What's Hot in AI Planning?

(Reflections on ICAPS-17)

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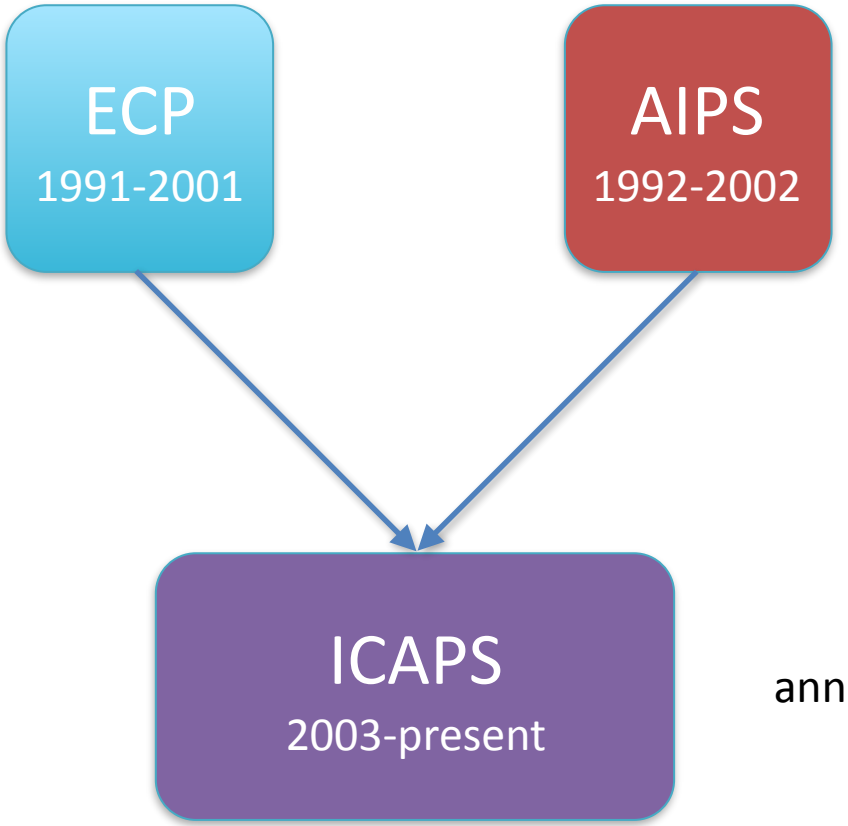
History



Proceedings: aaai.org/Library/conferences-library.php

ICAPS 2017

- 228 attendees, 89 students
- 4 Tracks:
  - Main – 43
  - Applications – 7
  - Robotics – 15
  - Planning & Learning – 6

ICAPS 2017

- 7 Tutorials:
  - AI Planning for Robotics and Human-Robot Interaction
  - Deliberation in Planning and Acting
  - Introduction to CP Optimizer for Scheduling
  - Knowledge Engineering in Planning: Representation Matters
  - Answer Set Planning – Foundations and Applications
  - Alternatives to Explicit State Space Search: Symbolic Search
  - Alternatives to Explicit State Space Search: Decoupled Search
- 10 Workshops:
  - PlanSOpt: Planning, Search, and Optimization
  - SPARK: Scheduling and Planning Applications Workshop
  - GenPlan: Generalized Planning
  - UISP: User Interfaces for/with Scheduling and Planning
  - HSDIP: Heuristics and Search for Domain-independent Planning
  - KEPS: Knowledge Engineering for Planning and Scheduling
  - PlanRob: Planning and Robotics
  - PSHS: Planning and Scheduling for Healthcare and Society
  - COPLAS: Constraint Satisfaction Techniques for Planning and Scheduling Problems
  - IntEx: Integrated Planning, Acting, and Execution: Challenges and Competition Discussion

Nominated Dissertations

2016

- Exploiting Imprecise Information Sources in Sequential Decision Making Problems under Uncertainty – Drougard
- Fast and Optimal Pathfinding – Harabor
- Planning Challenges in Human-Robot Teaming – Talamadupula
- Experience Graphs: Leveraging Experience in Planning – Phillips
- Planning Techniques and the Action Language Golog – Roeger
- Hierarchical Goal Networks: Formalisms and Algorithms for Planning and Acting – Shivashankar
- Symbolic Search and Abstraction Heuristics for Cost-Optimal Planning – Torralba

2017

- Temporal and Hierarchical Models for Planning and Acting in Robotics – Bit-Monnot
- Anytime Optimal MDP Planning with Trial-based Heuristic Tree Search – Keller
- A Constraint-Based Approach for Hybrid Reasoning in Robotics – Mansouri
- Planning and Scheduling in Temporally Uncertain Domains – Micheli
- Multi-Objective Decision-Theoretic Planning – Roijers
- Using Plan Decomposition for Continuing Plan Optimization and Macro Generation – Siddiqui
- Subdimensional Expansion: A Framework for Computationally Tractable Multirobot Path Planning – Wagner
- Exploration in Greedy Best-First Search for Satisficing Planning – Xie

