

DECISION AID METHODOLOGIES IN TRANSPORTATION

Lecture 4: Heuristics

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Heuristics

Heuristics

Definition:

A heuristic is a technique designed for solving a problem more quickly when classic methods are too slow, or for finding an approximate solution when classic methods fail to find any exact solution. This is achieved by trading optimality, completeness, accuracy, and/or precision for speed.

Types:

- 1 Approximation
- 2 Rule-based
- 3 Meta-heuristic

Dynamic programming

Principle of optimality

An optimal policy has the property that whatever the initial state and initial decision are, the remaining decisions must constitute an optimal policy with regard to the state resulting from the first decision.

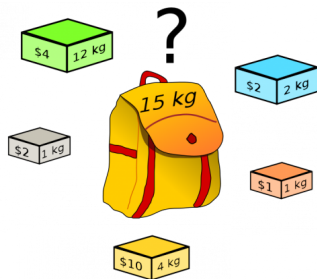
Curse of dimensionality

When solving dynamic optimization problems by numerical backward induction, the objective function must be computed for each combination of values. This is a significant obstacle when the dimension of the “state variable” is large.



Richard Bellman

Knapsack problem



$$\max : \sum_{j=1}^n c_j x_j$$

$$s.t. \sum_{j=1}^n w_j x_j \leq K$$

$$x_j \in \{0, 1\}, \forall j = 1, \dots, n$$

**Dynamic
programming!!!**

Knapsack problem (dynamic programming)

$$\begin{aligned} \max : \quad & F(V) = \sum_{j=1}^n c_j x_j \\ \text{s.t.} \quad & \sum_{j=1}^n w_j x_j \leq V \\ & x_j \in \{0, 1\}, \forall j = 1, \dots, n \end{aligned}$$

Dynamic programming recursion function:

$$F(V) = \max_{i=1, \dots, n} \{F(V - w_i) + c_i\}$$

Base case: $F(V) = 0$, in the case that $V \leq 0$

How to overcome the curse of dimensionality?

Heuristic

Examples:

- Beam search algorithm (by restricting the growth of dimension)
- A star search (by approximating the Bellman recursion function)

Applications

The screenshot shows a top-down view of a StarCraft II game. A Lightning Revenant unit is highlighted with a green circle. The game interface includes a top bar with 'Map Info (F9)', 'Menu (F10)', 'Allies (F11)', and 'Chat (F12)'. The top right shows '0' and '48' with a 'v6.60' version indicator. A 'Allpick (0/0/0 - 0/0)' button is visible. A 'SOFTPEDIA' watermark is present on the left. The bottom interface shows a 'Razor' unit selected, with its stats and abilities displayed.

Learn Eye of the Storm - [Level 1]
Requires:
 - Hero level: 6

The Lightning Revenant calls upon a powerful storm of crackling energy, which strikes weakened enemies with deadly bolts of lightning. The storm is charged with Razor's malevolent will, and will seek out only the most injured targets for its armor shattering blasts.

Level 1 - Lasts 20 seconds. 37.5 damage per strike, 0.85 seconds per strike.
Level 2 - Lasts 25 seconds. 50 damage per strike, 0.75 seconds per strike.
Level 3 - Lasts 30 seconds. 62.5 damage per strike, 0.60 seconds per strike.

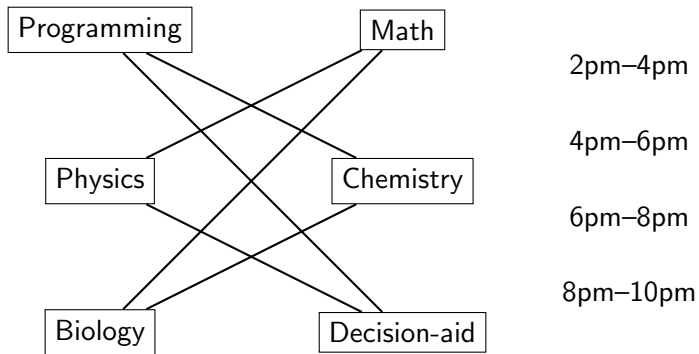
Cooldown: 80/70/60
Manacost: 100

Razor
 Level 1 Lightning Revenant

Damage: 45 - 47
 Strength: 17
 Agility: 22
 Armor: 1
 Intelligence: 1

Inventory: 1, 1, 2, 3, 1

Examination timeslot assignment problem



What is meta-heuristic?

Definition:

A metaheuristic is a higher-level procedure or heuristic designed to find, generate, or select a lower-level procedure or heuristic (partial search algorithm) that may provide a sufficiently good solution to an optimization problem, especially with incomplete or imperfect information or limited computation capacity.

Examples:

- 1 Genetic algorithm
- 2 Ant colony algorithm
- 3 Tabu search

Ant colony optimization

