PARIS:
Planning Algorithms for Reconfiguring Independent Sets

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July 10, 2023
CoRe Challenge 2022 (Combinatorial Reconfiguration)
First iteration
Submission PARIS based on planning

What’s the problem?
Power Distribution

Reconfigure network while keeping all households connected.
Graph Coloring

Change from one coloring to another via colorings.
Independent Sets

Independent Set

A set of vertices such that **no two are adjacent**.
Independent Set Reconfiguration

**Input**
- graph
- initial set
- goal set
Independent Set Reconfiguration

Input
- graph
- initial set
- goal set

Output
- sequence of token jumps
Planning Encoding

Single action
- move

\[ \rightarrow \text{SAS}^+ \]

Split action
- pick
- place

\[ \rightarrow \text{SAS}^+ \]
### Solver Tracks

- Existent
- Shortest
- Longest

### Graph Tracks

- 10
- 50
- 100

No resource limits; solutions are submitted
Competition Results – Solver Tracks

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**Existant Track**
- Any solution
- similar to agile IPC track
## Competition Results – Solver Tracks

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### Existent Track
- Any solution
- Similar to agile IPC track

### PARIS
- GBFS + Landmarks (70min)

### Competitors
- **2** Answer Set Programming
- **3** Greedy heuristic search + Bounded Model Checking
## Competition Results – Solver Tracks

### Existent Track

- Any solution
- Similar to agile IPC track

### PARIS

1. **Counter abstraction** (10s)
2. Symbolic search (70min)
3. A* + Landmarks (70min)
4. GBFS + Landmarks (70min)
5. **Counter abstraction** (14h)

### Competitors

- **IDA** + Breadth-first search (7 / 16)
Counter Abstraction – Motivation

- Grid instances
- $4 \times 4$ to $200 \times 200$
Counter Abstraction – Motivation

- Grid instances
- $4 \times 4$ to $200 \times 200$
- 1–2 gaps
- $n \times n$ unsolvable if fewer than $n/2$ gaps
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Counter Abstraction – Motivation

- Grid instances
- $4 \times 4$ to $200 \times 200$
- 1–2 gaps
- $n \times n$ unsolvable if fewer than $n/2$ gaps
Counter Abstraction

• Color the graph
• Count number of tokens on each color
• Abstract states:

```
2 3 4
4 3 2
```

Encode independent set + count constraints as MIP

If constraints unsatisfiable for abstract state → prune
Fully explored abstract state space → unsolvable
Counter Abstraction

- Color the graph
- Count number of tokens on each color
- Abstract states:
  - Encode independent set + count constraints as MIP
  - If constraints unsatisfiable for abstract state → prune
  - Fully explored abstract state space → unsolvable
### Shortest Track

- Shortest solution among competitors
- similar to **satisficing** IPC track

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### Shortest Track
- Shortest solution among competitors
- similar to *satisficing* IPC track

### PARIS
- GBFS + Landmarks (70min)

### Competitors
1. Answer Set Programming
2. Reinforcement Learning
Competition Results – Solver Tracks

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Shortest Track

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PARIS

1. Counter abstraction (10s)
2. Symbolic search (70min)
3. A* + Landmarks (70min)
4. GBFS + Landmarks (70min)
5. Counter abstraction (14h)

Competitors

1. Greedy heuristic search + Bounded Model Checking
3. Answer Set Programming
## Competition Results – Solver Tracks

### Longest Track

- Longest loopless solution among competitors
- No IPC equivalent

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**Longest Track**

- Longest loopless solution among competitors
- no IPC equivalent

**PARIS**

- Symbolic top-k search (70min)

**Competitors**

- 2 Answer Set Programming
- 3 Bounded Model Checking
Competition Results – Solver Tracks

Longest Track

- Longest loopless solution among competitors
- No IPC equivalent

PARIS
1. GBFS + Landmarks (5min)
2. **Symbolic top-k search** (65min)

Competitors
2. Answer Set Programming
Symbolic Top-k Search

- Run loopless symbolic top-k search
- Reconstruct one plan per cost
- **Iteratively** find longer plans
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Competition Results – Graph Track

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Graph

- Find difficult graphs
- Fixed number of nodes
- Longest optimal sequence

PARIS

- Great graphs (pretty)

Competitors

1. Slightly “better” graphs (not pretty)
The House Widget

- Optimal for $n = 5$
- Cannot fit more than 2 tokens
- “Anchor” is occupied throughout flip
• Anchors fully connected and occupied during flip
• One flip at a time
• **Rule 1:** house \( k + 1 \) must be on
• Rule 1: house $k + 1$ must be on
• Rule 1: house $k + 1$ must be on
• Rule 2: houses $\geq k + 2$ must be off
• Rule 1: house \( k + 1 \) must be on
• Rule 2: houses \( \geq k + 2 \) must be off
• Start: \( \langle \text{off, off, \ldots, off} \rangle \)
• Goal: \( \langle \text{on, off, \ldots, off} \rangle \)