Nominated Dissertations

2018

Creating planning portfolios with predictive models – Cenamor

Effective Planning with Expressive Languages - Francès

Proactive Sequential Resource (Re)distribution for Improving Efficiency in Urban Environments – Ghosh

New Perspectives on Cost Partitioning for Optimal Classical Planning – Pommerening

Domain-Independent Planning for Markov Decision Processes with Factored State and Action Spaces – Raghavan

Multi-agent planning by combination of distributed and local heuristic search – Stolba

Engineering scalable propagation in constraint programming – Van Cauwelaert

Collaborative Diagnosis of Over-Subscribed Temporal Plans – Yu

http://icaps17.icaps-conference.org/

Problem Dimensions

Determinism: D/FOND/POND (8 –, 12 +)

Time: inst/durative/continuous (10, 3 +)

Numeric: none/integer/linear/nonlinear (1, 4 +)

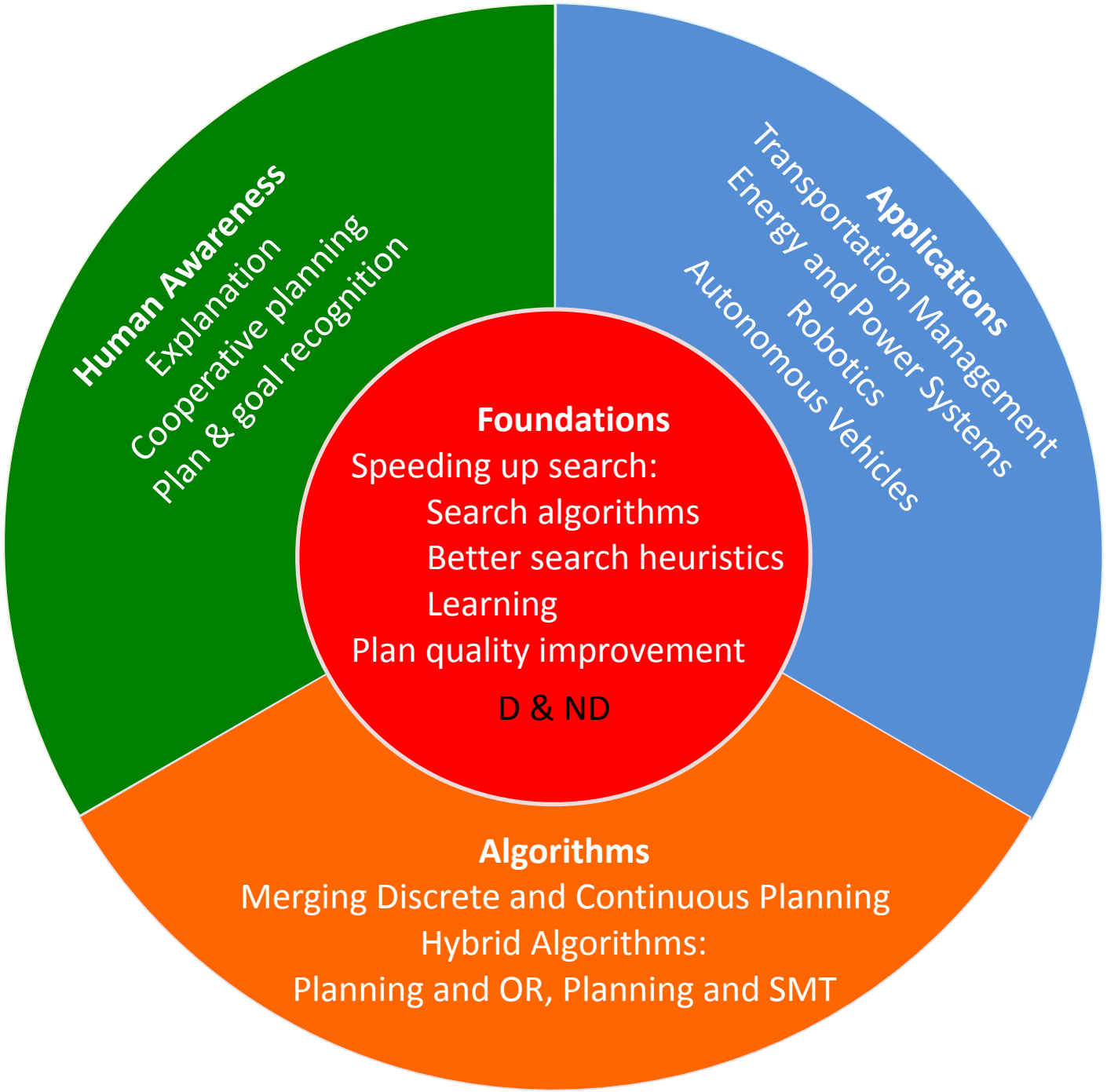
Optimization: satisficing/additive costs/complex/MO (–, 5 +, 8 +, 3 +)

