Artificial Intelligence Methods
(G52AIM)

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Constructive Heuristic Methods
Constructive Heuristics – method

- Start from an “empty solution”
- Repeatedly, extend the current solution until a complete solution is constructed
- Use heuristics to try to extend in such a way that the final solution is a good one

Some of the slides in this part are based on Dr Parkes’ previous teaching materials. See “Constructive Heuristic Methods” at http://www.cs.nott.ac.uk/~ajp/courses/g52aim/.
Constructive Heuristics – method

It is essential to know the difference between:

- Constructive methods
  - Extend empty solution until get complete solution
- Local search
  - Take complete solution and try to improve it via local moves
Constructive Heuristics for TSP

- Start: Pick a start city but an empty path
- Repeatedly:
  - Extend the path by adding an edge to an unvisited city selected using a heuristic choice
- Until no more unvisited cities, then close the path to give a tour
Constructive Heuristics for TSP

- Heuristics
  - Nearest Neighbour (NN) Heuristic
    - Pick the next city which is the nearest unvisited city
  - Any other good heuristics?
    - Online demo

- NN from A
  - A-D-B-C-A = 1+1+7+3=12

- A-C-D-B-A = 3+2+1+4 = 10
  - Optimal?
Constructive Heuristics for GC

- Graph colouring
  - Given a graph $G(V, E)$, assign colours to vertices
  - Constraint
    - Adjacent vertices cannot be coloured the same
  - Objective
    - Minimize: the number of colours to the graph
Constructive Heuristics for GC

- **Heuristics**
  - Largest degree
    - Pick the vertices with the largest degree
  - Most Constraining
  - Saturation degree
    - Pick vertices with the fewest remaining colours
    - Most Constrained
  - Any other good heuristics?
Constructive Heuristics

- Putting this into the context of depth first search in G51IAI*
  - At each choice suppose that branches are ordered left-to-right by the heuristic, with the preferred option on left
  - Standard one-shot construction is just to take one branch of the search tree

* You should be familiar with the blind search methods in G51IAI
Constructive Heuristics

- Putting this into the context of depth first search in G51IAI*
  - To avoid mistakes in picking the "wrong" branches, heuristics can help to pick branches which lead to relatively good solutions

* You should be familiar with the blind search methods in G51IAI
Heuristics

- Variable selection
  - Which variable to work on
  - In GC: which vertex to colour

- Value selection
  - Which value to assign
  - In GC: assign which colour to the chosen vertex
Heuristics

- **Variable selection**
  - Most constrained
  - In GC: largest degree

- **Value selection**
  - Least constraining: imposes fewest constraints on remainder of problem
  - In GC: which colour leaves the most colours to the remaining vertices
Constructive Heuristics

- Generally give better answers than random methods
- Very quick, but usually far from optimal
- Widely used with other methods
- Often used as initialization for meta-heuristics
  - Pick the best solution from several runs
Constructive Heuristics - hybridize

- As initialization for local search
  - Pick the best solution from several runs

- Hybridized with other meta-heuristics
  - With local search: GRASP, etc
  - With Genetic algorithms: Memetic algorithms
Constructive Heuristics - hybridize

- GRASP
  - Greedy Randomized Adaptive Search Procedure
  - Hybrid of
    - Constructive methods
      - Randomized & adaptive
    - Local search
      - Pick your favourite
Constructive Heuristics - hybridize

- GRASP

Loop
  Create a solution, $s$, using randomized constructor $g$ utilizing RCL
  Improve $s$ using a local search
End loop
Constructive Heuristics - hybridize

- **GRASP**
  - Main idea of “Restricted candidate list” (RCL)
  - At each iteration, within randomized constructor $g$
    1. Use heuristic to select a limited number of good solution components; the RCL
    2. Randomly select a choice from the RCL
    3. Use this in order to extend the current partial assignment
Constructive Heuristics - hybridize

- **GRASP**
  - Main idea of “Restricted candidate list” (RCL)
  - Size of RCL $r$
    - If $r$ is too big, then $g$ becomes random
    - If $r$ is 1, then $g$ becomes pure greedy heuristic
    - Typical size of RCL is 3~5, but maybe problem dependent
Learning Objectives

- Know the general idea of constructive heuristics
- Know GRASP – so you could apply them in your coursework if you had to 😊