Beliefs We Can Believe in: Replacing Assumptions with Data in Real-time Search

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Motivation

Real-time Search: agent has bounded time to select next action for execution

Setting is deterministic, single agent

Must efficiently allocate limited number of search node expansions

Classical solutions are often intuitive adaptations of offline search, such as RTA* and LSS-LRTA*

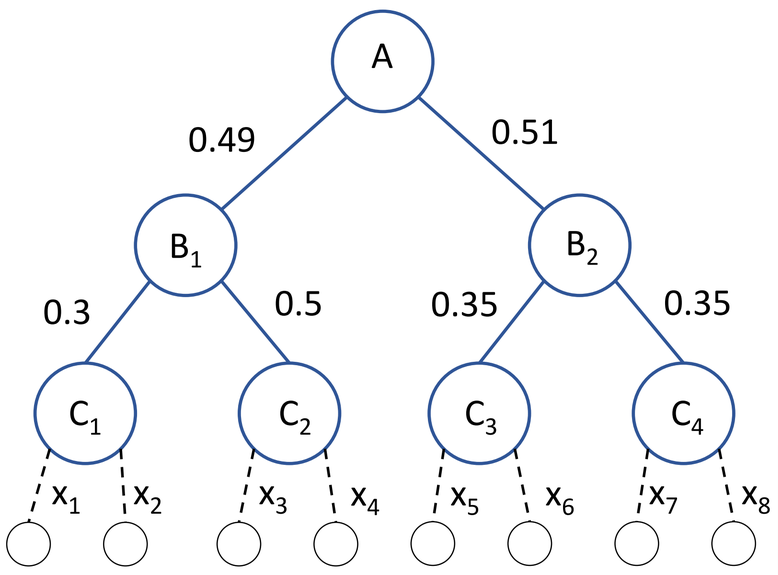
What if we designed for real-time planning from scratch?

Contribution

AAAI-19: The Nancy Framework
- Nancy Backup
- risk-based lookahead

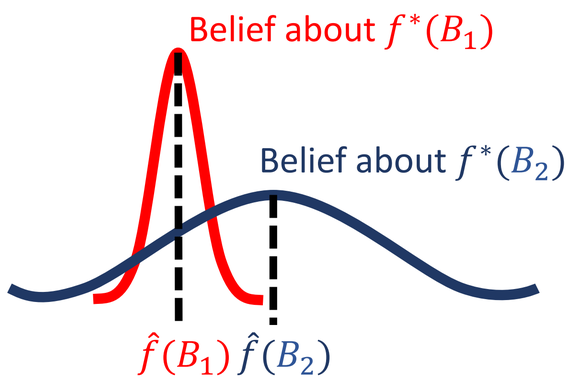
AAAI-20: Data-Driven Nancy
- replace assumptions with data
- completeness proof

How to Gather Information?



Given these search nodes should an agent at A move to B_1 or B_2?

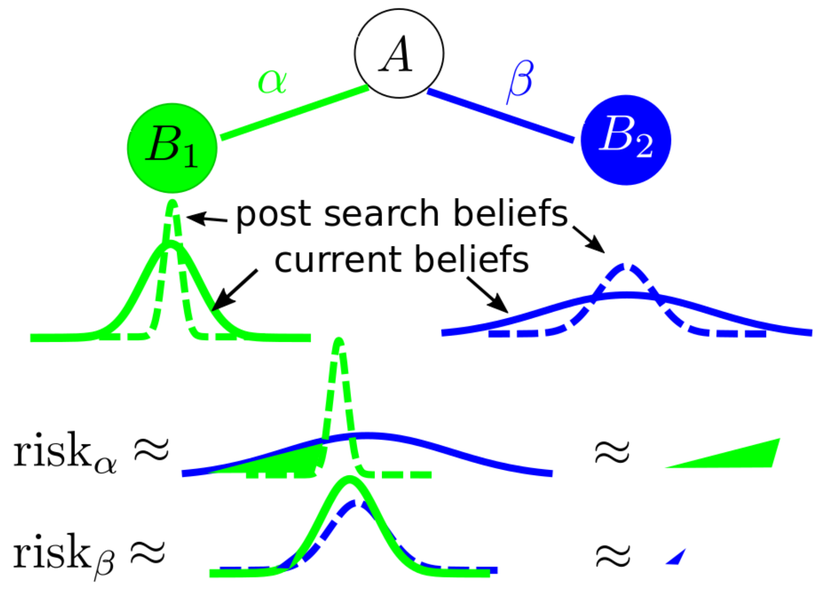
Which Node to Expand?



