MP-EDA: A Robust Estimation of Distribution Algorithm with Multiple Probabilistic Models for Global Continuous Optimization*

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Abstract. Extending Estimation of distribution algorithms (EDAs) to the continuous field is a promising and challenging task. With a single probabilistic model, most existing continuous EDAs usually suffer from the local stagnation or a low convergence speed. This paper presents an enhanced continuous EDA with multiple probabilistic models (MP-EDA). In the MP-EDA, the population is divided into two subpopulations. The one involved by histogram model is used to roughly capture the global optima, whereas the other involved by Gaussian model is aimed at finding highly accurate solutions. During the evolution, a migration operation is periodically carried out to exchange some best individuals of the two subpopulations. Besides, the MP-EDA adaptively adjusts the offspring size of each subpopulation to improve the searching efficiency. The effectiveness of the MP-EDA is investigated by testing ten benchmark functions. Compared with several state-of-the-art evolutionary computations, the proposed algorithm can obtain better results in most test cases.

Keywords: Estimation of Distribution Algorithm, Evolutionary Computation, Histogram, Multivariate Gaussian Distribution, Global Optimization.

1 Introduction

The estimation of distribution algorithms (EDAs) are a new class of evolutionary computation algorithms [1] [2]. They generate new individuals by sampling a probabilistic model, which is estimated based on the current promising solutions. As the probabilistic model can capture promising areas in a statistically sound manner and can explicitly express the interactions among variables, EDAs usually can outperform traditional EAs on a number of complex problems .

* This work was supported in part by the National Natural Science Foundation of China No. U0835002 and No.61070004, by the National High-Technology Research and Development Program ("863" Program) of China No. 2009AA01Z208.
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K. Deb et al. (Eds.): SEAL 2010, LNCS 6457, pp. 85–94, 2010.
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The EDAs are first proposed to solve discrete problems with binary representation. For the last few years, various efforts have been made on extending them to the continuous optimization [3] - [11]. Most existing continuous EDAs use the Gaussian model or the histogram model to estimate the distribution of promising areas. The marginal Gaussian probabilistic model was used to guide the search in early continuous EDAs, such as the PBILc [3] and the UMDAc [4]. Lately, the multivariate Gaussian models also appeared in continuous EDAs [5] [6]. EDAs with a single Gaussian model are excellent in finding the global optima for unimodal optimization. However, for multimodal problems, they usually suffer from a slow convergence speed or even a local stagnation. Though clustering techniques have been utilized to address some of these issues [7], more efficient methods are greatly desirable.

Meanwhile, the histogram has multimodal density and can capture multiple local optima at the same time. Hence the histogram-based EDAs (HEDAs) are less likely to get trapped in local optima [8]. However, the HEDAs usually need a heavy computational cost to search for a highly accurate solution. To tackle this problem, the local search techniques [9], the shrink strategy [10], and the sub-divided method [11], have been proposed in recent few years. Nevertheless, since the histogram ignores interactions among variables, the HEDAs are not efficient enough to solve problems containing variable dependency.

In this paper, we present an enhanced EDA with multiple probabilistic models (named MP-EDA) for the global continuous optimization. The proposed MP-EDA has made two major improvements as below. First, the robustness to find a highly accurate solution is guaranteed by adopting two different types of probabilistic models: the multivariate Gaussian model and the fixed-height histogram (FHH) model. Second, the efficiency of the search is improved by utilizing an adaptive control strategy. In the MP-EDA, the population is initially divided into two subpopulations, with each involved by a probabilistic model. The one involved by the FHH is used to roughly capture the global optima, and the other involved by the multivariate Gaussian model is aimed at finding highly accurate solutions. During the evolution, a migration operation is carried out periodically to exchange some best individuals between the two subpopulations. By sharing information of better individuals, both subpopulations can converge faster. Besides, in order to improve the search efficiency, an adaptive strategy is used to adjust the offspring sizes of the two subpopulations. The performance of a probabilistic model is measured by the average fitness of new individuals generated by it during recent generations. The better probabilistic model is allowed to generate more offspring individuals, and vice versa.We investigate the effectiveness of the proposed MP-EDA by solving ten test functions with different characteristics. Several state-of-the-art EAs (i.e PLSO [12], DE [13], FEP [14] and CMA-ES [15]) are used for the comparison. Experimental results show that the proposed MP-EDA can achieve better results in most test cases.

The rest of the paper is organized as follows. Section 2 briefly describes the EDAs' general framework and two classical continuous EDAs. Section 3 illustrates the detailed implementations of the MP-EDA. The experimental studies on the MP-EDA are presented in Section 4. At last, Section 5 draws the conclusions.