ex: class atmosphere, ...
2. Quantitative data
   - Easily measured by numbers
   - Ex: Numbers of tv programs a day; number of applications in a phone; ...

Models are used every day

- A Scenario: Driving to school
  - At what time do you need to leave home to be at school on time?
  - Distance= Rate $\times$ Time
  - Time = Distance/Rate

Formal models vs Informal models

- A formal model is a precise statement of components to be used and the relationships among them.
- Formal models are usually stated via mathematics, often equations.
- Formal models can be precisely communicated because they are well-defined.
- Formal models give replicable results. This is the simple meaning of "mathematical proof".

Formal models vs Informal models

- Formal models are not reality: you must choose the model.
- Formal models may not correspond to reality: the prediction will turn out to be false.
- An informal model is one in which the symbols are mental, verbal, or pictorial: e.g. we toss a coin, we ask an oracle, we visit an astrologer, we consult an expert, we think
- Informal models simply have some lack of precision. Some relationships may not be stated as equations

Outline

A definition of Decision

- The act or process of deciding; determination, as of a question or doubt, by making a judgment:

  Ex: They must make a decision between these two contestants.

- The act of or need for making up one's mind:

  This is a difficult decision.

- Something that is decided; resolution:

  Ex: She made a poor decision when she dropped out of school.

- A judgment, as one formally pronounced by a court:

  Ex: It is the decision of this court that the appeal is granted.

- The quality of being decided; firmness:

  Ex: He spoke with decision and calm authority.

Source: `http://www.dictionary.com/browse/decision`

Provisional definition of Decision [RONALD HOWARD]

"Decision-making is what you do when you do not know what to do"

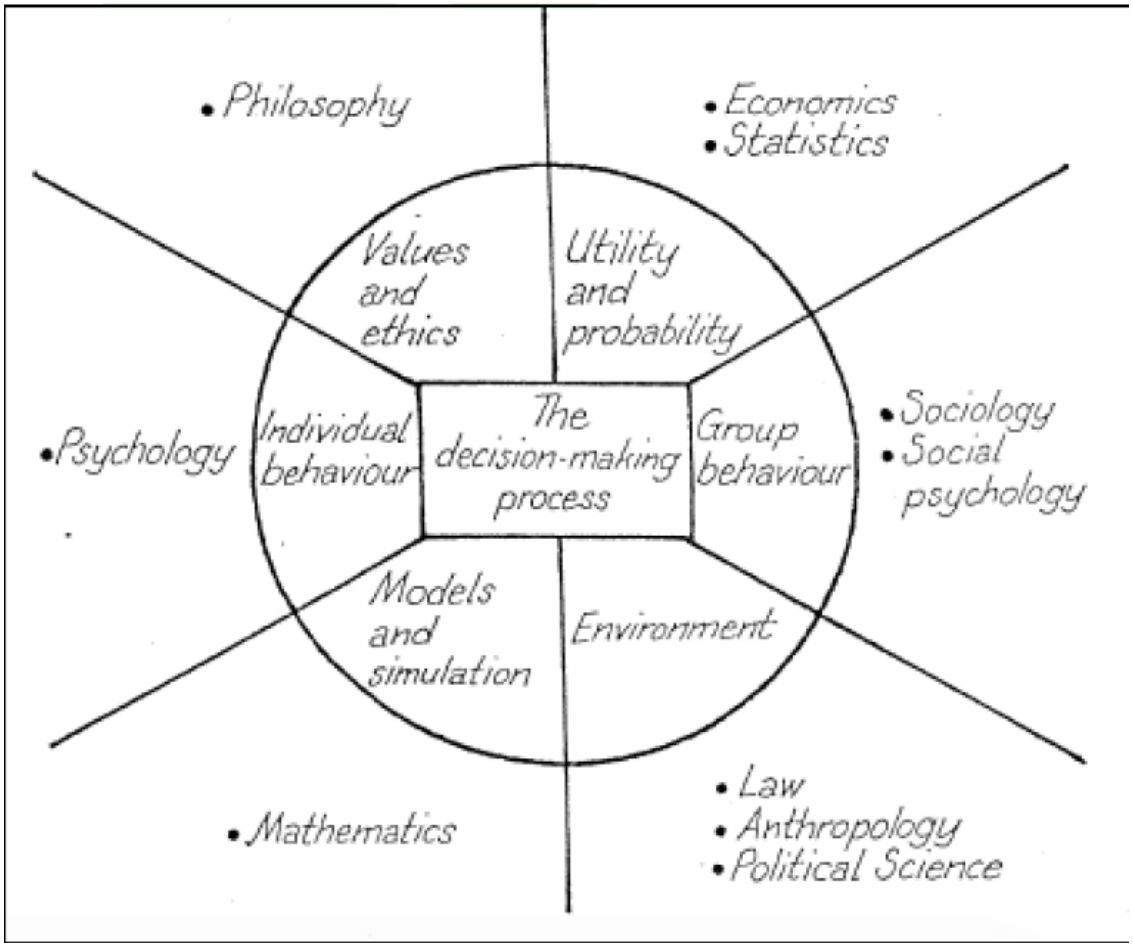
A definition of Decision in our context

- A choice that you make about something after thinking about several possibilities
  - Ex: We need to take a lot of factors into account in our decision-making.
  - Ex: She has had to make some very difficult decisions.
  - Ex: The company will reach/come to/make a decision shortly.

