Correlation Complexity of Classical Planning Domains

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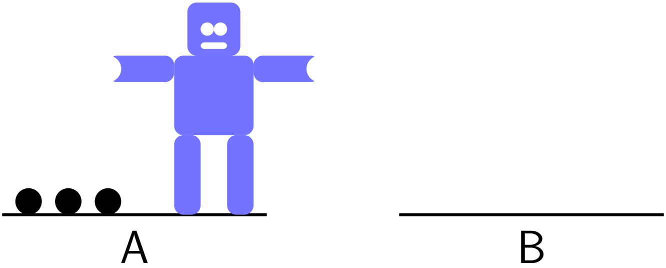
Some Planning Tasks are Easy

- Domain independent planning is (PSPACE) hard.
- But some domains are easy.
- How can we quantify this?



Related Concepts

Width

- (macro-)persistent Hamming width (Chen and Giménez, 2007; 2009)
- serialized iterated width (Lipovetzky and Geffner, 2012; 2014)

Search space topology

- Fixing the heuristic, how do search algorithms behave (Hoffmann, 2005)

Our approach

- Fixing the behavior of search algorithms, how complex does the heuristic need to be?

Main Question

How complex must a heuristic be
to guide a forward search directly to the goal?

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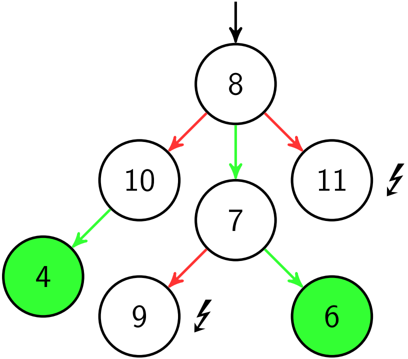
Heuristic Properties

- alive state: reachable + solvable + non-goal
- descending: all alive states have an improving successor
- dead-end avoiding: all improving successors of alive states are solvable



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  $\rightarrow$ descending and dead-end avoiding
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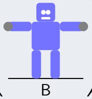
Potential Heuristics

States factored into facts

Features: conjunction of facts

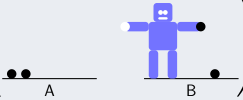
Weights for features

$w\Big($ 

$\Big) = 8;\ w\Big($ 

$\Big) = 1;\ w\big($  $\big) = 4$

Heuristic value

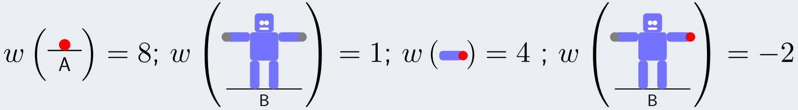
$h\Big($ 

$\Big) = 8 + 8 + 1 + 4 = 21$

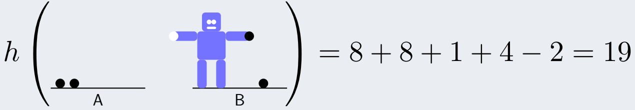
Potential Heuristics

States factored into facts
Features: conjunction of facts

Weights for features



Heuristic value



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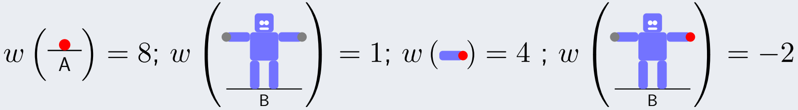
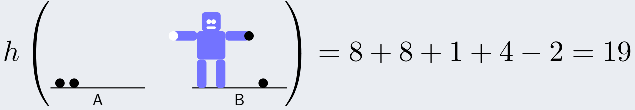


Heuristic value



Dimension: number of facts in largest feature

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  $\rightarrow$ dimension of potential heuristics

Correlation Complexity

Definition (correlation complexity of a planning task)

minimum dimension of a descending, dead-end avoiding potential heuristic for the task

Definition (correlation complexity of a planning domain)

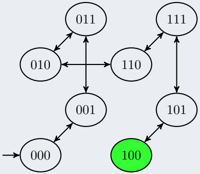
maximal correlation complexity of all tasks in the domain

Correlation Complexity of Some Domains

Correlation Complexity 2

- Blocksworld without an arm
- Gripper
- Spanner
- VisitAll

Correlation Complexity 3



Construction based on 3-bit Gray code

Conclusion and Future Work

- New measure for the complexity of classical planning tasks.
- Measures how interrelated the task's variables are.
- All studied benchmark domains have correlation complexity 2.
- Next: find good features and weights automatically.

