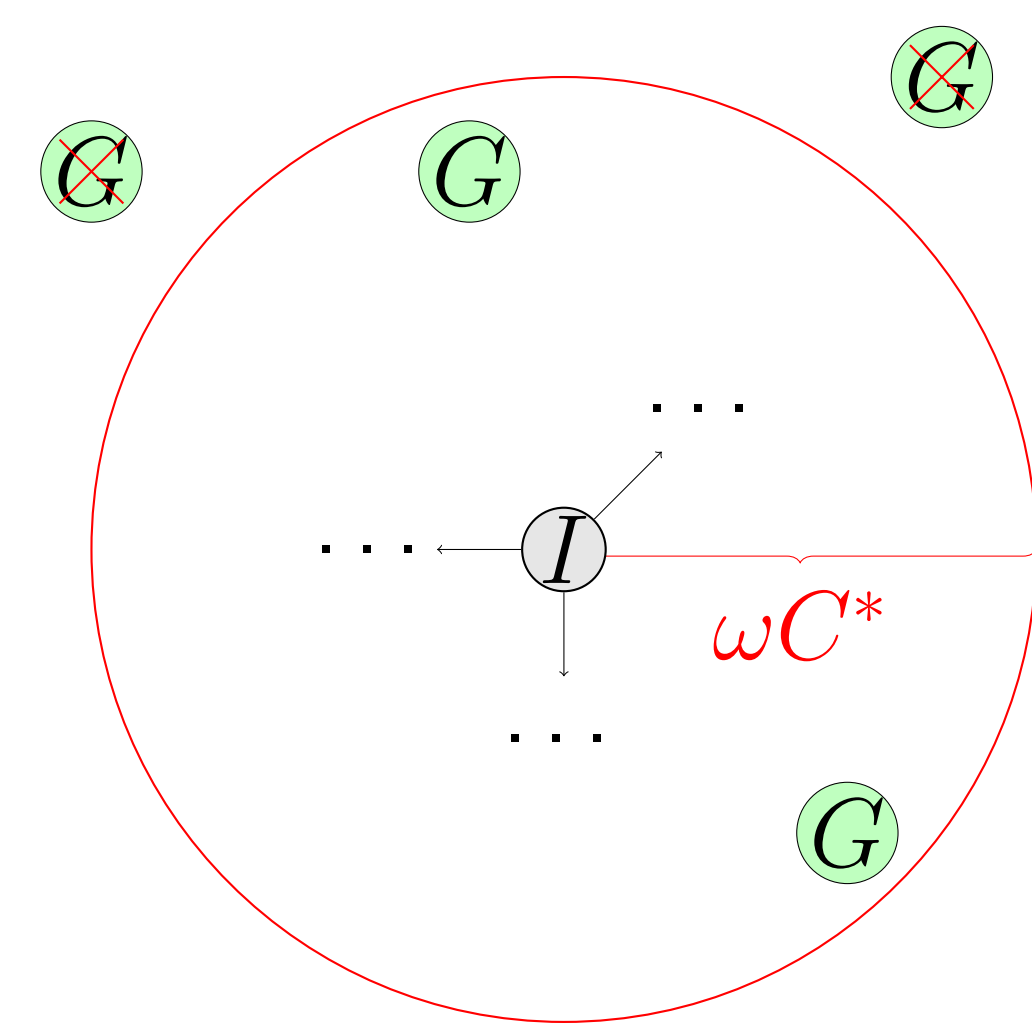


New Results in Bounded-Suboptimal Search

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The Problem Setting



- Motivation: many real-world problems are too hard to solve optimally. Need bounded-suboptimal solution!
- Problem: initial state (I), goal states (G), and a suboptimality bound $\omega \geq 1$.
- Objective: Find a solution with cost at most $\omega \cdot C^*$ as fast as possible.

