PasMoQAP

A Parallel Asynchronous Memetic Algorithm for solving the Multi-Objective Quadratic Assignment Problem

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Outline

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- Motivation
- Multi-Objective Quadratic Assignment Problem
- PasMoQAP
- Conclusions and future work

Motivation

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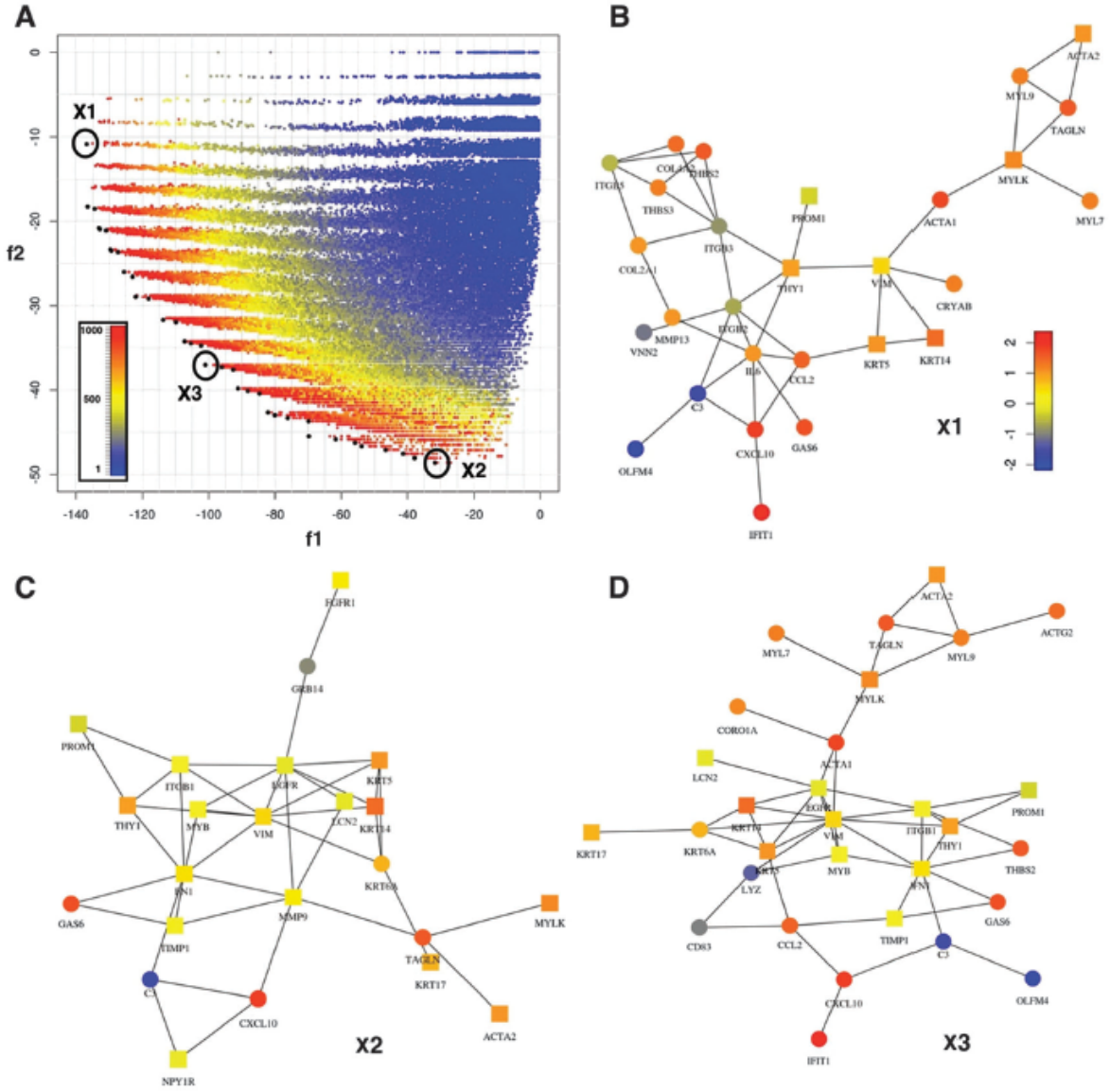
- Multi-objective Optimization: simultaneous optimization of multiple and possibly conflicting objectives
- Augmented MOEAs using Local Search
- Parallel and distributed approaches to approximate the Pareto set

Motivation



Mosca, E., & Milanesi, L. (2013). Network-based analysis of omics with multi-objective optimization. Molecular BioSystems, 9(12), 2971-2980.

