Correlation Complexity of Classical Planning Domains

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June 13, 2016

Motivation

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

- What does "guide directly to the goal" mean?
  $\rightarrow$ descending and dead-end avoiding
- How can we measure the complexity of a heuristic?
  $\rightarrow$ dimension of potential heuristics

Related Concepts

Width

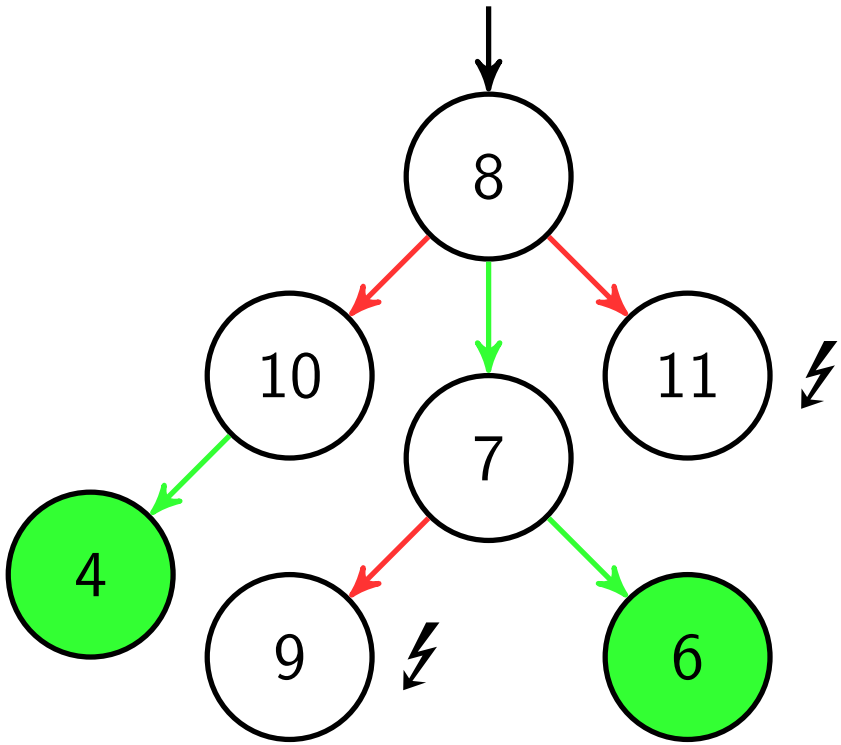
- (macro-)persistent Hamming width
  (Chen and Giménez, 2007; 2009)
- serialized iterated width
  (Lipovetzky and Geffner, 2012; 2014)

comparisons to correlation complexity in the paper

Definition

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



Potential Heuristics

- features $\mathcal{F}$: conjunctions of facts
- weight function w: assigns numeric value to each feature
- heuristic value φ: sum of a state's feature weights
- dimension: size of largest feature

$$\varphi(s) = \sum_{F \in \mathcal{F}} w(F)[s \models F]$$

Correlation Complexity

Definition

- correlation complexity of a planning **task**:
  minimum dimension of a descending, dead-end avoiding potential heuristic for the task
- correlation complexity of a planning **domain**:
  maximal correlation complexity of all tasks in the domain

