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Solving Three-objective Optimization Problems Using Evolutionary Dynamic Weighted Aggregation: Results and Analysis

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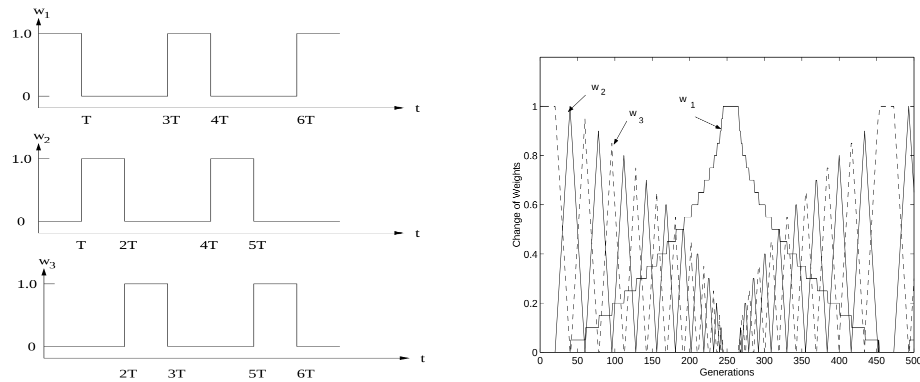
The main purposes of this paper is twofold. First, the evolutionary dynamic weighted aggregation (EDWA) [1] approaches are extended to the optimization of three-objective problems. Fig. 1 shows two example patterns for weight change. Through two three-objective test problems [2], the methods have shown to be effective. Theoretical analyses reveal that the success of the weighted aggregation based methods can largely be attributed to the following facts:

– The change of the weights is equivalent to the rotation of the Pareto front about the origin. All Pareto-optimal solutions, no matter whether they are located in the convex or concave region, are dynamically capturable. In contrast, classical analyses of the weighted aggregation method only consider the static stability of the Pareto-optimal solutions. Note that a dynamically capturable Pareto-optimal solution is not necessarily statically stable.
– Many multiobjective optimization problems exhibit the characteristics known as global convexity, which means that most Pareto-optimal solutions are concentrated in a small fraction of the parameter space. Furthermore, the solutions in the neighborhood in the fitness space are also in the neighborhood in the parameter space, and vice versa. This property is also known as the connectedness.
– The evolution strategies are able to carry out locally causal search. Once the population has reached any point on the Pareto front, the local search ability is very important for the algorithms to "scan" the Pareto front point by point smoothly. The resolution of the scanning is determined by the speed of the weight change.

In the second part of the paper, we show some additional nice properties of the Pareto-optimal solutions beyond the global convexity. It is empirically shown that the Pareto-optimal set exhibits surprising regularity and simplicity in the parameter space, which is very interesting and helpful. By taking advantage of such regularities, it is possible to build simple models from the obtained Pareto-optimal solutions for approximating the definition function. Such an approximate model can be of great significance in the following aspects.

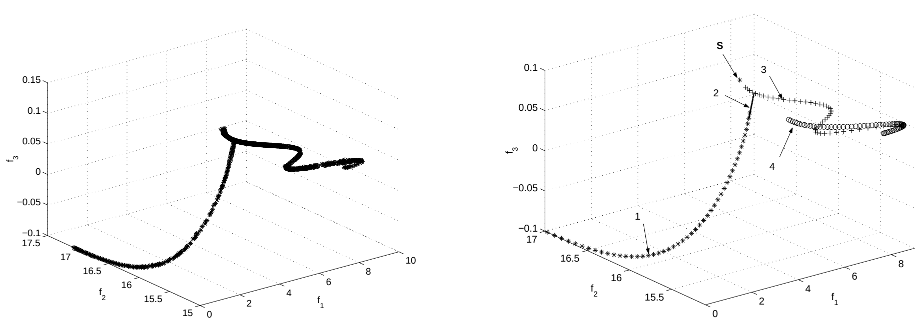
– It allows to get more accurate, more complete Pareto solutions from the approximate solutions obtained by an optimizer. Fig. 2(a) shows the Pareto front obtained by the EDWA. The Pareto front reconstructed from the approximate definition function is presented in Fig. 2(b).



(a) (b)

Fig. 1. An example of changing weights for (a) BWA and (b) DWA for solving three-objective optimization problems.

– It alleviates many difficulties in multiobjective optimization. If the whole Pareto front can be reconstructed from a few Pareto solutions, then many requirements on the optimizer can be alleviated, e.g., a uniform distribution is no more critical in approximating Pareto-optimal solutions.



(a) (b)

Fig. 2. (a) Obtained by the optimizer, (b) Reconstructed.

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