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Full paper

Migrant Selection in Island-Based Optimization

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Abstract: Island-based metaheuristics have gained significant attention in the field of optimization due to their ability to maintain population diversity and avoid premature convergence. A critical component of these algorithms is the migration strategy, which determines how individuals are exchanged between islands. This paper investigates the impact of different migration strategies on the performance of island-based metaheuristics, with a particular focus on the number of migrated individuals and the criteria for their selection. We propose several strategies for selecting individuals for migration, including random selection, fitness-based, diversity-based and hybrid approaches, and evaluate their effectiveness on a set of TSP (Traveling Salesman Problem) and BBOB (Black-box Optimization Benchmarking) problems. Our results demonstrate that the choice of migration strategy significantly affects the algorithm's performance. Specifically, selecting individuals based not only on fitness but also on their potential to increase diversity leads to better outcomes.

Cooperating portfolio of metaheuristics

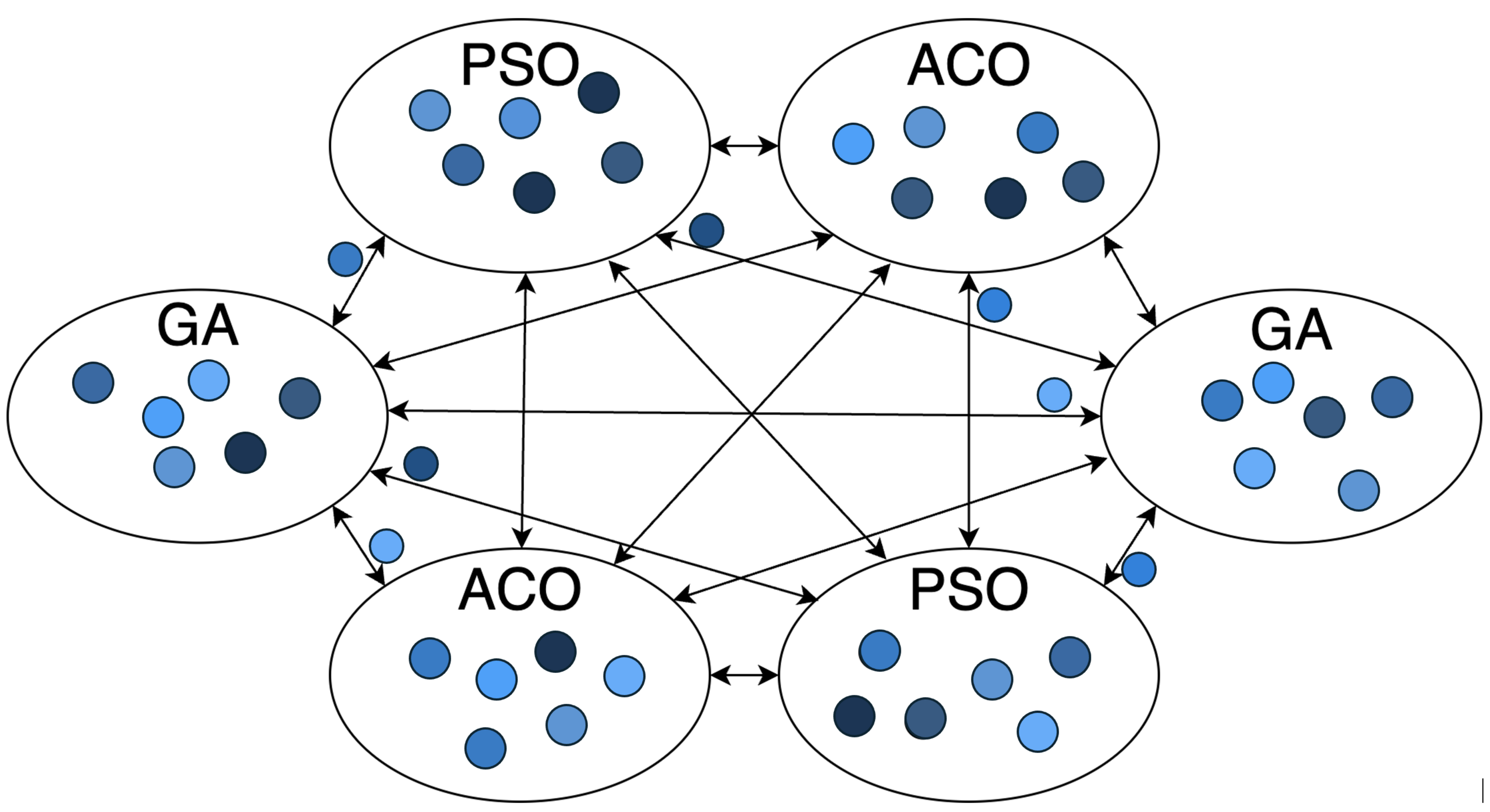

Figure: Overview of the baseline DdCPM framework used for testing migration strategies. Populations in multiple islands are developed by different metaheuristics, with migrations between islands governed by certain migration triggers. A degree of shading indicates an individual's fitness value.

Żychowski, A., Yao, X., Mańdziuk, J.: Diversity-driven cooperating portfolio of metaheuristic algorithms. The Genetic and Evolutionary Computation Conference (GECCO 2025).