Results

Domains with Correlation Complexity 2

- Blocksworld-no-arm
- Gripper
- Spanner
- VisitAll

Example

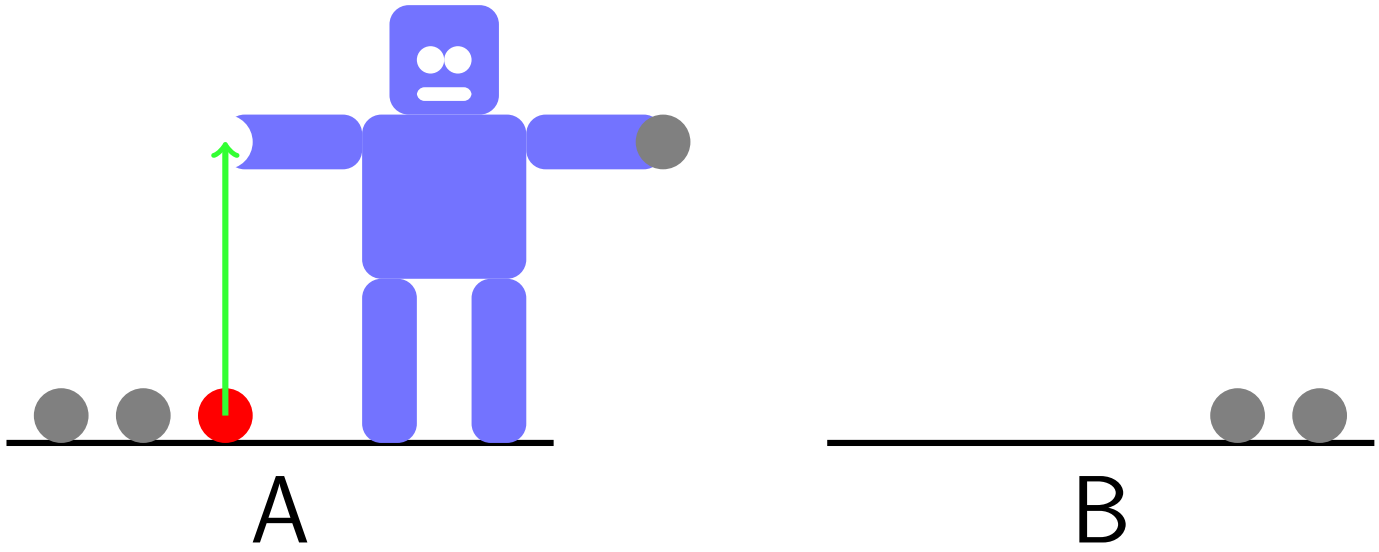
Gripper has Correlation Complexity 2

Weight Function

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

Pick-in-A

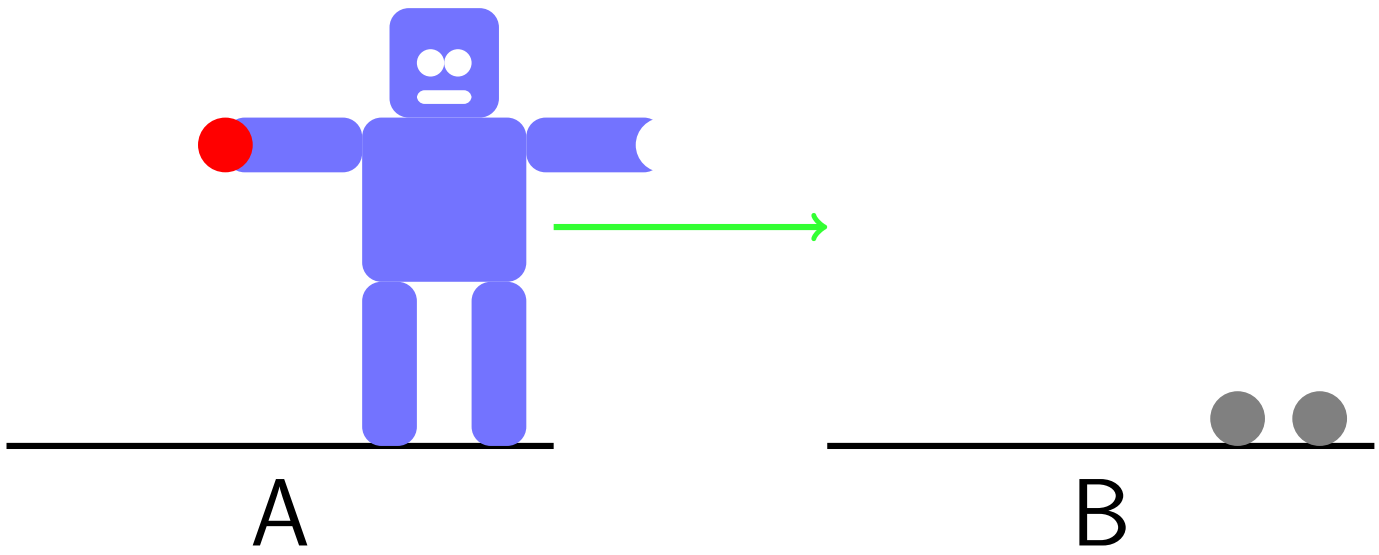
$$w(\text{r-in-B}) = 1, w(\text{b-in-A}) = 8, w(\text{b-in-G}) = 4, w(\text{r-in-B} \wedge \text{b-in-G}) = -2$$



