Improving the Efficiency of Nondominated Sorting Genetic Algorithms

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Multi-Objective Optimization

Multiobjective optimization is an appropriate and necessary tool used in solving the contemporary complex problems.

$$\min(f_1(x), f_2(x), \ldots, f_k(x))$$
$$s.t.\, x \in X$$

Where integer k > 1 is the number of objectives and the set X is the feasible set of decision vectors

Pareto Efficiency

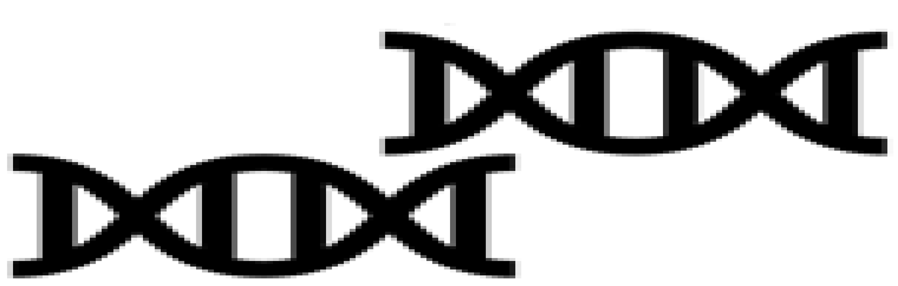
Instead of finding a single solution in one dimensional space, multiobjective optimization finds a set of Pareto Efficient solutions defining the solution space.

If $f_i(x^a) \leq f_i(x^b)\ \forall\, i \in \{1,2,\ldots,k\}$ and $f_j(x^a) < f_j(x^b)$ for at least one index $j \in \{1,2,\ldots,k\}$ then x^a is said to Pareto dominate x^b.

Those solutions that are not dominated by any other solution in the set are Pareto Efficient.

These are the objectively superior solutions to the multiobjective problem.

Genetic algorithms are used to discover this set of Pareto Efficient solutions, from which a final selection is to be made.



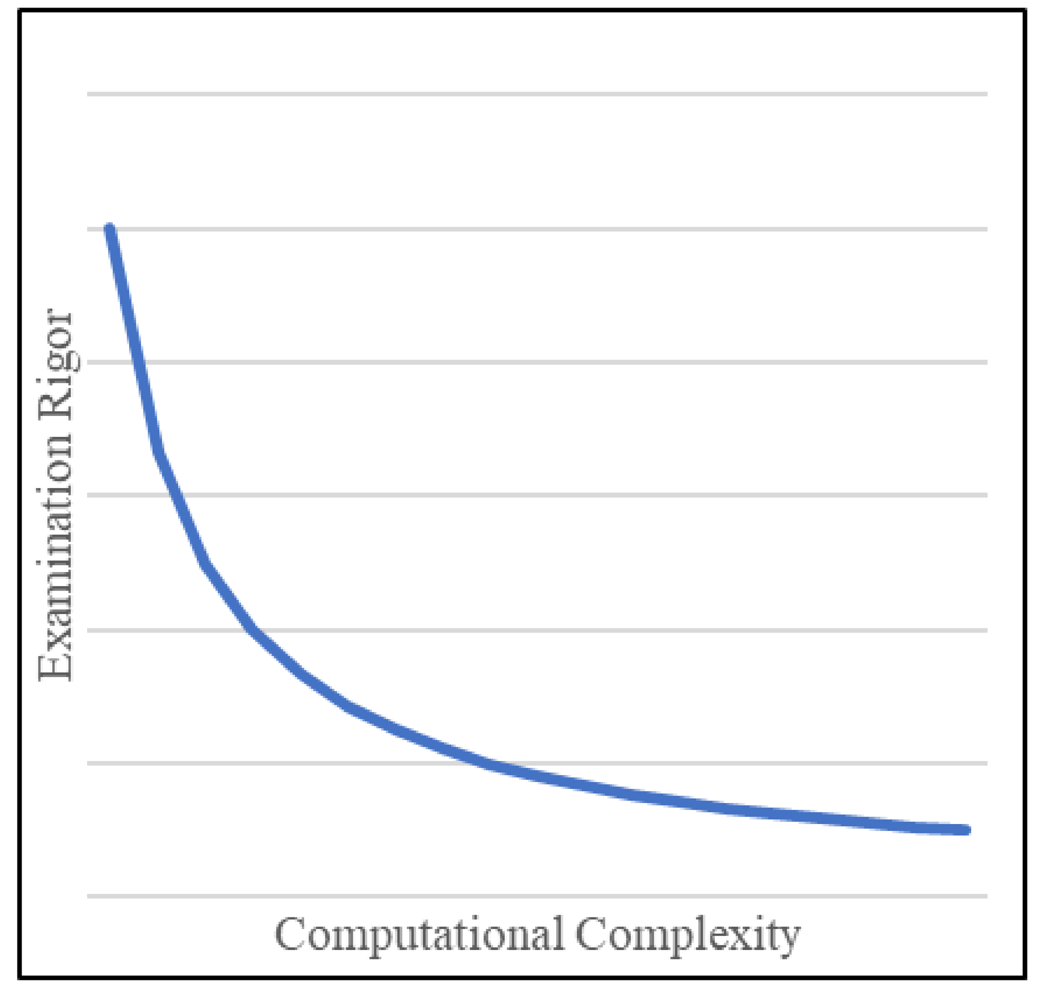
Expedited Nondominated Sorting → Improved Decision-Making

Genetic algorithms are restricted by the computational complexity of the nondominated sorting algorithms they employ.

