PREDICTING THE EFFECTIVENESS OF BIDIRECTIONAL HEURISTIC SEARCH

BACKGROUND
Necessary expansions in bidirectional search can be measured by solving the minimum vertex cover of a problem-specific bipartite graph.

The solution tells us how far we should search forward/backwards to solve a problem optimally.

1. Number of eligible states (715) with $g$-cost 9 in the forward direction.
2. Total expansions in a bidirectional search of cost 6 forward and cost 5 backward.
3. Optimal meeting point (expand blue states)

States necessarily expanded by forward/backward $A^*$

Example: 4-Peg Towers of Hanoi

In 4-peg Towers of Hanoi a PDB heuristic might divide the discs into groups and compute the exact heuristic for each group. This results in many critical states (states with low and inaccurate heuristic values).

Such a heuristic would return a value of 1 on the problem above where the optimal solution is 9. Thus, there are many critical states in this problem.

For more info...
See paper for:
- measures for critical states
- a discussion of asymmetry
- extensive experimental results

KEY OBSERVATIONS
Performance of bidirectional search depends on the critical states in the bipartite graph.

Critical states have large $g$-cost and low/inaccurate $h$-values.

More critical states $\rightarrow$ better bidirectional performance.

Example: TOH with PDB heuristic

Number of eligible states (715) with $s$ / $\exists s$.

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Nodes expanded by different algorithms and heuristics. (Heuristic is # discs in pattern.)

<table>
<thead>
<tr>
<th>Heuristic</th>
<th>Unidir $A^*$</th>
<th>Bidirectional</th>
<th>DVCBS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>10+2</td>
<td>64,334</td>
<td>100,080</td>
<td>69,010</td>
</tr>
<tr>
<td>8+4</td>
<td>457,401</td>
<td>411,085</td>
<td>434,347</td>
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<tr>
<td>6+6</td>
<td>789,603</td>
<td>446,603</td>
<td>525,811</td>
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<tr>
<td>4+8</td>
<td>548,850</td>
<td>411,212</td>
<td>427,702</td>
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<tr>
<td>2+10</td>
<td>172,088</td>
<td>199,880</td>
<td>192,271</td>
</tr>
<tr>
<td>Zero</td>
<td>8,262,691</td>
<td>450,539</td>
<td>425,576</td>
</tr>
</tbody>
</table>

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