More Deliberation with Incomplete Information Can Do Worse

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MOTIVATION
Heuristic Search in Real-time Decision Making

- Limited computing resources
- Unknown goal state

Examples
- MR ADORE
- Real-time Strategy games

Question: With limited computing resources, should we search as deep as possible?

Answer: NO!

PATHOLOGIES
Deeper lookahead in real-time heuristic search can, on average, lead to worse solutions!

TEST BED

N x M-1 puzzle
- Braching factor = 2, 3, or 4
- Use g(s) + h(s) to evaluate state s, h(s) is an estimation of $h^*(s)$

1-D Maze

1-D Maze

T1(k) PATHOLOGIES

Expected solution length matrix
- $M_j$: expected number of moves towards goal
- $c$: starting state
- $k$: lookahead depth

- A state is T1(k) pathological
- $h^*(s)$ is expected solution length vector that has exactly $k$ consecutive increase in it.
- Heuristic is called T1(k) pathological

REMEDIES

Remedy - pathology detection
- Off-line detection
- Machine-learned detectors
- On-line detection
- Adjust heuristics online
- Reinforcement learning [Sutton&Barto]
- Real-time dynamic programming [Barto]
- Meta-level control
- Adaptive lookahead depth selection

FUTURE RESEARCH
- Pathologies in other types of search
- Pathologies with other heuristics
- Pathologies in real life domains
- RTS games
- MR ADORE
- Remedies in real life domains
- Pathologies in two-player games

CONTRIBUTIONS
- Demonstrate that pathologies exist in non-trivial domains with natural, admissible, and consistent heuristics
- Empirical study of how pathologies affect the quality of search
- Observations from empirical study
- Remedies of pathologies