Should the agent expand nodes on the frontier under B_1 or B_2?

Searching use beliefs

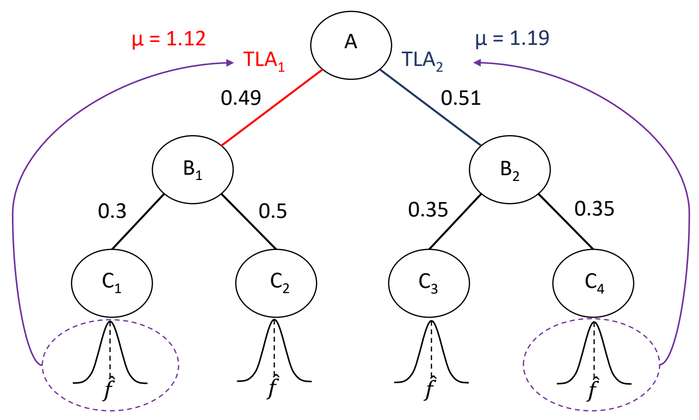
Risk-based Expansion: given beliefs about top level action values, expand nodes on the frontier under top level action that minimizes risk, the expected regret



expand under β!

Where do beliefs come from?

Purpose of search is to gather information to inform decision-making process. Which information on the search frontier should be used to form beliefs about top level actions?



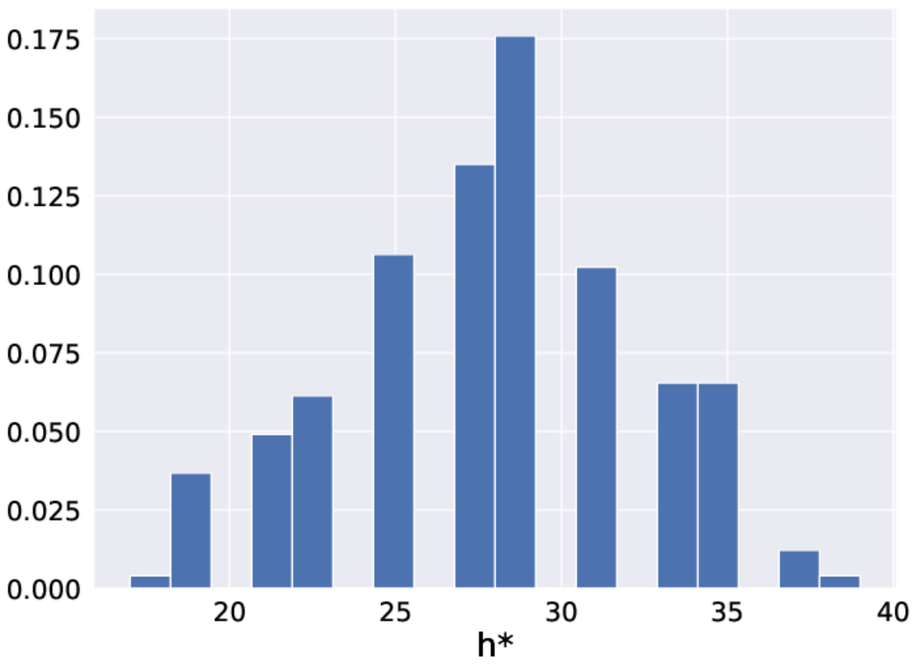
$$\hat{f} = g + \hat{h} = g + h + \epsilon d$$

Nancy: based on assumptions
Truncated Gaussian based on h and d
Data-Driven Nancy:
replace the assumptions with data!
Offline learning with many parameters

