Decision under uncertainty: introduction

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AOS04 master courses

Outline

- Some examples
- Introductory matters

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Example 1

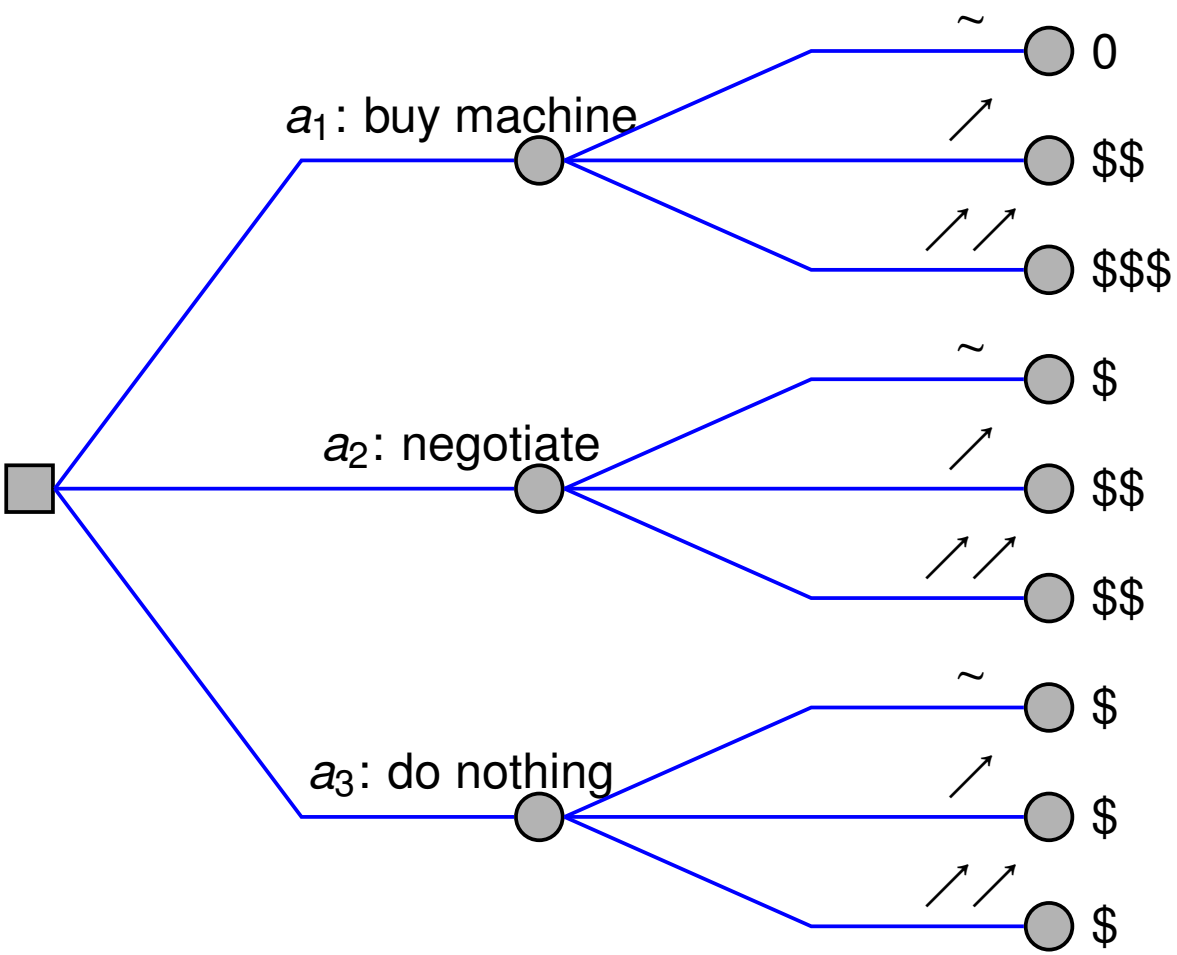
Example (Facing tomorrow's market)

As head of a company selling AI.stuff, you know that the market demand is unlikely to **go crazy** ($\nearrow\nearrow$), will most probably **go up reasonably** ($\nearrow$), but is also unlikely to **remain stable** ($\sim$). You can either:

- Buy a new machine (a_1)
  - If market stable ($\sim$), loss of money (0)
  - If market increase, higher income ($$)
  - If market go crazy, you become rich ($$$)
- Negotiate extra hours with employees if needed (a_2)
  - If market stable ($\sim$), normal income ($)
  - If market increase or go crazy, higher income ($$)
- Do nothing about it (a_3)
  - Whatever happens, normal income ($)

How would you model this decision problem? What would you recommend?