Multi-objective QAP

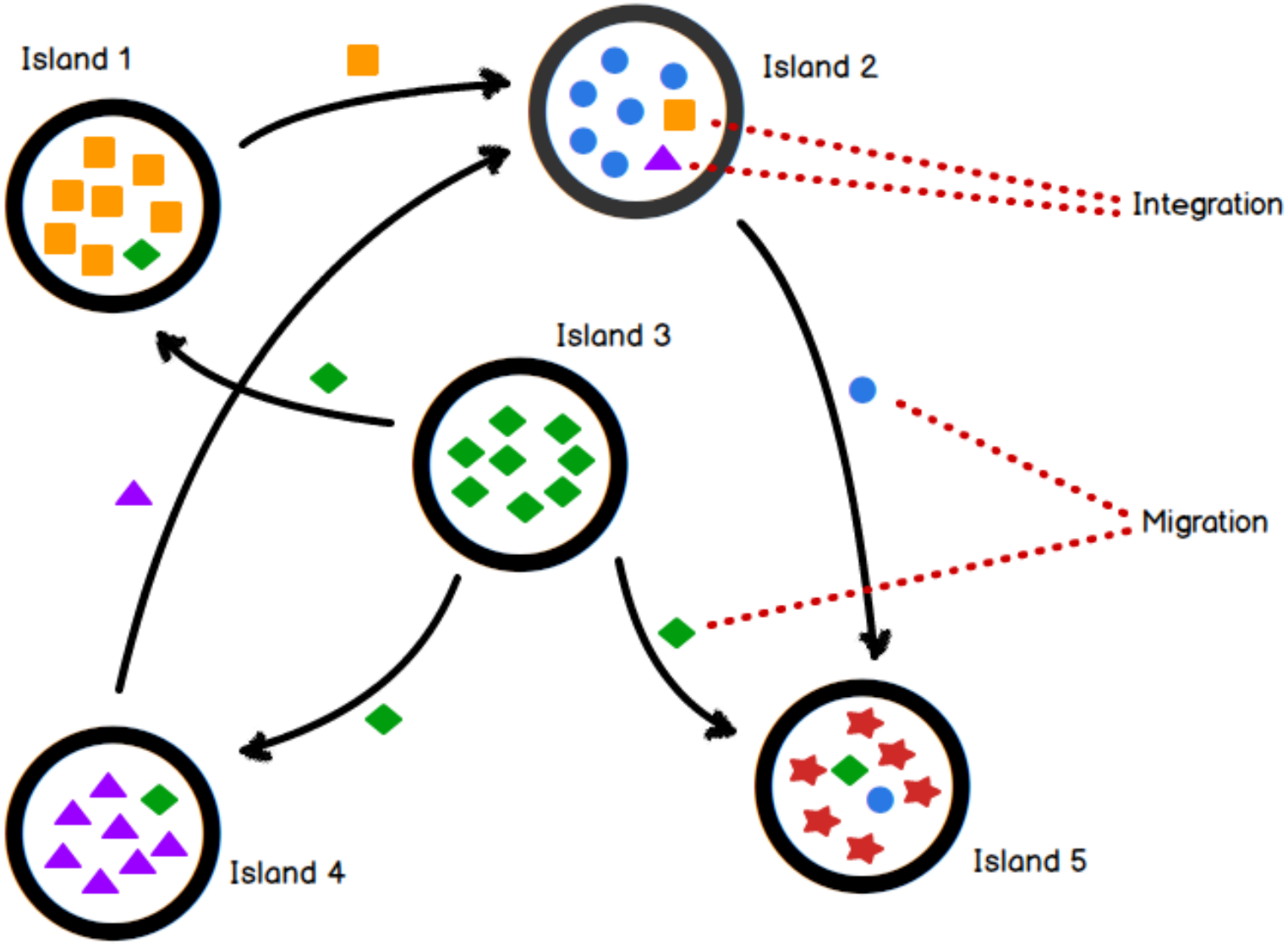
$$\underset{\pi \in P_n}{\text{minimize}} \; C(\pi) = \{C^1(\pi), C^2(\pi), ..., C^m(\pi)\}$$

$$C^r(\pi) = \sum_{i=1}^{n} \sum_{j=1}^{n} d_{ij} f^r_{\pi(i)\pi(j)}, \; r = 1, ..., m$$

