Transition Landmarks from Abstraction Cuts

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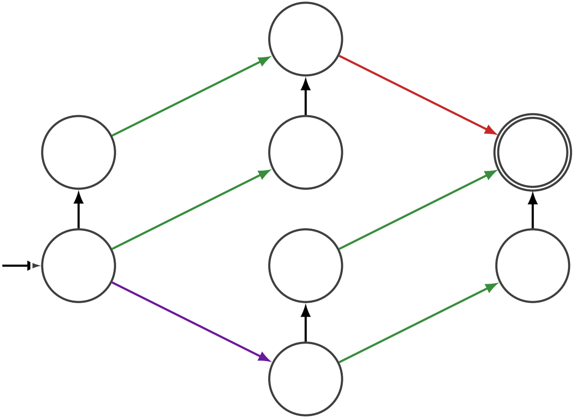
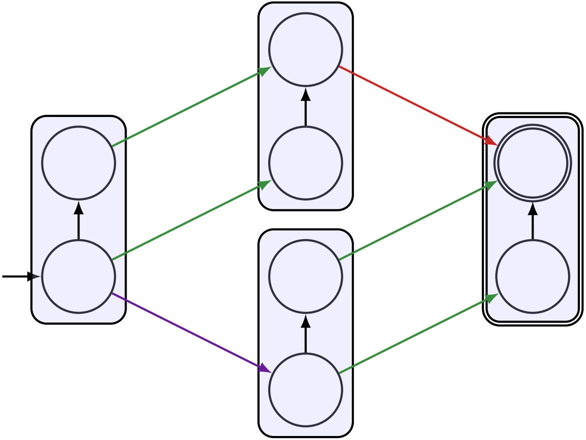
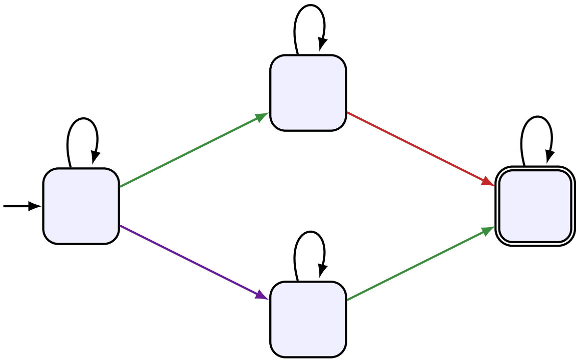
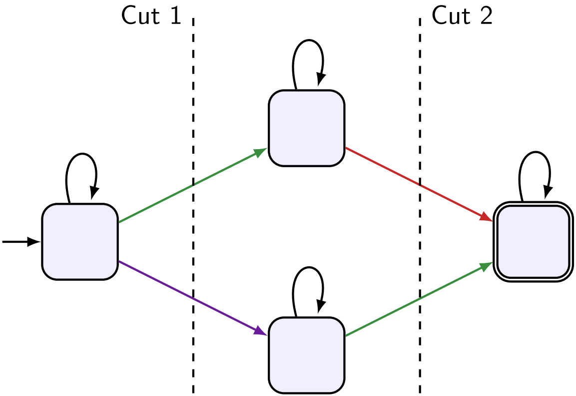


Classical Planning and Abstractions

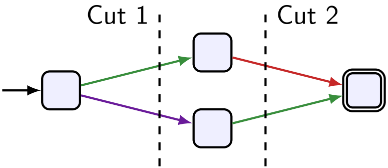




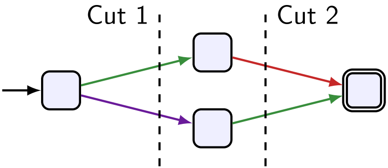
Cuts in Abstractions are Landmarks



Operator-Counting Constraints from Cuts



Operator-Counting Constraints from Cuts

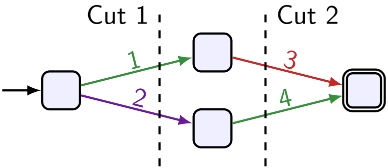


Operator-Counting Constraints

$$Y_{\color{green}\rightarrow} + Y_{\color{purple}\rightarrow} \geq 1 \qquad \text{// Cut 1}$$
$$Y_{\color{red}\rightarrow} + Y_{\color{green}\rightarrow} \geq 1 \qquad \text{// Cut 2}$$

Issue: The constraints are satisfied by a single use of $\color{green}\rightarrow$ even though we clearly need two steps here.

Transition-Counting Constraints from Cuts



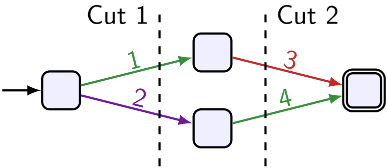
Transition-Counting Constraints

$Y_{\underrightarrow{1}} + Y_{\underrightarrow{2}} \geq 1$ // Cut 1

$Y_{\underrightarrow{3}} + Y_{\underrightarrow{4}} \geq 1$ // Cut 2

Issue: Transition counts have to be connected to operator counts.

Transition-Counting Constraints from Cuts



Transition-Counting Constraints

$$Y_{\underrightarrow{1}} + Y_{\underrightarrow{2}} \geq 1 \qquad \text{// Cut 1}$$

$$Y_{\underrightarrow{3}} + Y_{\underrightarrow{4}} \geq 1 \qquad \text{// Cut 2}$$

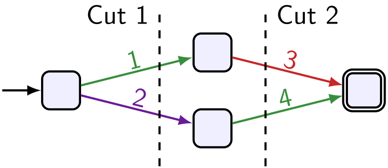
$$Y_{\rightarrow} = Y_{\underrightarrow{1}} + Y_{\underrightarrow{4}} \qquad \text{// Link } \rightarrow$$

$$Y_{\rightarrow} = Y_{\underrightarrow{2}} \qquad \text{// Link } \rightarrow$$

$$Y_{\rightarrow} = Y_{\underrightarrow{3}} \qquad \text{// Link } \rightarrow$$

Issue: One variable per (abstract) transition can be too much.