Source:
`https://dictionary.cambridge.org/dictionary/english/decision`

Decision in many domains

Philosophy, Economics, Mathematics, Operational Research, Psychology, Computer sciences, Political sciences, Biology? Theology?



What Decision Analysis is not !

- A general method for taking "good decisions"
  - Example 1: Choice of new job
  - Example 2: medical decision
  - Etc.
- What is a "good decision"?
  - Good for whom, according to what criteria, at which moment in time?
- Good decision processes vs. good decisions?
- A description on how "wise people" decide
  - Expert systems
  - Doctors / Politicians: Nuclear Industry vs Road safety; Prevention vs First Aid
- How do you recognize "wise people"?
  - Luck vs. Wisdom

Decision Analysis

- Definition (B. Roy): "consists in trying to provide *answers* to questions raised by actors involved in a *decision process* using a *model*"
- Decision process: strategy of intervention: aid, communication, justification, etc.
  - Many different ways to provide decision-aid
  - Difficulty to compare methods
  - What is a "good" Decision Analysis model ?
  - Different models may lead to different recommendations

Decision Analysis

- Definition (B. Roy): "consists in trying to provide *answers* to questions raised by actors involved in a *decision process* using a *model*"
- Answers: "Optimal solution" or "Good decision" is absent
- Models: formalized or not

Decision Making

- Decision Making $\neq$ "Solving" a well-defined problem
- Intervention in a decision process:
  - imagine compromises
  - communicate
  - coordinate
  - control
  - motivate
  - conduct change
- Importance of "final choice" ?

Formalized models in Decision Analysis

- Drawbacks: complex, opaque
- Advantages:
  - Provide a clear language: communication tool
  - Capture the essence of a situation: structuration tool
  - Answers "what-if" questions (sensitivity, robustness): Exploration tool
- Example: choosing a car.

Possible objections

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

Outline

Developing a decision model (Step 1)

Formulation: Translate the problem scenario into a mathematical model

- Define the problem
- Develop a decision model
  - Variables: Measurable quantity that can be variable
  - Parameters: measurable quantity inherent to problem

Developing a decision model (Step 2)

Solution: Mathematical expressions from formulation are solved

- Develop a Solution: Manipulate model to arrive at the best solution. Ex: Time=Distance/Rate
- Test Solution: Does the solution make sense?

Developing a decision model (Step 3)

Interpretation: Implication of results

- Conduct sensitivity analysis:
  - what happens if parameters vary?
  - Testing outcomes under a variety of states
- Implement results: Enact solution & monitor it performs as expected

Possible problems

Possible problems

- Defining the problem: Conflicting viewpoints, impact on other stakeholders
- Model development: Fitting problem scenario to textbook model, understanding of others
- Acquering data: Existence, validity
- Developing a solution: Limitations of one answer
- Implementation: Management and user support

Outline

- Decisions made by algorithms can be opaque because of technical and social reasons, in addition to being made purposely opaque to protect intellectual property.
- For example, the algorithms may be too complex to explain or efforts to explain the algorithms might require the use of data that violates a country's privacy regulations.

An algorithm : Definition

An algorithm is a sequence of instructions, typically to solve a class of problems or perform a computation.

An algorithm has to be

- Finite: The algorithm must eventually solve the problem;
- Well-defined: The series of steps must be precise and present steps that are understandable;
- Effective: An algorithm must solve all cases of the problem for which someone defined it.

An algorithm : Definition

Objectives sometimes contradictory

- An algorithm has to be simple to understand, to implement;
- The computation time of an algorithm should be reasonable.

Transparency

Algorithmic Transparency

- Algorithmic transparency is the principle that the factors that influence the decisions made by algorithms should be visible, or transparent, to the people who use, regulate, and are affected by systems that employ those algorithms.
- Algorithmic transparency is openness about the purpose, structure and underlying actions of the algorithms used to search for, process and deliver information.

Transparency

Two important properties

- Explanation: Systems and institutions that use algorithmic decision-making are encouraged to produce explanations regarding both the procedures followed by the algorithm and the specific decisions that are made. This is particularly important in public policy contexts
- Accountability: Institutions should be held responsible for decisions made by the algorithms that they use, even if it is not feasible to explain in detail how the algorithms produce their results.

Outline

Our Program

- Chapter 0: Introduction to Decision Modeling
- Chapter 1: Preferences as binary relations
  - Definition
  - Numerical representation
  - Exercises + Practical works (Assignments): Binary relations properties; Preferences for holidays
- Chapter 2: Group decision-making
  - Social choice theory models
  - Exercises + Practical works (Assignments): Voting methods, Collaborative filtering;
- Chapter 3: Multi-Criteria Decision Aid models
  - Multi-Attribute values approaches
  - Outranking approaches
  - Exercises + Practical works (Assignments)
- Project: Elaboration of an understandable evaluation model based on a MCDA approach (Report + defense of the report)
- Evaluation: Practical works (20 %)+ Written Exam (50%) + Project (30%)