PES-GM/CEC/GECCO 2021 Competition

Presto: Population regeneration star-guided optimization

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This article introduces Presto (Population REgeneration STar-guided Optimization), an evolutionary algorithm that we have designed to solve problems of both Track 1 and Track 2 of the competition. Presto has been inspired from Particle Swarm Optimization and Differential Evolution algorithms and seeks to provide efficient control over diversification. Presto achieves this goal by employing independent feasible solutions (individuals or particles) throughout the algorithm. These individuals are not dependent on the population at any iteration. As a result, Presto is inherently diversified, irrespective of the iteration or population size and without the need for additional mechanisms such as mutation. Furthermore, Presto can be employed for solving discrete optimization problems by adopting any suitable recombination strategy that generates a new individual from two individuals.

In Presto, regeneration of the population is star-guided. The population follows two feasible and influential individuals called *leaders*. The first leader is emerged from the population and is chosen based on the relative performance of the individuals in the population. The second leader is emerged from an independent population. Some individuals in the population follow the first leader while the rest follow the second. While the second leader is randomly selected from the feasible region, the selection of the first leader is based on the relative fitness of the individuals in the population which can be done in different ways. In general, this leader does not have to be one of the individuals of the population, but rather any representative of them (e.g., a weighted average of them in continuous optimization). The *influence* of the leaders is the degree to which they can attract an individual of the population. We assume that the two leaders have the same influence depending on the generation. The *power* of a leader is the proportion of the accessible population that it can influence. In an adaptive implementation, influence and power of the leaders are updated from generation to generation. Algorithm 1 presents the general framework of Presto for a minimization problem. The required notation can be found in Table 1.

Table 1: The mathematical notation used to describe Presto

Notation	Definition
X	The population
$\|X\|$	The population size
g	Generation/iteration number
G	Maximum number of iterations
x^i	The ith individual in the population
$f(x^i)$	The fitness of x^i
x^i_j	The jth dimension of x^i
$x^\star$	The leader emerged from the population (the first leader)
x'	The leader emerged from an independent population (the second leader)
p	The probability of change in each dimension of an influenced individual
α	The influence of the leaders in a generation, $\alpha \in [0, 1]$
r	The power of the first leader (the power of the second leader $= 1 - r$), $r \in [0, 1]$
N	A subset of $X \setminus \{x^\star\}$ denoting individuals that are influenced by the first leader
M	The set of individuals that are influenced by the second leader, i.e., $M = X \setminus N$
n	The number of individuals in N, i.e., $n = \lfloor r \cdot (\|X\| - 1) \rfloor$

Algorithm 1: The general framework of the Presto for a minimization problem

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Randomly generate a feasible population X
g ← 1
while g ≤ G do
    Update x*
    Generate M, N and x'
    for i ∈ N do
        for each dimension j of x^i do
            Change x^i_j to y^i_j = (1 − α)x^i_j + αx*_j with probability p
        end
        Replace x^i with y^i if f(y^i) < f(x^i), otherwise discard x^i
    end
    for i ∈ M do
        for each dimension j of x^i do
            Change x^i_j to y^i_j = (1 − α)x^i_j + αx'_j with probability p
        end
        Replace x^i with y^i if f(y^i) < f(x^i), otherwise discard x^i
    end
    g ← g + 1
end
```

The new solution y^i generated from x^i is always feasible with respect to the boundaries since y^i is a convex combination of two feasible solutions. As can be seen, the leader that emerges from the population, the first leader, is always influenced by the independent leader. Therefore, at its highest level of power, the first leader will influence only $|X| - 1$ individuals. This improves diversity of the algorithm and makes the algorithm well-defined in the case of $|X| = 1$, in which $N = \emptyset$ and $M = X = \{x^\star\}$. We use $|X| = 1$ for Track 1. In our implementation of Presto for Track 2 (with $|X| = 30$), the first leader is randomly selected from the population with a probability that is dependent on its fitness value (the lower the fitness value, the higher the selection probability).