Data-Driven Nancy

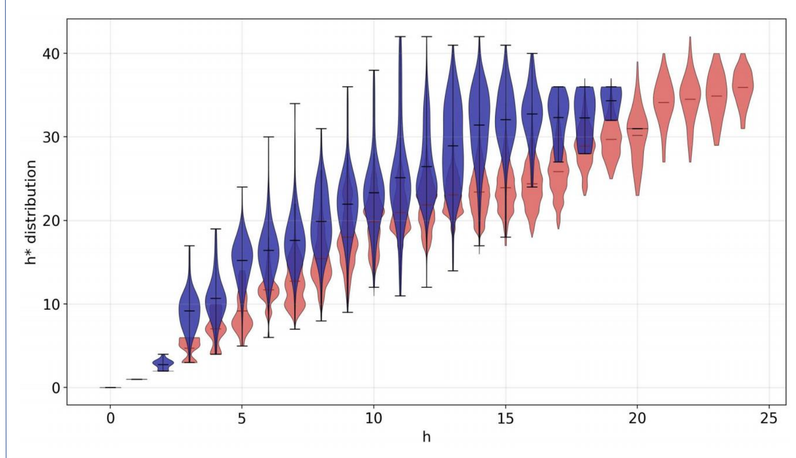
Gathering data:
1.Run weighted-A* on random problems
2.Collect all states
3.For each observed h value pick common states
4.Compute h*

Example h* belief for unit tiles: h = 10



Results

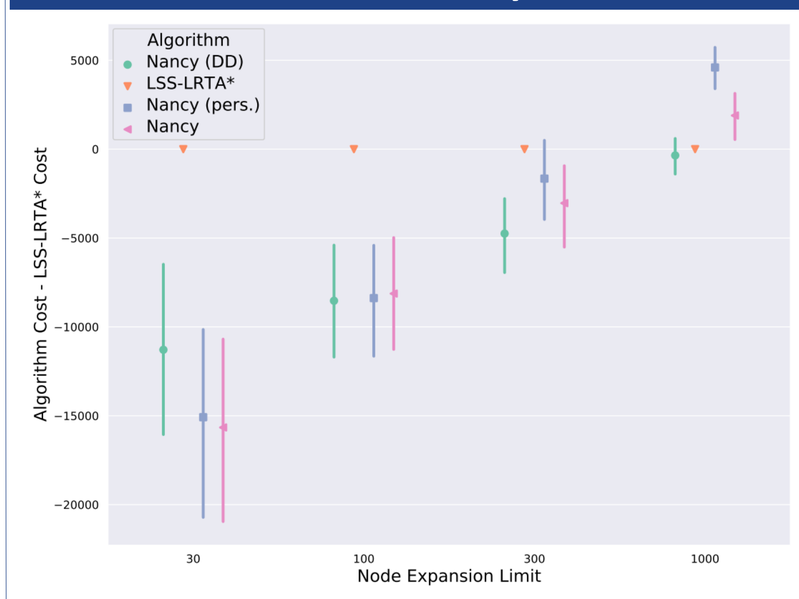
Example h*: Transport vs Blocks World



Solution Cost on Planning Domains

Domain	L	LSS-LRTA*	Nancy ('19)	Nancy (P)	Nancy (P+DD)
Blocksw. (35)	100	46	67	**33**	38
	300	36	46	**30**	34
	1000	30	44	32	**27**
Transport (60)	100	631	1116	615	**496**
	300	519	705	559	**485**
	1000	499	607	567	**422**
Transport (60) (unit-cost)	100	48	79	40	**31**
	300	47	43	**30**	34
	1000	35	36	29	**27**
Elevators (30) (unit-cost)	100	50	55	**35**	39
	300	32	40	**29**	30
	1000	34	31	27	**26**

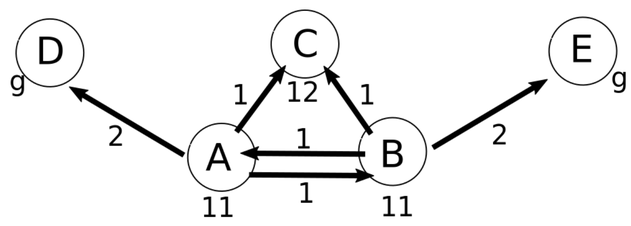
Solution Cost on Heavy-cost Tiles



Completeness Proof

Original Nancy is incomplete due to subtle issue: not guaranteed to see best node from previous iteration.

Our solution is to **Persist** on the previous target state if current lookahead does not yield a better one (with lower f-hat)



Conclusions

- Nancy framework outperforms conventional LSS-LRTA*
- Replacing assumptions with data increase robustness
- all uncertainty is due to bounded rationality

metareasoning about uncertainty pays off, even for deterministic domains!