The Cross-domain Heuristic Search Challenge (CHeSC 2011)

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Hyper-heuristics

A hyper-heuristic is an automated methodology for selecting or generating heuristics to solve hard computational search problems

Challenge

- Can we develop the ability to automatically work well on different problems?
- Raising the level of generality
- Develop search methodologies that are more generally applicable

However ...

Current hyper-heuristic research

- Papers deal with very few problems: sometimes 2, rarely 3, ... mostly only 1!
- **Question**: Can we produce a benchmark to test the generality of heuristic search algorithms?

HyFlex (Hyper-heuristics Flexible framework)

- A software framework (benchmark library) for designing and evaluating general-purpose search algorithms
- Provides the *problem-specific* components
- Efforts focused on designing high-level strategies

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3 The Cross-domain Heuristic Search Challenge (CHeSC 2011)
HyFlex: re-use and Interchange

Problem Domains
(problem specific)

1

2

... 

n

HyFlex

Hyper-heuristics
(general purpose)

1

2

... 

m

The Cross-domain Heuristic Search Challenge (CHeSC 2011)
Decide which heuristic, \( i \), to apply to which solution, \( j \), and where to store it in the list of solutions, \( k \). Based only on past history of heuristics applied and objective function values returned.

Hyper-heuristic

\[ f(s_k) \]

Domain Barrier \( (i, j, k) \)

Problem Domain

- Problem representation
- Problem instances
- Evaluation function \( f(s_k) \)
- \textit{List of solutions}
- Others…

HH framework: (Cowling P., Kendall G. and Soubeiga, 2000, 2001), (E. K. Burke et al., 2003)


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Overview of the problem domain modules

1. A routine to initialise (randomised) solutions
2. A set of heuristics to modify solutions
   a. **Mutational**: makes a random modification
   b. **Ruin-recreate**: partially destroy a solution and rebuild it using a constructive procedure
   c. **Local-search**: iterative procedures searching on the neighbourhood of solutions
   d. **Crossover**: takes parent solutions and produce offspring solution
3. A set of interesting instances, that can be easily loaded \((\text{LoadInstance}(i))\)
4. A population or list of solutions
Four Problem Domains

- MAX-SAT
- Flow Shop
- Personnel Scheduling
- Bin Packing

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Personnel Scheduling

Instances: Wide range of data sets (Industry, Academia, +10 countries)

Low level heuristics: 12, different types. LS based on new, horizontal and vertical moves

<table>
<thead>
<tr>
<th>Instance</th>
<th>Size</th>
<th>Shifts</th>
<th>Days</th>
<th>LS Moves</th>
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<td>8</td>
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Horizontal swap: move shifts in single employee’s work pattern
The “cross-domain” competition

- Conduct a competition (“cross-domain” challenge):
  - Using HyFlex
  - **Winner**: algorithm with best overall performance across all of the different domains
  - The *Decathlon Challenge* of search heuristics

- Why run a competition?
  - Competitions appear to help advance research
  - **Success examples**: Timetabling, Nurse Rostering, Planning, SAT, CSP, RoboCop, ...
  - Bring together researchers from sub-fields of CS, AI and OR
  - Achieve a deeper understanding of the design principles of hyper-heuristics across a wide set of problems
Scoring System

Instances:

SAT Instance 1:
HH1 – 34
HH2 – 23
HH3 – 27
HH4 – 10
HH5 – 30
...

MAX-SAT

Flow Shop

Personnel Scheduling

Bin Packing

Hidden Domain

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Scoring System

Formula 1

- For each instance (race): algorithms will be ranked by the best objective function value (single run)
- The top eight ‘drivers’ score points
- Ties: Points to the relevant positions added and shared equally
Interesting Instances

And not so interesting...

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The Cross-domain Heuristic Search Challenge (CHESC 2011)
The Java Software

HyperHeuristic abstract class

ExampleHyper-Heuristic1.java
ExampleHyper-Heuristic2.java
ExampleHyper-Heuristic3.java
Your Hyper Heuristic??
The Cross-domain Heuristic Search Challenge (CHeSC 2011)

Personnel Scheduling

Example Run 1
(with main method)

Your Hyper Heuristic??

- Set problem instance
- Set time limit
- Run experiment
The Cross-Domain Heuristic Search Challenge

Develop the most general high level strategy

Your Hyper Heuristic??

MAX-SAT
Personnel Scheduling
Hidden Domain 1
Flow Shop
Bin Packing
Hidden Domain 2

...
Questions?

Important Dates:

May 15, 2011: Registration deadline.

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