Previous Approaches

- **Weighted A***
- **Explicit Estimation Search (EES)**¹
→ focal search:
 - *cleanup* sorted by f , all generated nodes
 - *open* sorted by \hat{f} , only nodes with $g + \hat{h} \leq \omega \cdot f_{min}$
 - *focal* sorted by d , only nodes with $g + \hat{h} \leq \omega \cdot f_{min}$ (\hat{h} is corrected for the observed heuristic error²)
- **Dynamic Potential Search (DPS)**³
→ best-first search on $\frac{\omega \cdot f_{min} - g(n)}{h(n)}$

¹Thayer and Ruml, 2011.

²Thayer, Dionne, and Ruml, 2011.

³Gilon, Felner, and Stern, 2016.

Dynamic Expected Effort Search

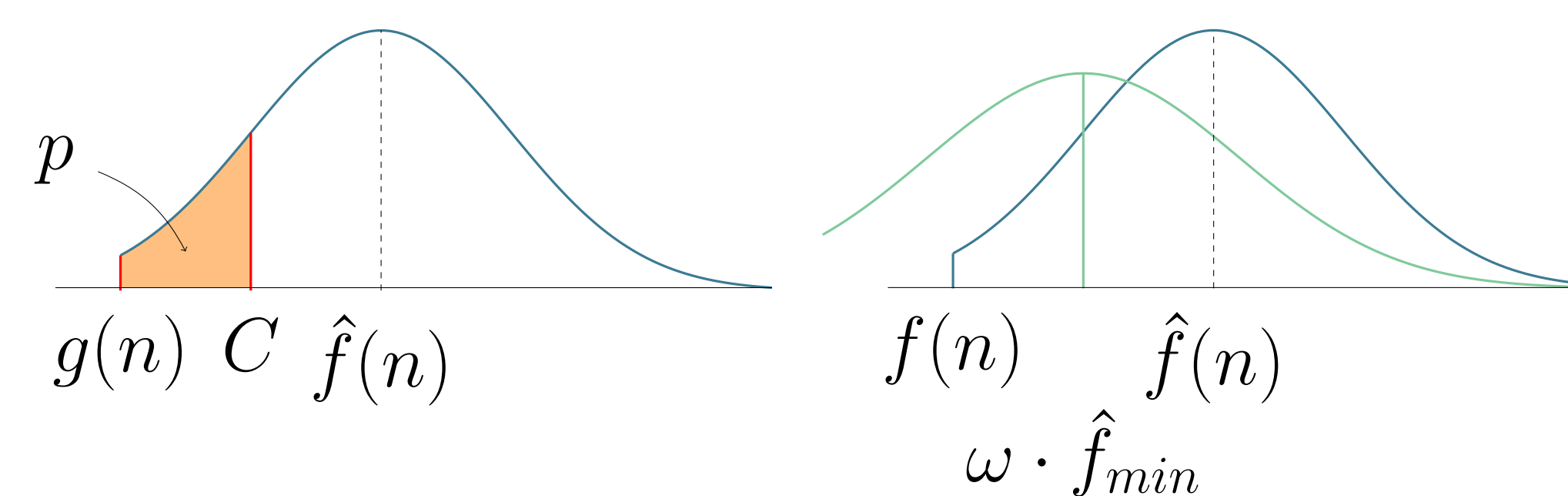
Best-first search on the expected effort:⁴ $\frac{T}{p}$

- $T(n)$: search effort to find a solution under n
- $p(n)$: probability that n leads to a solution within estimated bound

$$\textcircled{n_1} \quad T = 10 \quad p = 0.5 \quad \rightsquigarrow 20 \qquad \textcircled{n_2} \quad T = 6 \quad p = 0.25 \quad \rightsquigarrow 24$$

How to obtain T and p ?

- Obtaining T use distance-to-go d
- Obtaining p from belief distributions



hard to estimate when raising the bound is useful!

