



**Harnessing Algorithm Bias**  
in Classical Planning

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## Bias in Search

- Algorithm Instance
  - Search Control
  - Determinism
  - Search Topology
  - Memory
  - Heuristic
  - Learning
- Problem Instance
  - Structural Features
  - Problem Distribution
  - Size
  - Difficulty

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## The Portfolio Approach

- Combines complementary or competing technologies to:
  - Hedge performance differences
  - Maintain robustness across uncertainty
- Drives innovation / insight by:
  - Focusing on the “weak” or “interesting”
  - Identifying strengths and weaknesses of existing approaches

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## We study a portfolio of classical planning systems

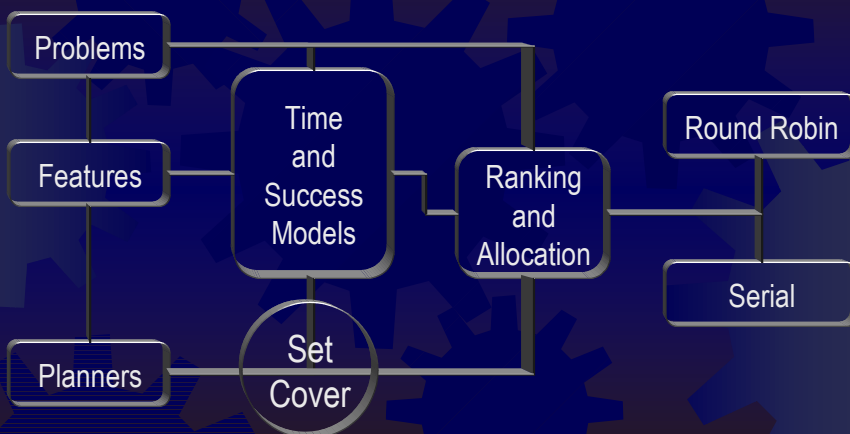
- to understand *why / when* one algorithm is favored over another.
- to link algorithm performance with problem structure

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## Portfolio Design



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## Portfolio Notes

- ✦ Portfolios typically *algorithm* focused
- ✦ Our work is *systems* focused

A key goal is to minimize search cost

We could also seek to maximize solution quality (we don't do that ... yet)

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## Modeling Questions

- ✦ What do we model?
  - features (static or dynamic)
  - target
- ✦ What do we evaluate?
- ✦ Which learning methods to apply?
- ✦ How much effort is involved?

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## Performance Models

- Will the planner succeed?
  - binary
- How long will the planner take?
  - discrete bins
  - log bins
  - regression
- Will the planner succeed within a given time?
  - binary plus log bin

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## Generating Performance Data

- 4726 Problems
- 29 Planners
- 57 Features
  - Domain/Problem (32)
  - Action Interaction (5)
  - Topological (20)

132328 rows  
30 minutes each row  
7.5 months of processing

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## Success Models

- Which features are critical
- Simple ML techniques average 96.8 %
- Best Advanced ML 96.59 % (new data)
- Findings:
  - expensive features not critical
  - simple techniques work well enough
  - “Train on old, test on new” generalizes

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## Runtime Models

- Binned time
- Log-binned time
- Continuous time (regression)
- Findings:
  - time models not as strong
  - heavy-tails and wide variance problematic

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## Portfolio Questions

- How to apply models in a portfolio?
- Do we include all planners?
- How do portfolio strategies compare?
  - Ranking the Systems
  - Allocating runtime to them
- Does the portfolio outperform any single system?

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## Portfolio Findings

- about half the systems are dominated
- running round robin is better than serially
- time models perform the same as random
- The current best portfolio:
  - solves more than the best planner
  - slightly faster than the average planner

( ICAPS 07 – W1 )

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## Key contributions to date

- ✦ Planner and Problem Repository
  - 31 planners – 27 working – 86 versions
  - 4726 problems (300+ in the works)
  - 57 features (85 planner in the works)
- ✦ Some modeling / portfolio questions
  - We can build reasonably accurate models
  - A portfolio can put use these models

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## Along the way ...

- ✦ Portfolio Literature Review
  - Perhaps you have some papers from fields outside my area of Planning and Scheduling
- ✦ Classical Planning Resources
  - Perhaps you know of or can link this work to another planner

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## Current Focus

- ✦ Linking problem structure with planner performance?
  - data and models rich with information
  - grouping problems based on performance
- ✦ Better runtime models
  - ✦ get a better handle on wide variance
- ✦ Using generated problems to test specific hypotheses

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## Linking Questions

- ✦ Do certain classes of planners perform similarly to one another?
  - Looked at Heuristic Search Planners
  - Found that performance of HSPs was significantly different than non-HSP planners

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et al.

- Adele Howe: dissertation advisor
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- CSU Student Group: Mark Rogers, Andrew Sutton, Crystal Redman, Artem Sokolov, Keith Bush, Laura Barbulescu, and others
- ICAPS 2005/6 attendees: Too many names
- The International Planning Competition, public planners and problems

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## Discussion

- Better time modeling
- Ideas for linking
- Possible *portfolio-like* systems from other disciplines

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# Portfolio Strategies

- Include only non-dominated planners
- Rank by :
  - Time (T) or Probability of Success (P)
  - Simon & Kadane (T/P)
  - Set Cover order
- Allocate by :
  - Model prediction or runtime distribution
- Run in Serial or in Round Robin

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