Learning Relational Decision Trees for Guiding Heuristic Planning

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Outline

Background and Motivation

Learning Helpful Context Policies

Planning with Helpful Context Policies

Conclusions
Heuristic Planning

Advantages

▶ One of the top approaches in AI Planning
▶ Heuristic function correctly leads the search in most classical planning benchmarks
▶ Used for other planning paradigms

Issues

▶ Scalability: Node evaluation is expensive.
▶ In some benchmarks heuristic function is not good enough.
Heuristic Planning

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Learning for Heuristic Planning

Learning Opportunities

▶ Avoiding node evaluations
▶ Developing more accurate heuristics

Other Learning Approaches

▶ Macros [Botea et al., 2005, Coles and Smith, 2007, Newton et al., 2007]
▶ Cases [De la Rosa et al., 2007]
▶ Heuristic Functions [Yoon et al., 2006, Xu et al., 2007]
Learning for Heuristic Planning

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▶ Cases  [De la Rosa et al., 2007]
▶ Heuristic Functions  [Yoon et al., 2006, Xu et al., 2007]
▶ General Policies  
  [Khardon, 1999, Martin and Geffner, 2004, Yoon et al., 2007]
Learning Helpful Context Policies

- Learning an action policy in form of relational decision trees
- Using a relational classifier (TILDE)
- The target is which instantiated action to select among the applicable candidates
Learning Helpful Context Policies

Learning Phases

- Generation of Learning Examples
- Action Classification
- Binding Classification
Learning Examples

Helpful Context

- Set of Helpful Actions
- Target Goals (goals remaining in the problem)
- Problem Static Facts
- *Executed Action*
Learning Examples

Helpful Context Example

% Static Predicates of problem
static_fact_calibration_target(sat_prob,instrument0,star0).
static_fact_supports(sat_prob,instrument0,infrared2).
static_fact_supports(sat_prob,instrument0,spectrograph1).
static_fact_on_board(sat_prob,instrument0,satellite0).

% Example sat_E1
selected(sat_e1,sat_prob,switch_on).
candidate_turn_to(sat_e1,sat_prob,satellite0,phenomenon3,star0).
candidate_turn_to(sat_e1,sat_prob,satellite0,phenomenon4,star0).
candidate_switch_on(sat_e1,sat_prob,instrument0,satellite0).
target_goal_have_image(sat_e1,sat_prob,phenomenon3,infrared2).
target_goal_have_image(sat_e1,sat_prob,phenomenon4,infrared2).
Learning Examples

Why not the state?

- Easier matching
- Helpful action encode information about goals
- Better recursive predicate handling
Learning Examples

Generating Examples

- Training problems solved with EHC and refined with DfBnB
- From each node of a best-cost solution
  - An example of helpful context for action classification
  - Examples of helpful context for binding classification
Action Classification

Action Examples

- Helpful Context
- The class is the selected operator
- \textit{Static predicates are shared by all problem examples}

Output

- Action decision tree
Action Classification

Action Examples

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Action Decision Tree

candidate_calibrate(A,B,D,E,F)?
  yes
  calibrate (44/44)
  no
  candidate_take_image(A,B,G,H,I,J)?
    yes
    take_image(110/110)
    no
    candidate_switch_on(A,B,K,L)?
      yes
      switch_on (59/59)
      no
      turn_to (147/149)
      switch_off (2/149)
Binding Classification

Binding Examples

- Helpful Context
- The positive classes are the operator bindings in one of the best-cost solutions
- The negative classes are the operator bindings not present in a best-cost solution

Output

- One binding decision tree for each operator in the domain
Binding Classification

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- One binding decision tree **for each operator in the domain**
Binding Decision Tree

$\text{turn_to}(A,B,C,D,E,F)$

$\text{target_goal_have_image}(A,B,E,G)$?
- yes
  - $\text{static_fact_calibration_target}(B,H,D)$?
    - yes
      - selected (12/12)
    - no
      - rejected (8/8)
  - no
    - rejected (40/40)

$\text{candidate_turn_to}(A,B,C,D,E)$, $\text{target_goal_pointing}(A,B,C,D)$?
- no
  - $\text{candidate_turn_to}(A,B,C,D,E)$, $\text{target_goal_have_image}(A,B,E,I)$?
    - yes
      - $\text{target_goal_have_image}(A,B,D,J)$?
        - yes
          - selected (220/222)
        - no
          - rejected (2/222)
    - no
      - rejected (48/48)
  - yes
    - selected (18/18)
Planning with Helpful Context Policy

Helpful Context Depth-first Search

At each node
  ▶ Helpful Context computation
  ▶ Candidate ordering
    ▶ by the action tree leaf matching current context
    ▶ by the selected/rejected ratio of the binding tree leaf

A backtrack-free search is the execution of the Helpful Context Policy

The best case ⇒ \((\text{Plan\_length} + 1)\) heuristic evaluations
Planning with Helpful Context Policy

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Sorted EHC

At each node

- Helpful Context computation
- Candidate ordering for heuristic evaluation

- Node evaluation reduction, but the search still relies on heuristic function performance
Planning with Helpful Context Policy

Sorted EHC
At each node
- Helpful Context computation
- Candidate ordering for heuristic evaluation

- Node evaluation reduction, but the search still relies on heuristic function performance
## Experimental Results (problems solved)

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<th>H-Context Policy</th>
<th>Sorted-EHC</th>
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</table>
Experimental Results
Conclusions

Representation

▶ Helpful Context as an alternative for representing the meta-state of the search
▶ Hierarchical information for planning benchmarks

Learning

▶ Control-knowledge acquisition as a classification task TILDE
▶ Generation of better training examples (DFBnB)

Planning

▶ Helpful Context DFS and Sorted EHC: additional means for embedding policies within search
▶ Reducing node evaluations for handling scalability problems
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Current Work

Helpful Context Lookahead Search IPC Competitor
At each node expansion a lookahead node is included
▶ Helpful Context computation
▶ Applicable actions of the relaxed plan are sorted
  ▶ by the action tree leaf matching current context (*still applicable*)
  ▶ by the selected/rejected ratio of the binding tree leaf
Thanks


