Pearl Hunter: An Inspired Hyper-heuristic

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Outline

1. Pearl Hunting
2. The Pearl Hunter
3. Training and Validation on HyFlex
4. Conclusions

Pearl Diving

- *Pearl diving* is an out-of-date diving activity of retrieving pearls from oysters.
- Can still be found in:
  - Some Asian tourist sites,
  - Virtual games.

Pearl diver in Japan (from Wikimedia Commons, public copyright)

In Australia (screenshot of "Introduction to pearls and Australian Pearl Divers", © by Australian Opal Cutter youtube.com/watch?v=V6vuBvglndw)

In Qatar (screenshot of "Pearling", © Qatar Pavilion, World EXPO 2010)

Pearl Diving and Simulation

- In a search perspective, pearl hunting consists of repeated
  - *diversification* (surface and change target area)
  - *intensification* (dive and find pearl oysters).
- In the paradigm of Iterated Local Search (Lourenço *et al*, 2003).
- Simulated operations
  - *move* (*diversification*, 1 source or multiple sources)
  - *dive* (*intensification*)
    - *snorkeling* (quick, low level local search, stops after any improvements)
    - *deep dive* (scuba; slow, high level local search, till no further improvements)

Correlations Between Snorkeling and Deep Dive

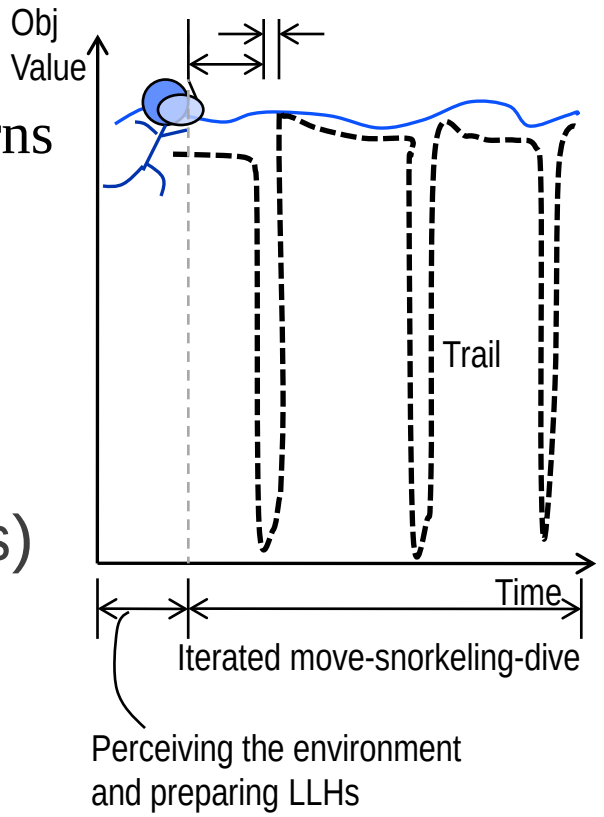
Table 1: Pearson correlations between improvements by snorkeling (10% maximum depth of search) and deep dive (maximum depth of search) in 3 domains of CHeSC

Diversification by LLH		Max-SAT	Bin Packing	Flow Shop
Crossover	Pearson Cor.	0.82*	0.47^	0.88*
	Sig. (2-tailed)	0.00	0.00	0.00
	N	466	143	317
Mutation	Pearson Cor.	0.61^	0.11	0.83*
	Sig. (2-tailed)	0.00	0.00	0.00
	N	112	1405	752
Ruin-recreate (extra)	Pearson Cor.	0.08	0.07	0.58^
	Sig. (2-tailed)	0.51	0.11	0.00
	N	70	551	328

- Correlations:
  - Strong (*) or moderate (^) positive coefficient with a significant level 0.01
  - $1 \leq N_{\text{snorkeling}}/N_{\text{deepdive}} \leq 10$, choose best of snorkeling in practice