Planning time: offline/online (8 +)

Interaction: oracle/mixed-initiative (1 +)

Agents: single/multi (9 +)

Domain: synth/real (–, 31 +)


Human Awareness
Explanation
Cooperative planning
Plan & goal recognition
Applications
Transportation Management
Energy and Power Systems
Robotics
Autonomous Vehicles
Foundations
Speeding up search:
Search algorithms
Better search heuristics
Learning
Plan quality improvement
D & ND
Algorithms
Merging Discrete and Continuous Planning
Hybrid Algorithms:
Planning and OR, Planning and SMT

Search Heuristics (17+)

- Novelty heuristics for satisficing planning

  Lipovetzky & Geffner: A polynomial planning algorithm that beats LAMA and FF

- Cost Partitioning for optimal planning

  Pommerening, Helmert & Bonet: Abstraction Heuristics, Cost Partitioning, and Network Flows

- Occupancy heuristics for probabilistic planning

  Trevizan, Thiebaux & Haslum: Occupancy measure heuristics for probabilistic planning

  Best paper awards, ICAPS 2016, 2017

Background: Search Paradigm

- Generative planners: heuristically guided FSS search

  classical, temporal/numeric, (FOND, POND)

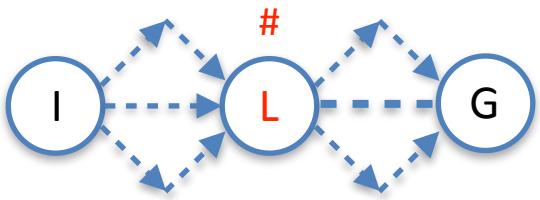
  e.g. FF, LAMA, POPf

- Standard Heuristics: goal distance/cost

  cost(relaxed plan)

  |unachieved landmarks|

  |unachieved disjunctive landmarks|



Novelty Heuristics

- Generative planners: heuristically guided FSS search

  classical, temporal/numeric, FOND, POND

- Hot New Heuristic: state novelty

  width(s) = |smallest new conjunction|

  p is new → width(s) = 1

  p & q is new → width(s) = 2

  prefer states with low width (& fewer unsatisfied goals)

  - performs incredibly well
  - works for domains without well defined goals (games)

Lipovetzky & Geffner: A polynomial planning algorithm that beats LAMA and FF

Optimization & Quality Improvement

- Quality measures (~32)
  - Plan Length (8)
  - Makespan (5)
  - Action costs (9)
  - Multi-Objective Cost (4)
  - Reward (6)

Cost Partitioning

- Multiple abstraction-based heuristic functions
  - e.g. projection to a subset of variables/propositions
- Partition action cost among different heuristics
  - sum heuristic estimates using the partitioned costs
  - retains admissibility if costs in partitions don't exceed original cost
- Flow-based formulation for heuristics
  - smaller & cheaper to compute than original 'operator count' heuristic

     undesirable lower cost estimates
  - simplifications improve the operator counts

    eliminate dead-ends, loops, single-transitions, mutexes

Pommerening, Helmert & Bonet: Abstraction Heuristics, Cost Partitioning, and Network Flows

Occupancy Measure Heuristic

- **Occupancy Measure**: # of times an action is taken in a state
- First Domain Independent Heuristic that **uses Probabilities**

  (as opposed to determinizing the domain and ignoring probabilities)
- Also works for other kinds of complex MDPs, e.g., Constrained SSPs

Trevizan, Thiebaux & Haslum: Occupancy Measure Heuristics for Probabilistic Planning

Dual LP Relaxation and Projections

Occupancy Measure: $x_{s,a}$ - No. of times an action is taken in a state

Dual LP

$$\min_{x} \sum_{s \in S, a \in A(s)} x_{s,a}\, C(a)$$

$$s.t$$

$x_{s,a} \geq 0$
$\sum_s in(s) = 1$ *for all goal states s*
$\text{out}(s_0) = 1, in(s_0) = 0$
out(s)-in(s) = 0 for all other states
$in(s) = \sum_{s',a} P(s'|s,a)\, x_{s',a}$
$\text{out}(s) = \sum_a x_{s',a}$

Flow constraints

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$$s.t$$

{Flow Constraints}

Projected LP

$$h(s) = \min_{x} \sum_{d \in D_v, a \in A(s)} x_{d,a}^{v,s} \, C(a)$$

s.t

{Flow Constraints}

$$\sum_{d_i \in D_{v_i}} x_{d_i,a}^{v_i,s} = \sum_{d_j \in D_{v_j}} x_{d_j,a}^{v_j,s}$$