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

Move-to-B

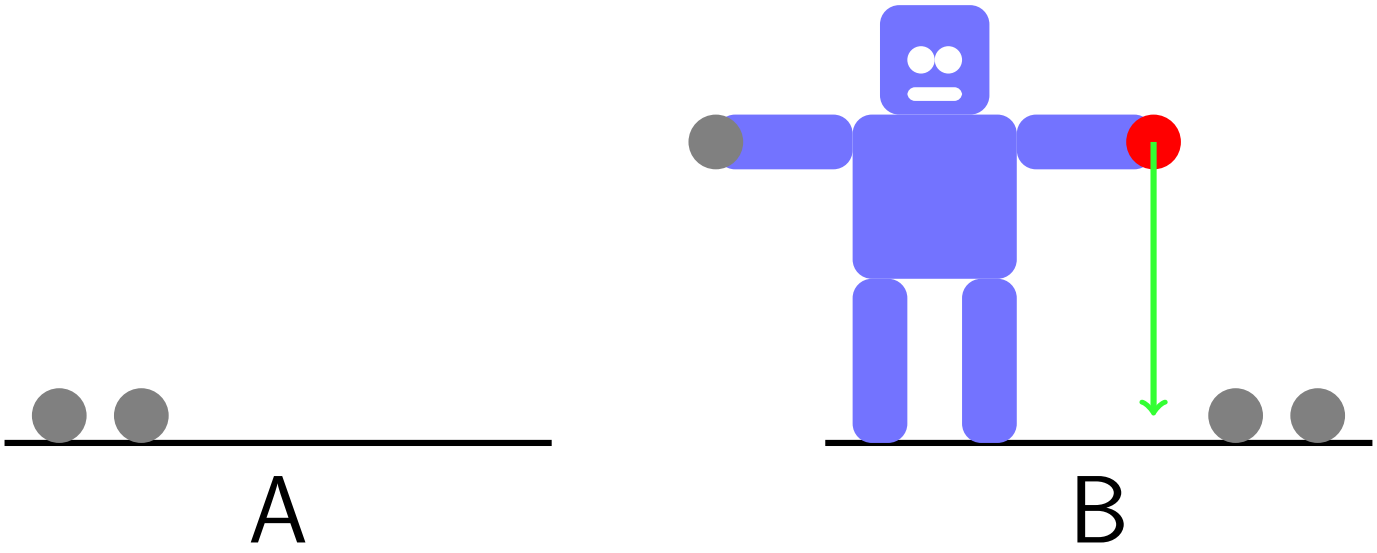
$$w(\text{r-in-B}) = 1, w(\text{b-in-A}) = 8, w(\text{b-in-G}) = 4, w(\text{r-in-B} \wedge \text{b-in-G}) = -2$$



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

Drop-in-B

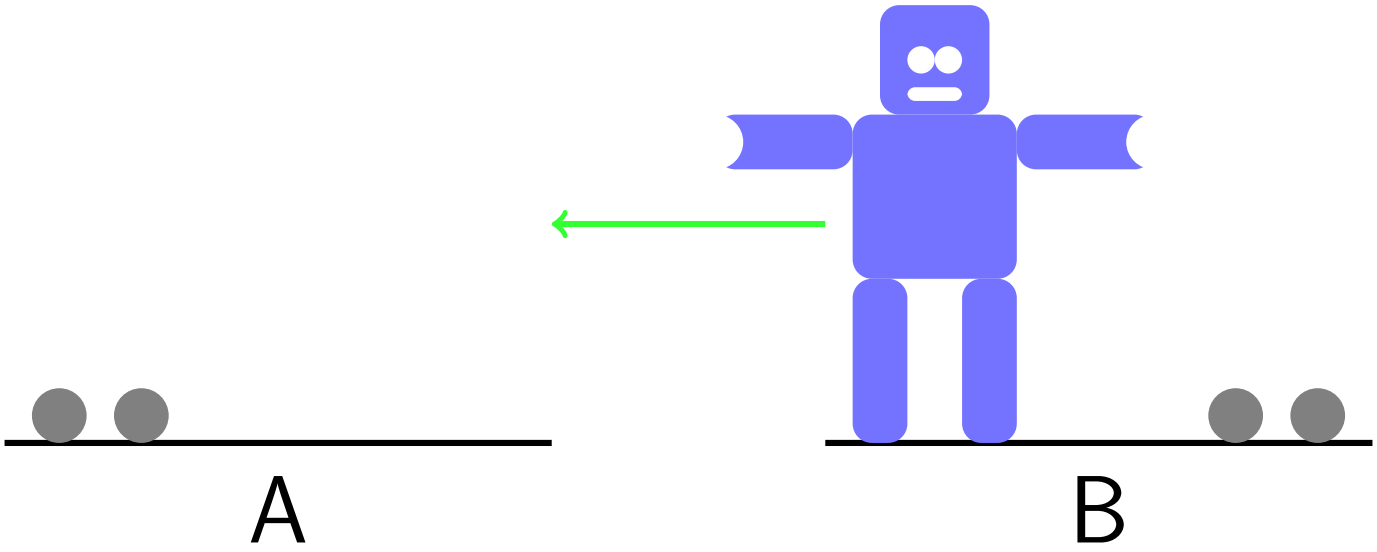
$$w(\text{r-in-B}) = 1, w(\text{b-in-A}) = 8, w(\text{b-in-G}) = 4, w(\text{r-in-B} \wedge \text{b-in-G}) = -2$$