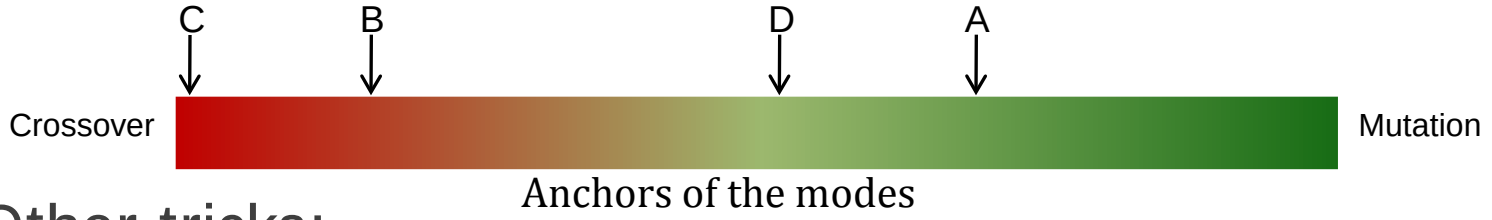
Pearl Hunter: A Hyper-heuristic Imitation

- "Environment":
  - *Shallow water*, where deep dive always returns the same as snorkeling
  - *Sea trench*, where deep dives cost too much time at maximum depth-of-search
  - *Default, otherwise*
- Preparation of Low Level Heuristics(LLHs)
  - Selective scheme (CHeSC2011)
    - Choose {A, B} from {A, B, C}
  - Constructive scheme
    - Pre-trained
    - Online trained



Pearl Hunter

- Pearl Hunter can drop a *Buoy* at the depth of first deep dive, to escape from local optimum by mutations (SIs).
- Four running modes (portfolios) of selected LLHs:
  - **A**: all moves averagely, with a *Buoy* mark
  - **B**: *crossover* with a *Buoy* mark (triggering a few mutations)
  - **C**: *crossover* only, no mutation, no *Buoy*
  - **D**: Sea trench mode, all surface moves averagely, no *Buoy*. Moves are subject to online pruning.