Computational complexity is inversely related to the number of solutions and objectives that can be examined in determining the Pareto Efficient set.

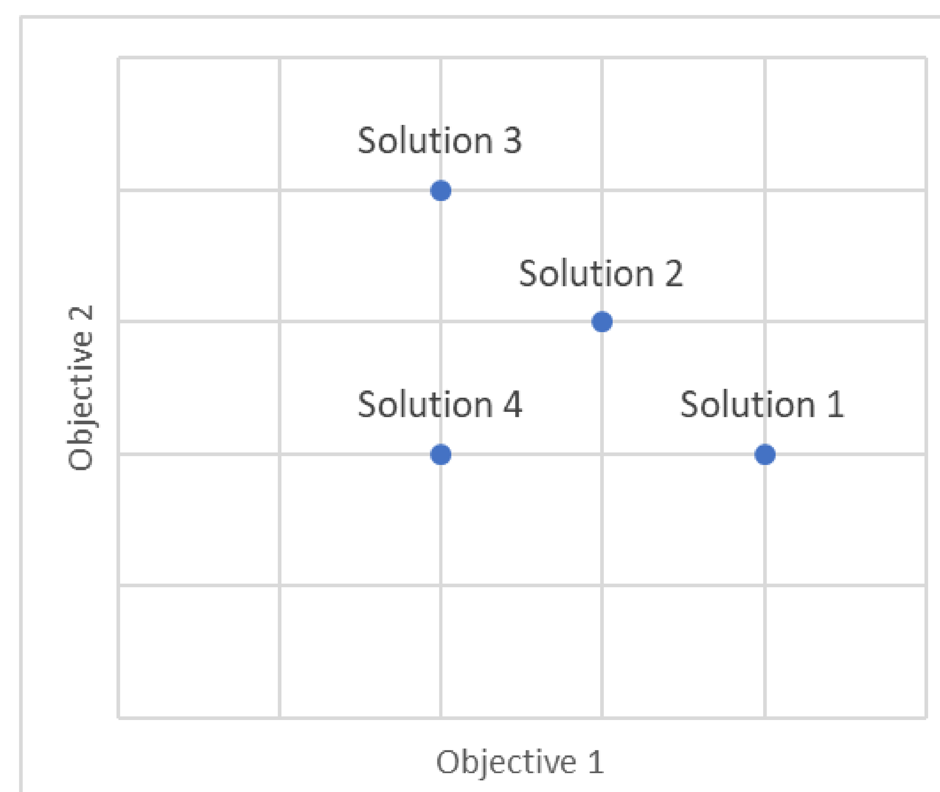
More Objectives + Examining More Alternatives
=
Better-Vetted Pareto Efficient Solutions

More Rigorously Examined Solutions enables Better Decision-Making



A Geometrically-Intelligent Deductive Sort Method

Coordinates	Objective 1	Objective 2
Solution 1	2	1
Solution 2	1.5	1.5
Solution 3	1	2
Solution 4	1	1
Ideal Point	Min(Obj. 1)	Min(Obj. 2)
	1	1



Deductive Sort is currently the most efficient terminable nondominated sorting method.

Comparisons Required to find Pareto Efficient Set:

6

Ordering the solutions by proximity to Ideal Point can improve efficiency.

Geometrically Intelligent Method Required Comparisons:

3

Geometrically Intelligent Ordering

Ordering the solutions before conducting the operations of deductive sort can reduce the overall complexity of finding the Pareto Efficient set.

In the proposed method solutions are preordered based on their geometric similarity to the ideal point of the set.

$$x_i^{ideal} = \inf_{x \in X} f_i(x)\ \forall\ i = 1,\ldots,k$$

Efficiency Comparison

The proposed method was compared to Deductive Sort across a series of cloud distribution solution sets.

The solutions sets had a varying number of alternatives and objectives as shown in the table below.

Altern.	Objectives				
	4	5	7	10	12
100	46.44%	43.06%	35.22%	34.11%	33.70%
500	48.66%	51.79%	47.64%	39.17%	35.61%
1000	48.02%	50.25%	48.66%	40.98%	36.90%
2500	43.82%	47.82%	50.09%	44.67%	40.00%
5000	39.94%	47.85%	49.20%	47.41%	42.19%

The table describes the percent reduction in algorithmic runtime achieved by the proposed method against Deductive Sort.

The proposed improves efficiency considerably, even exceeding 50%.

Acknowledgements

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