A Round-Robin Scheme

Replace EES selection rule with Round-Robin⁵:

- **open list**: sorted by \hat{f}
- **cleanup list**: sorted by f
- **focal list**: sorted by $d(\text{EES})$ or $ud(\text{DPS})$ or $xe(\text{DXES})$

⁴First suggested by Dobson and Haslum (HSDIP'17)

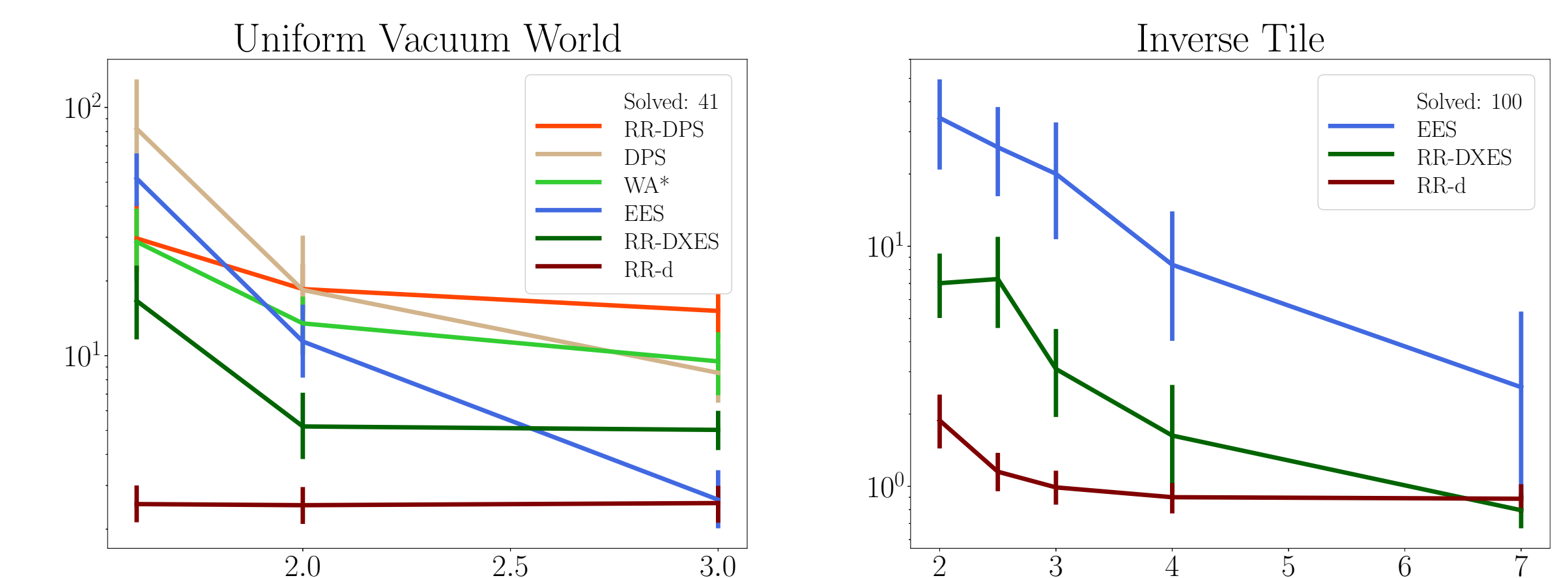
⁵Helmert and Roger, 2010

Experiments

Planning Domains: IPC optimal tracks (48 domains)

Coverage	WA*	EES	DPS	DXES	RR-DPS	RR-d	RR-DXES
Sum (1652)	995	967	1012	894	982	1025	1052
Normalized(%)	58.7	57.0	60.0	51.5	57.9	60.7	62.5
Expansions	569	558	472	734	665	383	371

Search Domains:



RoundRobin- d and RoundRobin- $DXES$ perform best overall.

Conclusion

- Weighted-A* is the first thing to try
- Round-Robin on d, \hat{f}, f is the next to try
- Round-Robin on xe, \hat{f}, f performs well in some domains

Still unresolved:

- When to raise bound, and when to pursue solution?
- How to best use belief distribution in bounded-suboptimal search?