Humanlike Problem Solving in the Context of the Traveling Salesperson Problem

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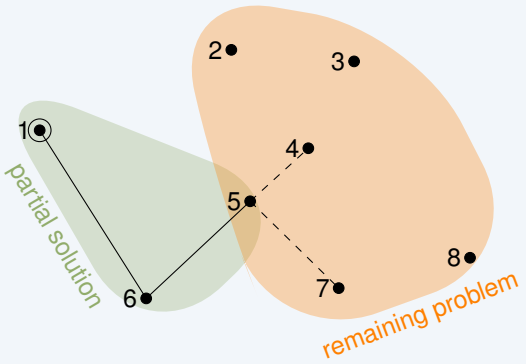
Computationally hard problems, like the Traveling Salesperson Problem, can be solved remarkably well by humans. Results obtained by computers are usually closer to the optimum, but require high computational effort and often differ from the human solutions. This paper introduces Greedy Expert Search (GES) that strives to show the same flexibility and efficiency as human solutions, while producing results of similarly high quality. The Traveling Salesperson Problem serves as an example problem to illustrate and evaluate the approach.

Goals

General decision-making/search algorithm for (uncertain, dynamic) real-world applications that is flexible and efficient and produces human-understandable results.

Example: TSP



Decision at point 5:

- direction experts restrict search horizon to 4 and 7
- evaluation experts evaluate addition of point 4 or 7 independently
- combination of evaluation experts decides on next point to add to path

GES Configuration for TSP

Direction Experts

NEIGHBOURHOOD returns *n* nearest points

CONVEX-HULL returns next point on convex hull or points on the way to the next convex hull point

PINWHEEL returns points on circle around center of mass

Evaluation Experts

POINT-DISTANCE nearest neighbour heuristic

INDENTATION of convex hull

CHEAPEST INSERTION into convex hull (only local estimation)

INNER POINTS number of points inside convex hull

PROBLEM DIAMETER preference of small remaining problems

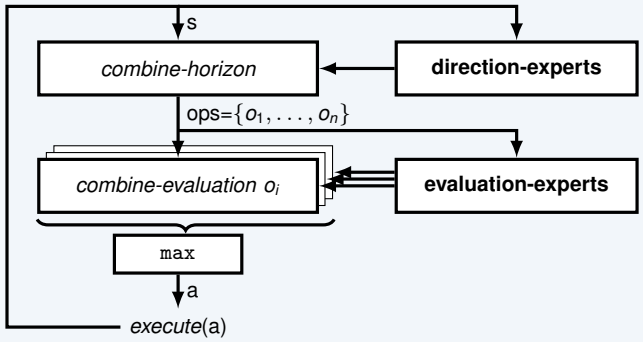
AVOID INTERSECTION as crossed lines are suboptimal

FOLLOW LINES simple use of gestalt principles

AVOID SPLITTING avoidance of intersections

GES Algorithm

- greedy search making extensive use of knowledge
- evaluation experts: cost functions to evaluate next state
- direction experts: filtering functions for next states



Evaluation

Comparison of results to human performance using different configurations of direction and evaluation experts

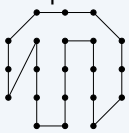
Quantitative Evaluation

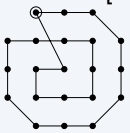
Comparison of tour lengths from [MacGregor & Ormerod (1996)]

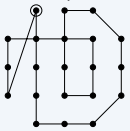
- no configuration is appropriate for all kinds of problems
- when combining configuration results:
  - best computed solution usually between best and mean human solution
  - worst computed solution sometimes below worst human solution

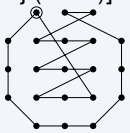
Qualitative Evaluation

Comparison of tours from [Tak, Plaisier, & van Rooij (2008)]


25% of participants (29.4)


CH-2, PW-1 (29.3)


PW-2 (32.5)


CH-1 (37.2)

Discussion

- general GES algorithm is general and efficient by design
- application to TSP generates acceptable results, with potential of improvement
- automatic combination of experts necessary to adapt to specific problems and situations

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