[Tying Constraints]

Project states on Individual Variables

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Occupancy Measure: $x_{s,a}$ - No. of times an action is taken in a state

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{Flow Constraints}

Project states on Individual Variables

Add Tying Constraints for each state

$$\sum_{d_i \in D_{v_i}} x_{d_i,a}^{v_i,s} = \sum_{d_j \in D_{v_j}} x_{d_j,a}^{v_j,s}$$

[Tying Constraints]

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{Flow Constraints}

Projected LP

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{Flow Constraints}

Project states on Individual Variables

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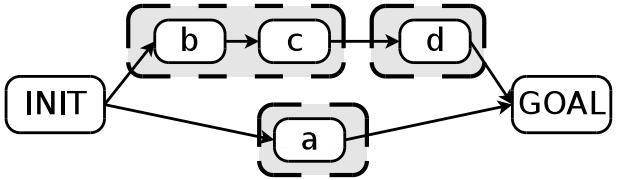
$$\sum_{d_i \in D_{v_i}} x_{d_i,a}^{v_i,s} = \sum_{d_j \in D_{v_j}} x_{d_j,a}^{v_j,s}$$

[Tying Constraints]

Projected Occupation measure heuristics are provably admissible

Plan Quality Improvement

- Generate a plan
- Block de-ordering of plan



- Intensive optimization of windows (LNS)
  - heuristics to guide window selection
  - multiple optimization methods
  - RL to choose optimization methods for windows
- Performance:
  - improves on best solutions found by previous anytime techniques
  - best known solutions to many difficult benchmark problems

Siddiqui: Using Plan Decomposition for Continuing Plan Optimisation and Macro Generation

Planning and Learning

New track at ICAPS'17

- Speedup learning
  - Learning macro actions for planning
  - Learning the best portfolio of planners for a problem
- Learning planning models
  - Learning planning models from natural language
- Learning with Planning
  - Learning for query optimization over graph DBs
- Planning in Learning
  - not yet!

Applications

- Robotics (19)
  - path & manipulation planning (12+)
    - multiagent(9)
  - hybrid task/motion planning (3+)
- Transportation management (5)
- Energy grid management (2)
- Aerospace (2)
- Machining (1)
- Elevators (1)

Applications

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Transportation Management

- Smart road networks

  Hu & Smith: Coping with Large Traffic Volumes in Schedule-Driven Traffic Signal Control **4pm ballroom B/C/D**

  McCluskey & Vallati: Embedding Automated Planning within Urban Traffic Management Operations

- Bike Sharing

  Ghosh & Varakantham. Incentivizing the Use of Bike Trailers for Dynamic Repositioning in Bike Sharing Systems

  Lowalekar, et al: Online Repositioning in Bike Sharing Systems

- Parking

  d'Orey, Acevedo & Ferreira: Automated Planning and Control for High-Density Parking Lots

Smart Energy Grids

- Power Restoration
- Managing generation capacity

  Piacentini, et al: An extension of metric temporal planning with application to AC voltage control, AIJ 229, 2015

- Managing distributed energy sources

  Scott & Thiébaux: Distributed multi-period optimal power flow for demand response in microgrids. *ACM 6th Int. Conf. on Future Energy Systems*, 2015

Important Characteristics:

uncertainty in demand and production
complex NL constraints on flow, voltage, capacities …
time constraints
optimization

Human Aware Planning

- Human/Robot interaction (2+T)

  Sanelli, et al: Short-Term Human-Robot Interaction through Conditional Planning and Execution

  Sebastiani, et al: Dealing with On-Line Human-Robot Negotiations in Hierarchical Agent-based Task Planner

- Explanation

  Chakraborti, et. al: Plan Explanations as Model Reconciliation, IJCAI-17

  Fox, Long & Magazzeni: Explainable Planning, IJCAI-17 XAI

  XAIP workshop, ICAPS-18

- Plan & Goal Recognition

  Pereira, Oren, & Meneguzzi: Landmark-Based Heuristics for Goal Recognition, AAAI-17

  Vered & Kaminka: Heuristic online goal recognition in continuous domains, IJCAI-17

  PAIR workshop, AAAI-17, AAAI-18

UISP Workshop (8+)

Focus on automated planning using classical GUI and novel human interaction modalities (AR, NL and more!)

Where To Find Stuff

- ICAPS 2017

  http://icaps17.icaps-conference.org/
- ICAPS Conferences

  http://www.icaps-conference.org/index.php/Main/Conferences
- Proceedings:

  http://aaai.org/Library/ICAPS/icaps-library.php
- This talk:

  http://psresearch.xyz/publications.html

http://icaps18.icaps-conference.org/

The 28th International Conference on Automated Planning and Scheduling
June 24 – 29, 2018, Delft, The Netherlands