Distance between location i and j

Flow between facility $\pi(i)$ and $\pi(j)$

PasMoQAP


Island 1
Island 2
Integration
Island 3
Migration
Island 4
Island 5

PasMoQAP

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- Implemented using framework Paradiseo
- Parallel Island models
  - Topology (migration path)
  - Selection (Fitness Then Diversity + Tournament Selection)
  - Migration
  - Integration (Elitist Integration)

PasMoQAP

- Evolutionary Algorithm
  - Sub-population based on topology
  - Cycle crossover and swap mutation
  - External archive to maintain diversity
- Dominance Based Local Search
  - Exhaustive selection
  - Order Swap Neighborhood Exploration
  - First Improving Criteria

Experimental design

Objectives	Instance	Size	Type	Correlation
2	Gar60-2fl-1uni	60	uniform	-0.3
	Gar60-2fl-2uni	60	uniform	0
	Gar60-2fl-3uni	60	uniform	0.3
	Gar60-2fl-4uni	60	uniform	-0.8
	Gar60-2fl-5uni	60	uniform	0.8
	Gar60-2fl-1rl	60	real-like	-0.3
	Gar60-2fl-2rl	60	real-like	0
	Gar60-2fl-3rl	60	real-like	0.3
	Gar60-2fl-4rl	60	real-like	-0.8
	Gar60-2fl-5rl	60	real-like	0.8
3	Gar60-3fl-1uni	60	uniform	0
	Gar60-3fl-2uni	60	uniform	-0.5
	Gar60-3fl-3uni	60	uniform	0.5
	Gar60-3fl-1rl	60	real-like	0
	Gar60-3fl-2rl	60	real-like	-0.5
	Gar60-3fl-3rl	60	real-like	0.5
4	Gar60-4fl-1uni	60	uniform	0
	Gar60-4fl-2uni	60	uniform	-0.5
	Gar60-4fl-3uni	60	uniform	0.5
	Gar60-4fl-1rl	60	real-like	0
	Gar60-4fl-2rl	60	real-like	-0.5
	Gar60-4fl-3rl	60	real-like	0.5

- 22 instances, 30 trials
- Comparison against island-based NSGA-II
- Normalized hypervolume indicator
- Topology: Complete
- 5, 8, 11, 16, 21 islands (cores)

Results

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	NSGA-II					PasMoQAP				
Instances	5	8	11	16	21	5	8	11	16	21
Gar60-2fl-1uni	0.8659	0.8745	0.8399	0.8570	0.8838	0.8790	0.8913	0.9128	0.8714	0.9080
Gar60-2fl-2uni	0.8529	0.8388	0.8421	0.8407	0.8551	0.8519	0.8749	0.8961	0.8587	0.9127
Gar60-2fl-3uni	0.8130	0.7893	0.8094	0.8136	0.8025	0.8415	0.8107	0.8673	0.8155	0.8868
Gar60-2fl-4uni	0.7846	0.7788	0.7656	0.7543	0.7613	0.8043	0.7944	0.8001	0.7677	0.8040
Gar60-2fl-5uni	0.3803	0.4031	0.3988	0.4472	0.4993	0.5037	0.3529	0.5188	0.3235	0.5255
Gar60-2fl-1rl	0.8952	0.8294	0.8598	0.9022	0.8757	0.9180	0.9169	0.9524	0.8697	0.9393
Gar60-2fl-2rl	0.8860	0.8657	0.8595	0.8307	0.8449	0.9259	0.9144	0.9473	0.8685	0.9419
Gar60-2fl-3rl	0.9010	0.8705	0.8852	0.8607	0.8852	0.8945	0.8812	0.9209	0.8797	0.8996
Gar60-2fl-4rl	0.8908	0.8700	0.8681	0.8840	0.9035	0.9307	0.9202	0.9428	0.9090	0.9325
Gar60-2fl-5rl	0.7734	0.8264	0.7456	0.7725	0.7241	0.8740	0.8376	0.8704	0.8032	0.8253
Gar60-3fl-1uni	0.8493	0.8332	0.8694	0.9090	0.9039	0.8550	0.8324	0.8910	0.8963	0.8843
Gar60-3fl-2uni	0.7633	0.7539	0.7703	0.7190	0.7308	0.8010	0.7838	0.7963	0.7398	0.7737
Gar60-3fl-3uni	0.8004	0.7531	0.7662	0.7789	0.7532	0.8494	0.8022	0.8730	0.7961	0.7268
Gar60-3fl-1rl	0.8802	0.8565	0.9272	0.9513	0.9194	0.8855	0.9009	0.9157	0.9460	0.9476
Gar60-3fl-2rl	0.8537	0.8506	0.8872	0.9324	0.8648	0.8703	0.8991	0.9006	0.9275	0.8744
Gar60-3fl-3rl	0.8579	0.8687	0.8719	0.8858	0.9107	0.8962	0.8876	0.9048	0.9107	0.8932
Gar60-4fl-1uni	0.7817	0.8123	0.8726	0.8252	0.8000	0.8134	0.8111	0.9083	0.8556	0.8251
Gar60-4fl-2uni	0.6892	0.7237	0.6920	0.6170	0.6133	0.7019	0.7184	0.6679	0.6480	0.6465
Gar60-4fl-3uni	0.7920	0.7764	0.7916	0.7893	0.7993	0.8017	0.7642	0.8729	0.7938	0.8995
Gar60-4fl-1rl	0.7264	0.8759	0.9181	0.8466	0.8488	0.8221	0.8684	0.9200	0.9018	0.8692
Gar60-4fl-2rl	0.8083	0.8599	0.9145	0.8354	0.8091	0.8338	0.8553	0.9131	0.8728	0.8640
Gar60-4fl-3rl	0.8015	0.8569	0.8914	0.8842	0.8557	0.8248	0.8275	0.9201	0.8783	0.8823