One tree model of the problem



Useful for sequential decision making, not seen here

Matrix form of the problem

A matrix with action as lines, states as columns

	↗↗	↗	~
a_1: buy	\$\$\$	\$\$	0
a_2: negotiate	\$\$	\$\$	\$
a_3: do nothing	\$	\$	\$

What would you decide? What would you definitely not decide?

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Matrix form of the problem: solutions?

	↗↗	↗	~
a_1: buy	\$\$\$	\$\$	0
a_2: negotiate	\$\$	\$\$	\$
a_3: do nothing	\$	\$	\$

Example 2

Example (A though call)

As the famous Dr. House, you face a difficult case. You suspect that your patient has either Lupus (L), Chimerism (C) or Baylisascaris (B). Now, you can one of these three actions:

- a_1: Run a test that detects Chimerism, but takes time (so patient will degrade)
- a_2: Run a short test that detects Baylisascaris, but will most certainly kill the patient in case of Lupus
- a_3: Launch a treatment that cures Chimerism effects, but may agravate a lot Baylisascaris
- a_4: Launch a treatment for Lupus, that would be fatal in the other cases

What do you do?

Matrix form of the problem

A matrix with action as lines, states as columns

	L	*C*	*B*
a_1: det C	☹	☺	☹
a_2: det B	✠	~	☺
a_3: cure C	~	☺☺	☹☹
a_3: cure L	☺☺	✠	✠

What you do heavily depends upon what you suspect.

Outline

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Overall lecture goal/content

What you will find in this course

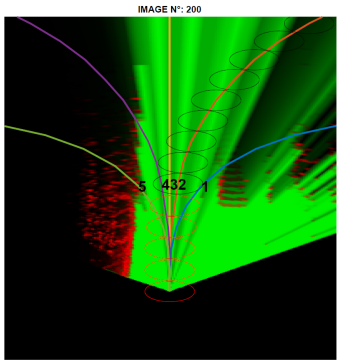
- Deciding with probabilities: motivating expected utility
  - Introduce the main formalism
  - Justify it through axioms
  - Probabilities and utilities: how can we get them?
  - A word about other justifications
  - Critics of expected utility
- Deciding without any probabilities + alternatives
- Illustration on classification/learning problems

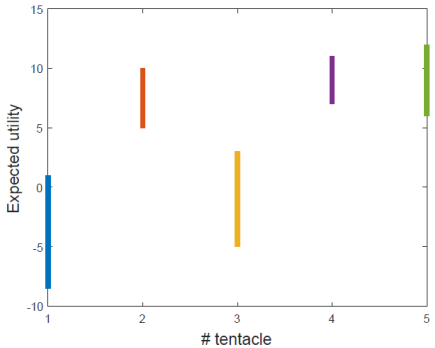
Basic modelling

- The state X of the world
  - take values in some (finite or not) set $\mathscr{X}$ of possible situations
  - $\mathscr{X}$ assumed exhaustive and of sufficient granularity
  - is uncertainly known
- A set $\mathscr{C}$ of consequences
  - that are the possible outcomes of taking a decisions
- A set $\mathscr{A}$ of actions/alternatives
  - whose consequences depend on the state of the world
- Decision: (partially) ranking alternatives in $\mathscr{A}$ and taking the best one(s)

Some further examples

- Autonomous vehicle
  - States: grids of cell with states (occupied/non-occupied)
  - Actions: steering wheel, brake, . . .





Some further examples

- Medical diagnostic
  - States: severity of disease (non-existent to lethal) . . .
  - Actions: possible treatments

Some further examples

- Threat detection
  - States: altitude, speed, size of flying object
  - Actions: further measurement, warning, preventive strike, . . .

Some further examples

- Bridge configuration
  - States: state of soil × wheather conditions
  - Actions: designs (materials, truss configuration, . . .)

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Some usual questions

- How to model our uncertainty about X?
  - by probabilities (decision under risk)
  - by sets (decision under uncertainty)
  - by more general models

  → discuss the two first points, give hints about the last
- How to take decisions?
  - by considering complete rankings
  - by allowing incomparabilities

  → discuss most common approaches
- How to measure the impact of consequences? How to escape numbers if those are not accessible?

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Next presentation

Probability theory and expected utility: formal introduction