Algorithm 1 Pseudocode of the baseline DdCPM method.

for each island $I \in \mathcal{I}$ **do**
  initialize $I_{population}$ with random individuals
end for
while $evaluation\_budget > 0$ **do**
  for each island $I \in \mathcal{I}$ **do**
    if needs_migration(I) **then**
      $I_{population} = I_{population} \cup$ migrate_from($I_{neighbours}$)
    end if
  end for
  for each island $I \in \mathcal{I}$ **do**
    $I_{population}$ = next_generation($I_{population}$, $I_{metaheuristic}$)
    evaluate($I_{population}$)
    $evaluation\_budget = evaluation\_budget - |I_{population}|$
  end for
end while
return the best individual from $\mathcal{I}$

Key research questions

- How many individuals should be migrated?
- Which individuals should be selected?
- How do different selection criteria affect algorithm performance?

Strategies of migrants selection

- **S0: Random Selection**: Randomly selects K individuals without considering fitness or diversity.
- **S1: Top K Fitness**: Selects K individuals with the highest fitness values from the donor islands.
- **S2: Top K Diversity**: Selects K individuals that maximize the diversity of the receiving island's population.
- **S3: Top $\frac{K}{2}$ Fitness + Top $\frac{K}{2}$ Diversity**: Selects half of the migrants based on fitness and the other half based on diversity.
- **S4: Top K (Fitness + Diversity)**: Selects K individuals based on a combined score of fitness and diversity.
- **S5: Weighted Random Selection**: Assigns selection probabilities to individuals based on the sum of normalized fitness and diversity scores.
- **S6: Weighted K (Fitness + Diversity)**: Selects K individuals using a dynamically weighted sum of fitness and diversity.
- **S7: Top 1 Fitness from K Clusters**: Clusters the population into K groups using the K-means algorithm based on solution similarity. The best-fitted individual from each cluster is then selected for migration.

Results

TSP	K							
Strategy	**1**	**2**	**4**	**8**	**12**	**16**	**20**	**24**
S0	36231 ± 107	36165 ± 113	**36211** ± 123	36267 ± 117	36249 ± 110	36255 ± 102	36272 ± 109	36285 ± 115
S1	35795 ± 81	35789 ± 48	35760 ± 66	35746 ± 87	35750 ± 44	35737 ± 42	**35731** ± 52	35768 ± 56
S2	36178 ± 74	36158 ± 55	36120 ± 83	36108 ± 39	**36100** ± 50	36103 ± 61	36105 ± 68	36119 ± 72
S3	-	35737 ± 78	35703 ± 40	35701 ± 53	**35689** ± 61	35696 ± 69	35712 ± 75	35728 ± 79
S4	35622 ± 44	35572 ± 67	35523 ± 49	**35461** ± 62	35475 ± 64	35521 ± 85	35540 ± 88	35562 ± 92
S5	35920 ± 89	35885 ± 92	35894 ± 87	**35884** ± 91	35912 ± 94	35968 ± 97	35985 ± 102	36010 ± 104
S6	-	35746 ± 80	35614 ± 53	35316 ± 76	35302 ± 71	**35238** ± 45	35272 ± 58	35310 ± 63
S7	35795 ± 71	35646 ± 42	35596 ± 59	**35474** ± 82	35485 ± 63	35532 ± 47	35558 ± 64	35582 ± 69

BBOB	K							
Strategy	**1**	**2**	**4**	**8**	**12**	**16**	**20**	**24**
S0	2.413 ± 0.13	2.377 ± 0.12	2.269 ± 0.14	**2.268** ± 0.12	2.285 ± 0.13	2.418 ± 0.14	2.506 ± 0.15	2.493 ± 0.14
S1	2.205 ± 0.10	2.122 ± 0.09	2.057 ± 0.10	2.046 ± 0.09	2.054 ± 0.10	**2.040** ± 0.10	2.058 ± 0.11	2.113 ± 0.10
S2	2.598 ± 0.13	2.611 ± 0.11	2.520 ± 0.12	2.555 ± 0.10	**2.504** ± 0.11	2.508 ± 0.11	2.571 ± 0.12	2.576 ± 0.11
S3	-	2.154 ± 0.10	2.140 ± 0.09	2.115 ± 0.09	2.155 ± 0.10	**2.063** ± 0.11	2.094 ± 0.10	2.155 ± 0.11
S4	1.594 ± 0.08	1.606 ± 0.07	1.530 ± 0.07	1.468 ± 0.07	**1.445** ± 0.08	1.455 ± 0.08	1.502 ± 0.09	1.554 ± 0.08
S5	2.090 ± 0.09	2.016 ± 0.10	1.987 ± 0.09	**1.891** ± 0.09	1.956 ± 0.10	2.062 ± 0.09	2.012 ± 0.10	2.005 ± 0.11
S6	-	2.200 ± 0.10	1.964 ± 0.09	1.532 ± 0.08	1.531 ± 0.07	**1.428** ± 0.07	1.478 ± 0.08	1.468 ± 0.08
S7	2.131 ± 0.10	1.854 ± 0.09	1.707 ± 0.08	1.589 ± 0.08	**1.512** ± 0.07	1.522 ± 0.07	1.520 ± 0.08	1.576 ± 0.07

Table: Averaged results for various K values and different migrants selection strategies for BBOB and TSP instances.

Summary

- Migration strategy significantly impacts optimization performance.
- Moderate migration sizes achieve a balance between exploration and exploitation.
- Combining fitness and diversity yields the best results.