Lecture 12 — Computational Decision-Making

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Systematic Decision-Making

General process for making decisions:

1. List all choices.
2. List all evaluation attributes (criteria).
3. Compare lists and remove impractical choices.
4. Evaluate the advantages and disadvantages of each remaining choice according to all of the criteria.

But how?

Computational Decision Making

Goal: quantify the decision-making process.

Assign a weight to each criterion
(according to importance); and
assign a score for each choice.

Combining weights and scores,
compute the value of a payoff function for each choice.

CDM: Assigning Weights and Scores

Assume that there are m choices and n criteria.

1. Assign a weight w_j to each criterion.
   Ensure $\sum_{j=1}^{n} w_j = 1$ (or 100%).
   Higher weights = more important.
2. For each choice i and criterion j, assign score p_{ij}, which summarizes goodness of i with respect to j.

$$p_{ij} \in [0, 1]$$

CDM: Computing Scores and Payoffs

[Assume that there are m choices and n criteria.]

We can then compute scores s_{ij} and a payoff f_i.
Choose alternative with the largest expected payoff f_i:

$$s_{ij} = p_{ij}w_j; \qquad f_i = \sum_{j=1}^{n} s_{ij} = \sum_{j=1}^{n} p_{ij}w_j,$$

(i.e. dot product of weights and scores).

Rather than choosing scores $p_{ij} \in [0, 1]$,
you can instead normalize the scores:

1. Assign $c_{ij} \in \mathbb{R}$ for each alternative i and criterion j. Use *same units* for all alternatives of a criterion.
   You can use different units for different criteria.
2. For each criterion, calculate

   $$C_j = \max\{|c_{1j}|, |c_{2j}|, \ldots, |c_{mj}|\},$$

   so that

   $$p_{ij} = \frac{c_{ij}}{C_j}.$$

3. The payoff function is then given by:

   $$f_i = \sum_{j=1}^{n} p_{ij} w_j = \sum_{j=1}^{n} \frac{c_{ij}}{C_j} w_j.$$

"How should I get to Montreal?"

Done on the board to facilitate understanding.

CDM: Potential Flaws in Example

Did we get an optimal decision?
Let's look at threats to validity:

- (not an issue here) scores might be stuck in a small subrange of the possible range, affecting values.
- values for flexibility are subjective:
  how you assign numbers to options changes outcome.
- cost depends on what you include;
  for instance, gas alone would be $72.50;
  but it would be less if you carpooled.
- weights are subjective.

Investigate impact of potential flaws.

Sensitivity Analysis: study of how variations influence outcome of a mathematical model.

Poor person’s sensitivity analysis: do what-if calculations.

Replace the original value with some other value
and repeat the analysis.
(Possible issues if scores not independent.)

Sensitivity Analysis: Examples

Train used to always be late,
so you might assign 9 instead of 7.7.
(mostly on time recently.)

Or, you might want to get to the airport slightly earlier than me, so you might also change the time for plane to 5.

Or, you might be more cost-sensitive and less time-sensitive.

Do these change the best decision?

CDM: Other References

Previous notes contained an example ("Where should I go to University?") and a reference to *Introduction to Professional Engineering in Canada*, Example 15.3 (pp. 232–233).

Another example: Waterloo Region's Rapid Transit alternatives
(no actual numbers).

Another example: choosing which phones to buy for ECE155.

Discussion

Computational decision-making systematically includes diverse factors to arrive at a “best” decision.

Disadvantages:

- must numerically estimate weights and scores;
- estimating may be infeasible;
- estimates may reflect pre-conceived notions;
- does not generate new alternatives.

Advantage:

- ensure that you give each alternative consideration.

Note: you’re not required to pick the highest-scoring alternative.