An Analysis of Merge Strategies for Merge-and-Shrink Heuristics

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June 15, 2016
Outline

1. Background

2. Evaluation
   - All Merge Strategies
   - Random Merge Strategies
   - DFP
   - A New Strategy
Setting

- Classical planning as heuristic search
- Merge-and-shrink: abstraction heuristic
**Merge Strategy**

- **Binary tree** over state variables
Motivation

- Recent development allows (efficient) non-linear merge strategies
- Presumably (and theoretically) large potential for better merge strategies
- Only little research on merge strategies
Outline

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All Merge Strategies – Zenotravel #5

% of strategies with ≤ expansions

expansions until last f-layer
All Merge Strategies – Zenotravel #5

The diagram illustrates the percentage of strategies with fewer expansions until the last $f$-layer for various strategies:

- **ALL**: All strategies combined.
- **CGGL/MIASM/MIASM-SYMM**
- **DFP/RL/CGGL-SYMM/DFP-SYMM/L-SYMM/RL-SYMM**
- **L**
Random Merge Strategies

- Sample of 1000 random merge strategies per task on the entire benchmark set
Random Merge Strategies

- Sample of **1000 random merge strategies** per task on the entire benchmark set
- Expected coverage: 680.17 (baseline: 710 – 757)
- 72 tasks in 19 domains solved by strategies from the literature, but no random one
Random Merge Strategies

- Sample of 1000 random merge strategies per task on the entire benchmark set
- Expected coverage: 680.17 (baseline: 710 – 757)
- 72 tasks in 19 domains solved by strategies from the literature, but no random one
- 21 tasks in 9 domains solved by at least one random strategy, but none from the literature
Random Merge Strategies – NoMystery-2011 #9

% of strategies with ≤ expansions

expansions until last $f$-layer

RND (278/1000)
Random Merge Strategies – NoMystery-2011 #9

The graph shows the percentage of strategies with ≤ expansions until the last f-layer. The x-axis represents the number of expansions until the last f-layer, while the y-axis represents the percentage of strategies. Different strategies are indicated by various line styles and colors:

- RND (278/1000)
- CGGL/
- MIASM
- MIASM-SYMM
- CGGL-SYMM
- DFP/RL
- RL-SYMM
- DFP-SYMM
- L/L-SYMM/
- RND (722/1000)
DFP

- **Score-based** merge strategy: prefer transition systems with common labels synchronizing close to abstract goal states
- Problem: many merge candidates with *equal scores*
Score-based merge strategy: prefer transition systems with common labels synchronizing close to abstract goal states

Problem: many merge candidates with equal scores

Use tie-breaking:

- Prefer atomic or composite transition systems
- Additionally: variable order (L or RL or RND)
- Alternatively: fully randomized
## DFP – Results

<table>
<thead>
<tr>
<th></th>
<th>Prefer atomic</th>
<th>Prefer composite</th>
<th>Random</th>
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<tbody>
<tr>
<td></td>
<td>RL</td>
<td>L</td>
<td>RND</td>
</tr>
<tr>
<td>Coverage</td>
<td>726</td>
<td>760</td>
<td>723</td>
</tr>
<tr>
<td>Linear (%)</td>
<td>10.8</td>
<td>10.9</td>
<td>10.6</td>
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</tbody>
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- Performance (coverage) strongly susceptible to tie-breaking
- Strategies ranging from mostly linear to mostly non-linear
A New Strategy

- Based on the causal graph (CG)
- Compute SCCs of the CG
- Use DFP for merging within and between SCCs
- Mixture of precomputed and score-based strategies
## A New Strategy (SCC-DFP) – Results

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<tr>
<td></td>
<td>RL</td>
<td>L</td>
<td>RND</td>
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<tr>
<td>Coverage</td>
<td>751</td>
<td>760</td>
<td>732</td>
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<tr>
<td></td>
<td>(+25)</td>
<td>(+0)</td>
<td>(+9)</td>
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<tr>
<td>Linear (%)</td>
<td>8.2</td>
<td>8.4</td>
<td>8.2</td>
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<tr>
<td></td>
<td>(-2.6)</td>
<td>(-2.5)</td>
<td>(-2.4)</td>
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- Complementary to MIASM
Conclusions

- Random merge strategies show the potential for devising better merge strategies
- DFP strongly susceptible to tie-breaking
- New state-of-the-art non-linear merge-strategy
- More details: paper or poster
Precomputed (sampling-based) merge strategy which aims at “maximizing pruning”: partitioning of state variables based on searching the space of variable subsets.
Appendix – MIASM

- **Precomputed** (sampling-based) merge strategy which aims at “maximizing pruning”: partitioning of state variables based on searching the space of variable subsets

- **Simpler score-based variant:**
  - Compute all potential merges
  - Choose the one allowing the highest amount of pruning
Appendix – MIASM

- **Precomputed** (sampling-based) merge strategy which aims at “maximizing pruning”: partitioning of state variables based on searching the space of variable subsets

- **Simpler score-based variant:**
  - Compute all potential merges
  - Choose the one allowing the highest amount of pruning
  - Performance **not far** from original MIASM
    (best coverage: 747)
## Appendix – Score Based MIASM

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<tbody>
<tr>
<td>Coverage</td>
<td>743 746 745</td>
<td>747 724 730</td>
<td>726</td>
</tr>
<tr>
<td>Linear (%)</td>
<td>10.4 10.5 11.9</td>
<td>45.2 53.2 51.2</td>
<td>11.8</td>
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