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Hierarchical Knowledge for Heuristic Problem Solving
A Case Study on the Traveling Salesperson Problem

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Abstraction is a fundamental feature of human-level intelligence. But it is not clear how to combine knowledge on different levels of abstraction. This paper examines the use of hierarchical knowledge for heuristic problem-solving algorithms, regarding three options for integrating hierarchical knowledge into heuristic search: as a state evaluation heuristic, as a search-guiding heuristic and as a hierarchical search strategy. The Traveling Salesperson Problem serves as an example of a problem-solving task and the different strategies are evaluated with respect to tour length, robustness against misleading hierarchy assignments and acceptability of results by humans. It turns out that the most effective and stable results can be achieved with hierarchical knowledge as a search-guiding heuristic combined with other heuristics.

Motivation

- Complex problem solving requires hierarchical approaches
- Standard approach: top-level solution restricts search space of lower-level "execution"
- Problems:
  - Strong reliance on quality of top-level solution
  - Inflexibility of execution
- Proposed solution: use abstract knowledge as a heuristic for execution

Heuristic Problem Solving
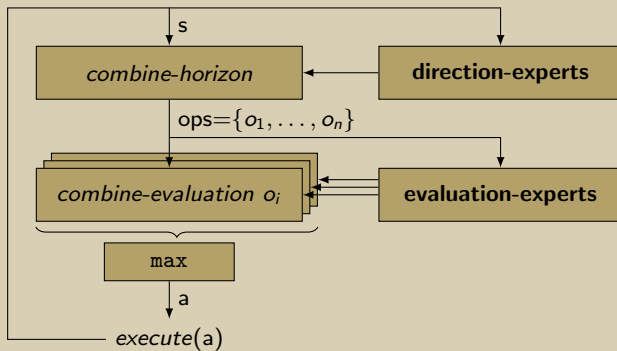
Region Heuristics for TSPs

Direction experts:

REGION-STRICT all remaining points in current region

REGION-PW points in current region or points of next region in a circle around center of problem
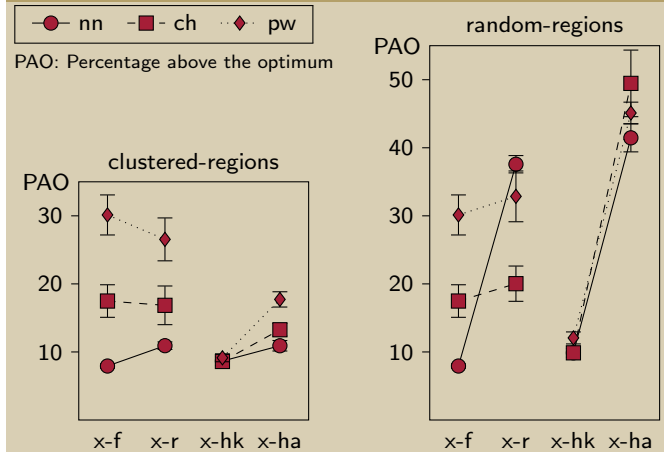
Evaluation expert:

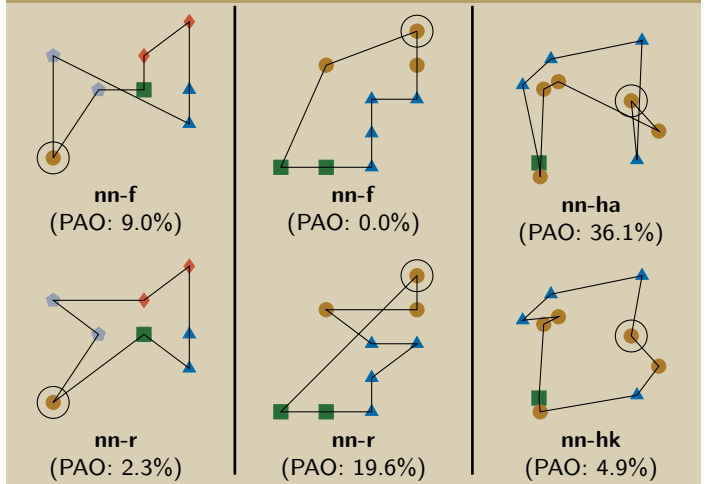REGIONS favor points in the current region

Expert Configurations

	nearest neighbor	convex hull	pinwheel
flat (no regions)	nn-f	ch-f	pw-f
with REGIONS expert	nn-r	ch-r	pw-r
hierarchical knowledge	nn-hk	ch-hk	pw-hk
hierarchical algorithm	nn-ha	ch-ha	pw-ha

Evaluation (Tour Length)

PAO: Percentage above the optimum

Evaluation (Examples)

nn-f (PAO: 9.0%)   **nn-f** (PAO: 0.0%)   **nn-ha** (PAO: 36.1%)

nn-r (PAO: 2.3%)   **nn-r** (PAO: 19.6%)   **nn-hk** (PAO: 4.9%)

User-centered Evaluation

believed to be human solution (0(no) – 1(yes))

quality of solution (0(bad) – 1(medium) – 2(good))