Counterexample-guided Cartesian Abstraction Refinement

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Overview

1. CEGAR algorithm
2. Evaluation
3. Ongoing research
CEGAR algorithm
Example refinement

drive, (un)load-in-A, (un)load-in-B
Example refinement

drive, (un)load-in-A

unload-in-B

drive

load-in-B
Example refinement

- Drive
- Load-in-A
- Drive
- Unload-in-B
- Drive

Unload-in-A
Load-in-B
Relation to other classes of abstractions?
Pattern database

CEGAR algorithm

Evaluation

Ongoing research
Classes of abstractions

- **Pattern databases**
  - Refinement at least doubles number of states

- **Cartesian abstractions**
  - Allow fine-grained refinement

- **Merge-and-shrink abstractions**
  - Preimage of abstract states not efficiently computable
Evaluation
Experiments

Setup

- 30 minutes, 2 GB
- 15 minutes refinement
## Experiments

### Results

<table>
<thead>
<tr>
<th>Coverage</th>
<th>$h^0$</th>
<th>$h_{iPDB}$</th>
<th>$h_{1m&amp;s}$</th>
<th>$h_{2m&amp;s}$</th>
<th>$h_{CEGAR}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>elevators-08 (30)</td>
<td>11</td>
<td>20</td>
<td>1</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>miconic (150)</td>
<td>50</td>
<td>45</td>
<td>50</td>
<td>74</td>
<td>55</td>
</tr>
<tr>
<td>mprime (35)</td>
<td>19</td>
<td>22</td>
<td>23</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>mystery (30)</td>
<td>18</td>
<td>22</td>
<td>19</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td><strong>Sum</strong> (1116)</td>
<td>397</td>
<td>450</td>
<td>391</td>
<td>449</td>
<td>441</td>
</tr>
<tr>
<td><strong>Worse than $h^0$</strong></td>
<td>0</td>
<td>30</td>
<td>68</td>
<td>40</td>
<td>1</td>
</tr>
</tbody>
</table>
Experiments
Results – $h(s_0)$ on transport #23

![Graph showing the evaluation of $h(s_0)$ on transport #23. The graph compares $h^*$, $h_{CEGAR}$, and $h_{iPDB}$ with abstract states on the x-axis and $h(s_0)$ on the y-axis.]
Ongoing research
Current work

- Break all optimal solutions
- Additive abstractions (AAAI-LBP 2013)
Current work

- Break all optimal solutions
- Additive abstractions (AAAI-LBP 2013)
Future work

- How to select flaws?
- Better termination criterion for refinement loop
Conclusion

- CEGAR for classical planning
- New admissible heuristic
- Robust performance

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