Projection for Disjoint Cuts



Transition-Counting Constraints after Projection

$$
\begin{aligned}
Y_{\color{green}\rightarrow} + Y_{\color{purple}\rightarrow} &\geq 1 && \text{// Cut 1} \\
Y_{\color{red}\rightarrow} + Y_{\color{green}\rightarrow} &\geq 1 && \text{// Cut 2} \\
Y_{\color{red}\rightarrow} + Y_{\color{purple}\rightarrow} + Y_{\color{green}\rightarrow} &\geq 2 && \text{// Cuts 1+2}
\end{aligned}
$$

- mathematically a projection to $\{Y_{\color{green}\rightarrow}, Y_{\color{purple}\rightarrow}, Y_{\color{red}\rightarrow}\}$
- equivalent with respect to operators

Approximating the Projection

General Form for Disjoint Cuts

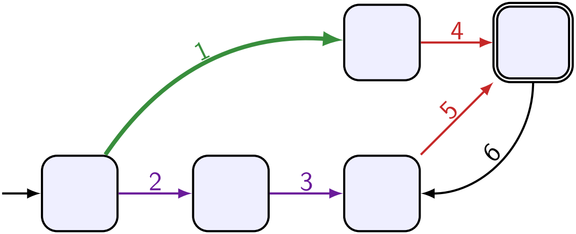
$$\sum_{\substack{o \in O \\ o \text{ mentioned in } S}} Y_o \geq |S| \qquad \text{for all subset of cuts } S$$

Issue: requires one constraint for each subset of cuts.

We can approximate the constraint by considering fewer subsets.

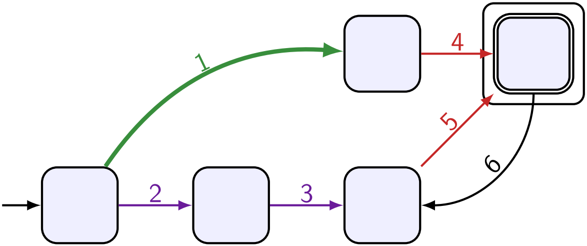
Finding Cuts

Our cut generation is inspired by LM-cut.



Finding Cuts

Our cut generation is inspired by LM-cut.

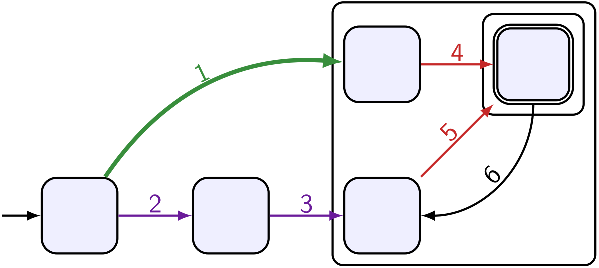


Cuts:

- $\{\xrightarrow{4}, \xrightarrow{5}\}$

Finding Cuts

Our cut generation is inspired by LM-cut.

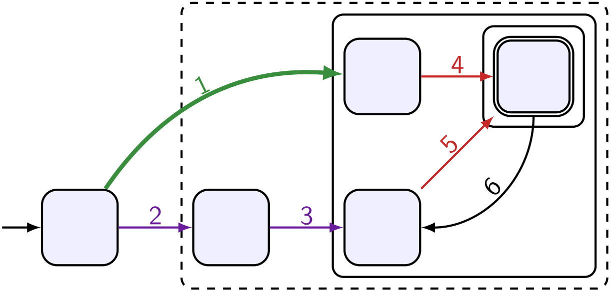


Cuts:

- $\{\xrightarrow{4}, \xrightarrow{5}\}, \{\xrightarrow{1}, \xrightarrow{3}\}$

Finding Cuts

Our cut generation is inspired by LM-cut.



Disjoint cuts:

- $\{\xrightarrow{4}, \xrightarrow{5}\}, \{\xrightarrow{1}, \xrightarrow{3}\}$

Overlapping cuts:

- $\{\xrightarrow{4}, \xrightarrow{5}\}, \{\xrightarrow{1}, \xrightarrow{3}\}, \{\xrightarrow{1}, \xrightarrow{2}\}$

Theoretical Connections

Dominance relations for a given set of abstractions

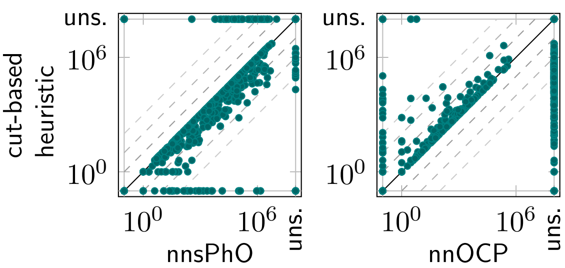
Non-negative saturated posthoc optimization heuristic

$\leq$

Transition-counting heuristic based on cuts

$\leq$

Non-negative optimal cost partitioning



(Details depend on cut generation and approximation.)

Experimental Evaluation

In practice

- projecting out transition-counting variables helps
- approximating constraints helps
- overall, not much benefit over operator landmarks

$\rightsquigarrow$ needs better cut generation

Summary

Link to paper, poster, slides, and source code

Take-away Messages

- Cuts in abstractions are landmarks.
- We can use them as operator-counting and transition-counting constraints.

Future Work

- Find better cut generation methods.