Searching with Distributional Heuristics

Stephen Wissow, Advisor: Wheeler Ruml

University of New Hampshire

Reason Under Uncertainty

bounded suboptimal:
- cost bound
- probability of finding goal within bound under given node

anytime:
- which node will lead to better solution
- search effort under given node to goal

contract:
- cost-to-go under given node
- search effort under given node to goal

In order to reason under uncertainty:

1. need **better measures** of uncertainty
2. need **to better exploit** those measures

New Distributional Heuristic

A rational search algorithm should prefer:

- low uncertainty when heuristic is low
- high uncertainty when heuristic is high

Heuristic belief variance can be assumed from single-step error (Fickert et al. IJCAI-21) but requires hyperparameter

New: h_{FFrand}

- don't assume, measure!
- parameterless distributional heuristic
- randomizes tie-breaking in FF
- distribution estimation via sampling
- see comparison below with other heuristics for start state of IPC benchmarks (Wissow & Asai 2022, unpublished collaborative work)

Contract Search

Objective:

- return best solution possible, subject to absolute time (or expansion) bound.

Current SotA:

- Deadline-Aware Search (Dionne et al. SoCS-11) is a best-first, priority queue based contract search algorithm that must estimate **two unknowns**:

$\hat{d}$: error-corrected distance-to-go

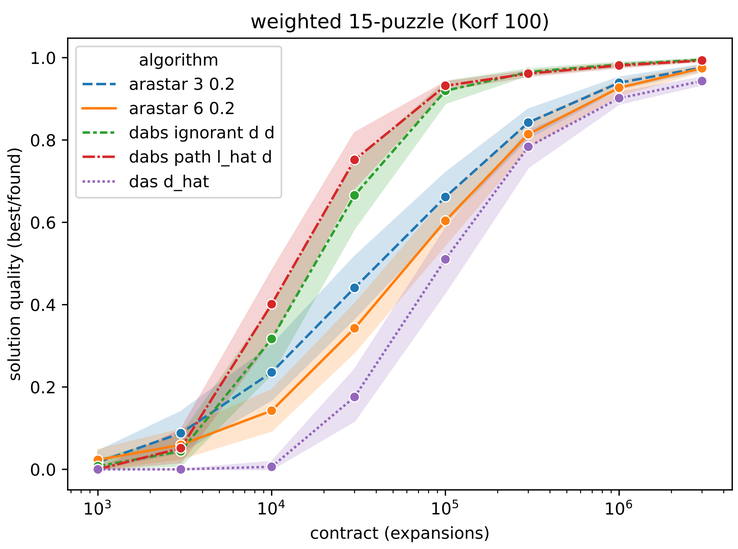
$\bar{\Delta e}$: average expansion delay

DAS also pathologically prunes all open nodes as unreachable—room for improvement!

Our Deadline-Aware Beam Search (DABS):

- dynamically adjusts width of parallel hill-climbing
- **only needs to estimate $\hat{d}$**

DABS beats DAS and ARA*:



Related Problems

Bounded Suboptimal: Fickert et al. (AAAI-22) formulate the work of bounded suboptimal search as comparing two distributions:

$B_{cost}(n)$: solution cost under n

B_{bound}: the cost bound itself

...but their best algorithm, RR-d, uses unprincipled round-robin queue alternation.

- Can uncertainty help decide proper strategy?

Anytime: Thayer et al. (SoCS-12) defined anytime objective as minimizing time between solutions, but this definition is incomplete:

an anytime algorithm also performs better than another by returning lower cost solutions, even if on the same solution schedule.

- Can uncertainty help balance earlier solutions with better ones?

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