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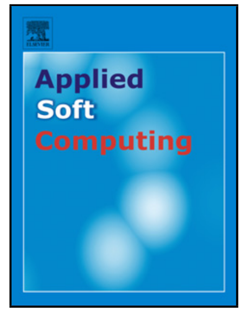


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# Enhancing the Performance of Differential Evolution with Covariance Matrix Self-adaptation☆

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**Abstract**

Differential evolution (DE) is an efficient global optimizer, while the covariance matrix adaptation evolution strategy (CMA-ES) shows great power on local search. However, utilizing both of these advantages in one algorithm is difficult since the randomness introduced by DE may reduce the reliability of covariance matrix estimation. Moreover, the exploration ability of DE can be canceled out by CMA-ES because they use completely different mechanisms to control the search step. To take advantage of both DE and CMA-ES, we propose a novel DE variant with covariance matrix self-adaptation, named DECMSA. In DECMSA, a new mutation scheme named "DE/current-to-better/1" is implemented. This scheme uses a Gaussian distribution to guide the search and strengthens both exploration and exploitation capabilities of DE. The proposed algorithm has been tested on the CEC-13 benchmark suite. The experimental results demonstrate that DECMSA outperforms popular DE variants, and it is quite competitive with state-of-the-art CMA-ES variants such as IPOP-CMA-ES and BIPOP-CMA-ES. Moreover, equipped with a constraint handling method, DECMSA is able to produce better solutions than other comparative algorithms on three classic constrained engineering design problems.

*Keywords:* differential evolution (DE), covariance matrix self-adaptation, optimization

## 1. Introduction

Evolutionary algorithms (EAs) have drawn wide attention in the field of numerical optimization over the last forty years. Among EAs, two main variants, differential evolution (DE) and covariance matrix adaptation evolution strategy (CMA-ES), are very popular algorithms and have shown excellent performance on global optimization. DE, first reported by Storn and Price in 1995 [1], is easy to implement, has few parameters to control, and is able to improve the performance through just changing parameters without imposing computation burden. CMA-ES [2] is a promising algorithm that utilizes a covariance matrix to describe the population distribution. Since this covariance matrix is independent of the coordinate system, CMA-ES is particularly suitable for handling ill-conditioned and non-separable problems.

However, both DE and CMA-ES have their drawbacks. Maintaining the effectiveness on separable multimodal functions, DE may fail to solve non-separable or ill-conditioned problems even on unimodal landscape [3]. On the contrary, CMA-ES is likely to be trapped in local optima on multimodal functions because the parameters and updating rules are originally designed for solving unimodal functions [4, 5].

Having mutually complementary characteristics, the drawbacks mentioned above can be solved by a hybrid of DE and CMA-ES. The simplest way is to execute these two algorithms serially [6, 7].

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