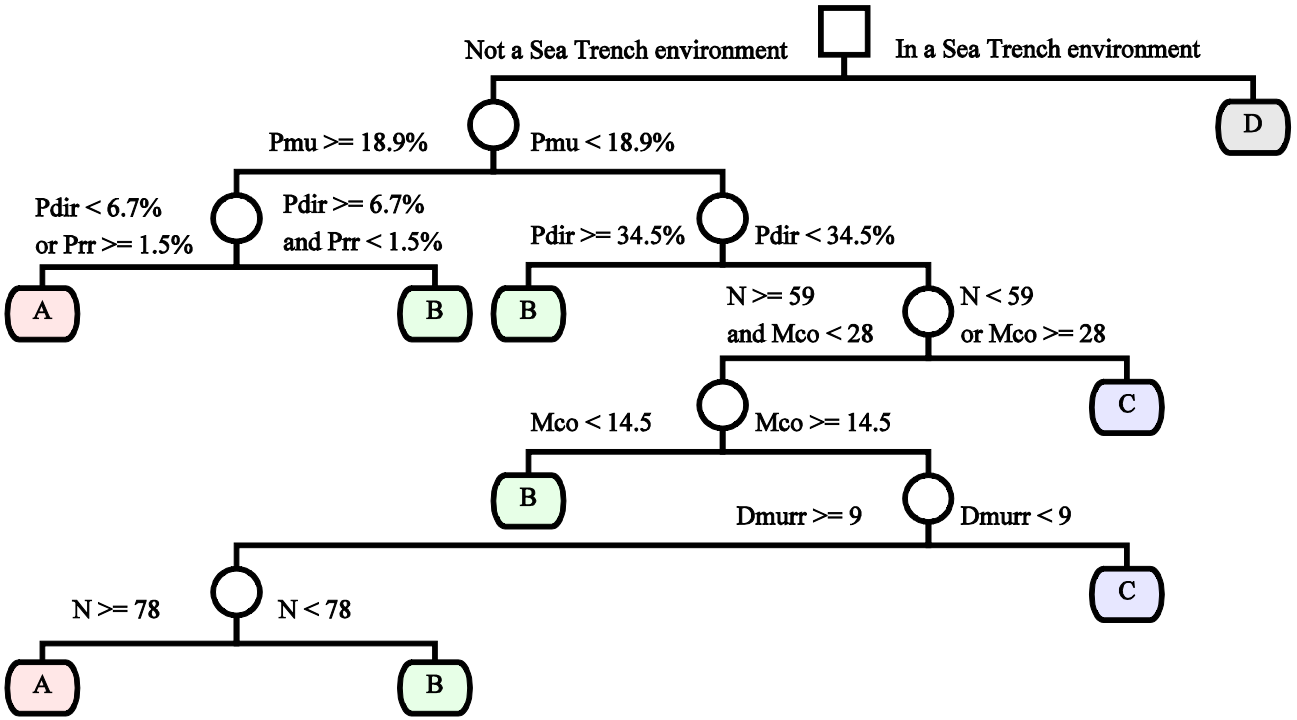


- Other tricks:
  - tabu lists (memory), “mission restarts” (go to new areas)

HyFlex and CHeSC

- HyFlex (Hyper-heuristics Flexible framework) is a java cross-domain platform (Burke *et al*, 2011)
  - 6 domains, 4 public (training domain) and 2 hidden
  - "Black-box" low-level heuristics in 4 categories:
    - Crossover, Mutation, Ruin-recreate, and Local search
  - Parameters to control low-level heuristics :
    - "Intensity" of mutations, and "depth of local search"
- CHeSC 2011 is the first Cross-domain Heuristic Search Challenge on HyFlex. (http://www.asap.cs.nott.ac.uk/chesc2011/)
- Pearl Hunter was ranked in CHeSC:
  - 4th out of 20 entries overall,
  - 1st out of 20 entries in the hidden domains.

HyFlex and CHeSC: BF-Tree Obtained by Offline Learning (by Weka v3.5)



- D_{murr}: Depth of the mission in the Mutation and Ruin-recreate test,
- M_{co}: Number of missions completed in the Crossover test,
- N: Number of sub-optimal solutions found in total,
- P_{dir}: Percent of sub-optimal solutions found right after some moves (before any dive),
- P_{mu}: Percent of sub-optimal solutions found in iterations started with Mutation moves,
- P_{rr}: Percent of sub-optimal solutions found in iterations started with Ruin-recreate moves,

Tests on Personnel Scheduling: Beyond the 600s Time Limit of CHeSC

- On large-scale personnel scheduling problems,
  - Running time was increased to 10 hours (normalized to P4 3GHz),
  - Same decision tree and algorithm codes
- New best known solutions:

Instance	Men | days	Time (h)	Result	Prev BK*	% improved
CHILD-2A	41 | 42	10	*1,095*	1,111	1.4
ERRVH-A	51 | 42	10	*2,142*	2,197	2.5
ERRVH-B	51 | 42	10	*3,121*	6,859	54.5

* Best known values were collected from http://www.cs.nott.ac.uk/~tec/NRP/misc/NRP_Results.xls

- A possible reason
  - A new "vertical" swap concept first implemented in low-level heuristics on HyFlex

Conclusion

- We present a hyper-heuristic
  - Imitates pearl hunting
  - Perceives “environment” of search
  - Determines a perturbation mode by offline learning
  - Generates different modes of ILS
- We find the results of tests encouraging
- Possible future works
  - Hunters can generate new LLHs besides a selection
    - (Custom designed for TSP) Generated an association-rules-based weighting hyper-heuristic to determine candidate set, and facilitated branch-and-bound and local search (2-Opt, 5-Opt) (Xue *et al*, 2010, 2012).

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Thank you for your attention!

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