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

Move-to-A

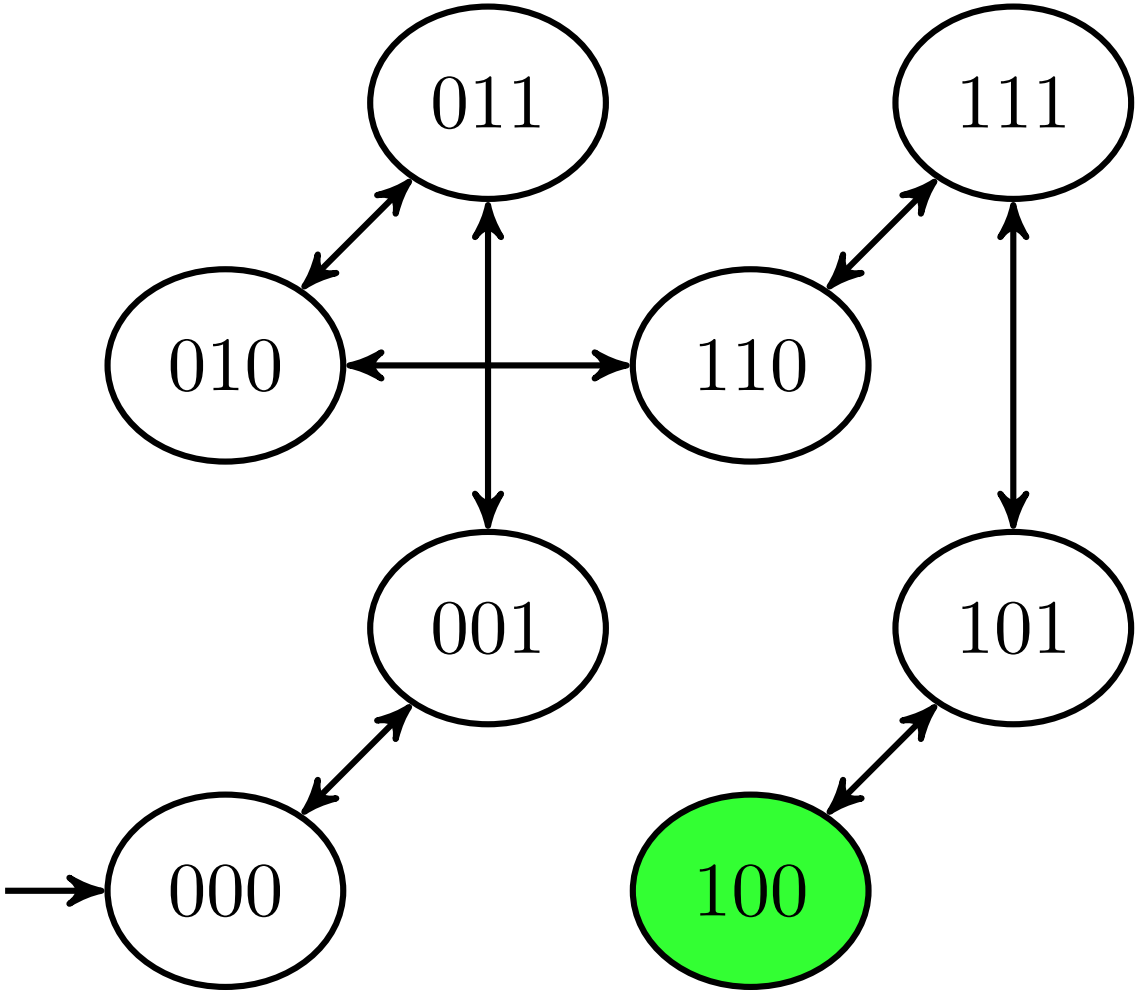
$$w(\text{r-in-B}) = 1, w(\text{b-in-A}) = 8, w(\text{b-in-G}) = 4, w(\text{r-in-B} \wedge \text{b-in-G}) = -2$$



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

Example Task with Correlation Complexity 3

- 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.
- Find good features and weights automatically.