Conclusions

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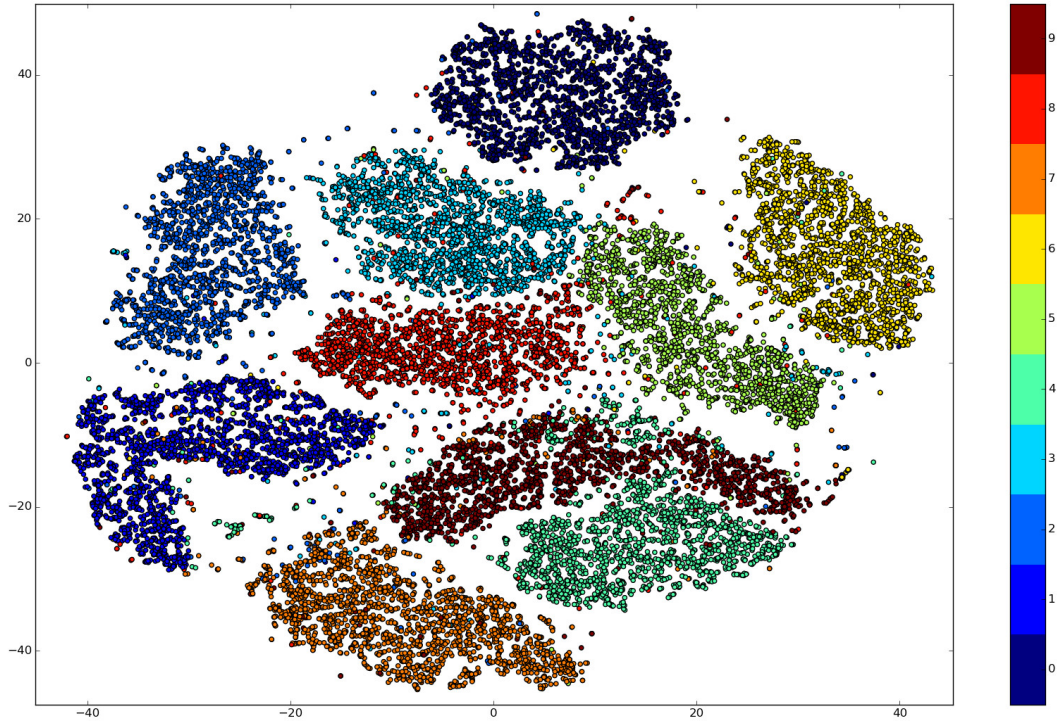
- We propose a parallel memetic algorithm based on the island model with subpopulations
- PasMoQAP is an algorithm to solve the multi-objective Quadratic Assignment Problems
- Further studies: instances, num. of objectives. Topologies, migration and integration
- Homogeneous or heterogeneous island models?

Future work

- mQAP for data visualization



Maaten, Laurens van der, and Geoffrey Hinton. "Visualizing data using t-SNE." *Journal of Machine Learning Research* 9.Nov (2008): 2579-2605.

Thank you
Questions

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