Pearl Hunter: An Inspired Hyper–heuristic

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CY Chan, Fan Xue, WH Ip, CF Cheung
Department of Industrial & Systems Engineering
Hong Kong Polytechnic University

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Department of
Industrial and Systems Engineering
工業及系統工程學系

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- *Pearl diving* is an out-of-date diving activity of retrieving pearls from oysters.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

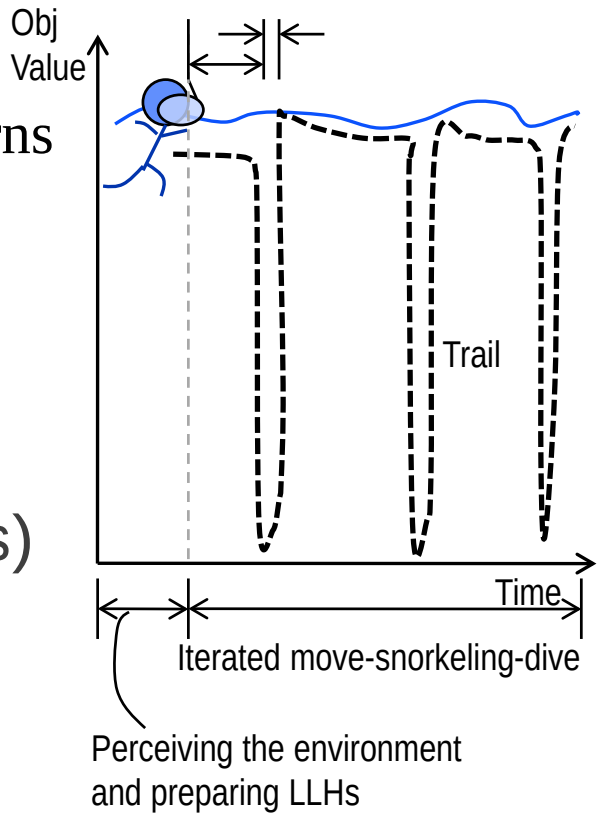
Table 1: Pearson correlations between improvements by snorkeling (10% maximum depth of search) and deep dive (maximum depth of search) in 3 domains of CHeSC

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

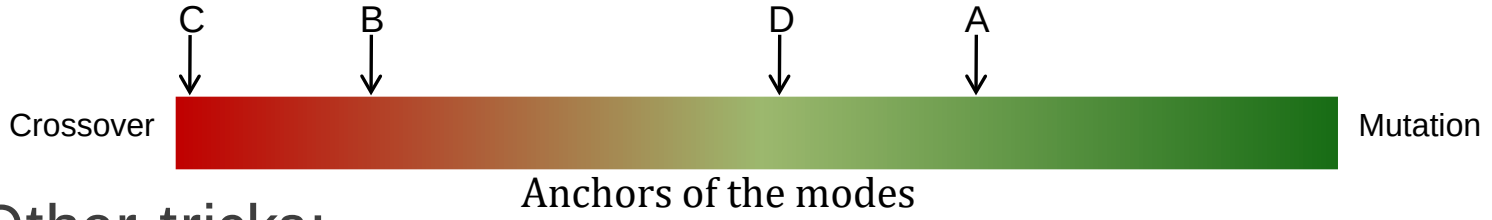
Pearl Hunter: A Hyper-heuristic Imitation

- "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.

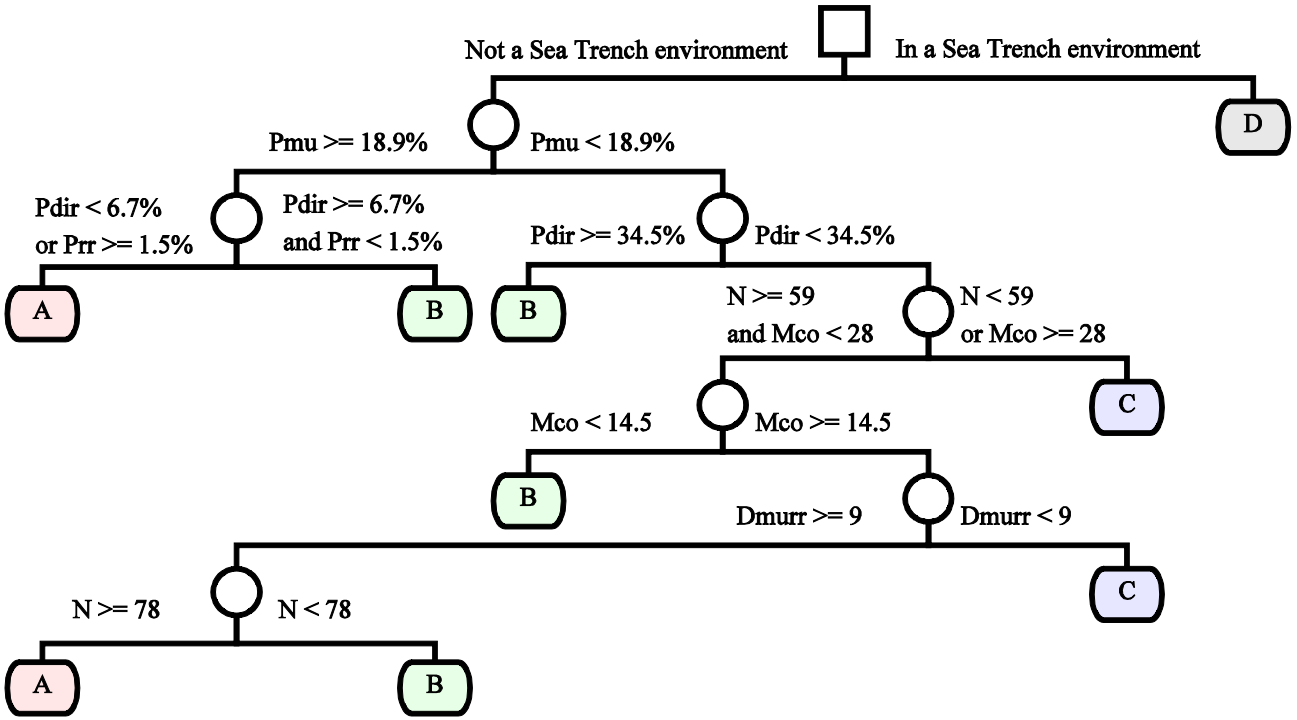


- Other tricks:
  - tabu lists (memory), “mission restarts” (go to new areas)

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!

E–mail addr.: mffxue@inet.polyu.edu.hk
dewolf_matri_x@msn.com

THE HONG KONG
POLYTECHNIC UNIVERSITY
香港理工大學

Department of
Industrial and Systems Engineering
工業及系統工程學系