Extra Slides

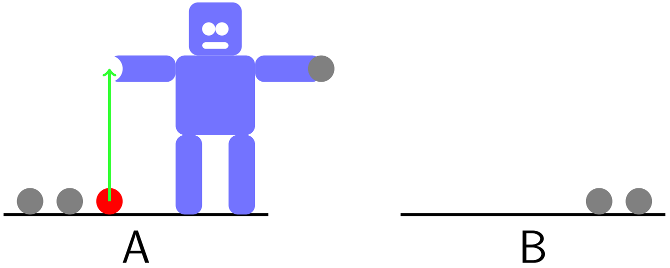
Gripper has Correlation Complexity 2

Weight Function

$$w(\text{r-in-B}) = 1$$
$$w(\text{b-in-A}) = 8$$
$$w(\text{b-in-G}) = 4$$
$$w(\text{r-in-B} \land \text{b-in-G}) = -2$$

Pick-up-in-A

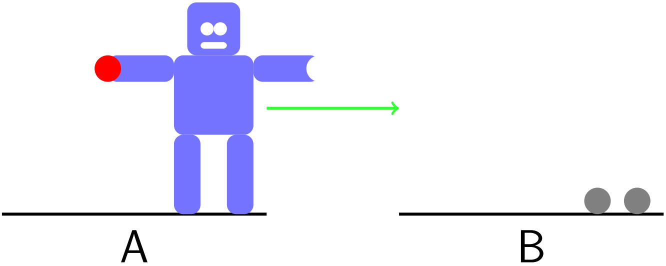
$w(\text{r-in-B}) = 1, w(\text{b-in-A}) = 8, w(\text{b-in-G}) = 4, w(\text{r-in-B} \wedge \text{b-in-G}) = -2$



adds:	b-in-G
removes:	b-in-A
difference:	$+4 - 8 = -4$

Move-to-B

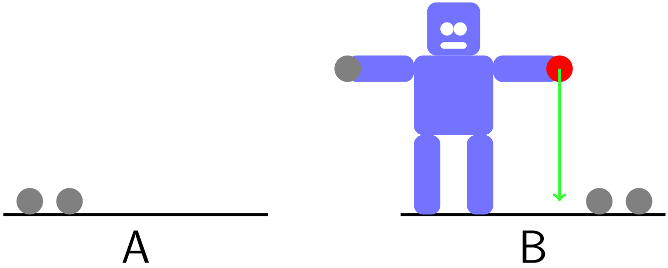
$w(\text{r-in-B}) = 1, w(\text{b-in-A}) = 8, w(\text{b-in-G}) = 4, w(\text{r-in-B} \wedge \text{b-in-G}) = -2$



adds:	r-in-B, r-in-B $\wedge$ b-in-G
removes:	—
difference:	$+1 + (-2) = -1$

Drop-in-B

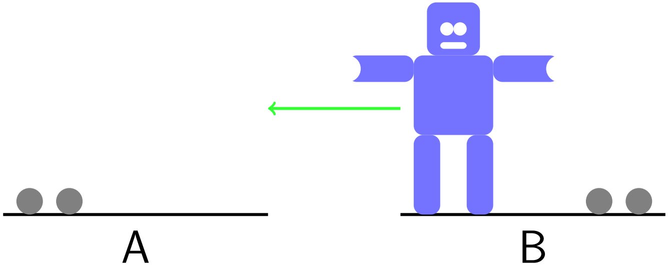
$w(\text{r-in-B}) = 1, w(\text{b-in-A}) = 8, w(\text{b-in-G}) = 4, w(\text{r-in-B} \land \text{b-in-G}) = -2$



adds:	—
removes:	b-in-G, r-in-B ∧ b-in-G
difference:	$-4 - (-2) = -2$

Move-to-A

$w(\text{r-in-B}) = 1, w(\text{b-in-A}) = 8, w(\text{b-in-G}) = 4, w(\text{r-in-B} \land \text{b-in-G}) = -2$



adds: —
removes: r-in-B
difference: -1

Example Task with Correlation Complexity 3

- 3-bit Gray code: