# Clustering and learning Gaussian distribution for continuous optimization

Lu, QYao, X

Since the Estimation of Distribution Algorithm (EDA) was introduced, different approaches in continuous domains have been developed. Initially, the single Gaussian distribution was broadly used when building the probabilistic models, which would normally mislead the search when dealing with multimodal functions. Some researchers later constructed EDAs that take advantage of mixture probability distributions by using clustering techniques. But their algorithms all need prior knowledge before applying clustering, which is unreasonable in real life. In this paper, two new EDAs for continuous optimization are proposed, both of which, incorporate clustering techniques into estimation process to break the single Gaussian distribution assumption.. The new algorithms, Clustering and Estimation of Gaussian Network Algorithm based on BGe metric and Clustering and Estimation of Gaussian Distribution Algorithm, not only show great advantage in optimizing multimodal functions with a few local optima, but also overcome the restriction of demanding prior knowledge before clustering by using a very reliable clustering technique, Rival Penalized Competitive Learning. This is the first time that EDAs have the ability to detect the number of global optima automatically. A set of experiments have been implemented to evaluate the performance of new algorithms. Besides the improvement over some multimodal functions, according to the No Free Lunch theory, their weak side is also showed.

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# Globally multimodal problem optimization via an estimation of distribution algorithm based on unsupervised learning of Bayesian networks

Peña, JMLozano, JALarrañaga, P

Many optimization problems are what can be called globally multimodal, i.e., they present several global optima. Unfortunately, this is a major source of difficulties for most estimation of distribution algorithms, making their effectiveness and efficiency degrade, due to genetic drift. With the aim of overcoming these drawbacks for discrete globally multimodal problem optimization, this paper introduces and evaluates a new estimation of distribution algorithm based on unsupervised learning of Bayesian networks. We report the satisfactory results of our experiments with symmetrical binary optimization problems.

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# Estimation of distribution algorithms with Kikuchi approximations

Santana, R

The question of finding feasible ways for estimating probability distributions is one of the main challenges for Estimation of Distribution Algorithms (EDAs). To estimate the distribution of the selected solutions, EDAs use factorizations constructed according to graphical models. The class of factorizations that can be obtained from these probability models is highly constrained. Expanding the class of factorizations that could be employed for probability approximation is a necessary step for the conception of more robust EDAs. In this paper we introduce a method for learning a more general class of probability factorizations. The method combines a reformulation of a probability approximation procedure known in statistical physics as the Kikuchi approximation of energy, with a novel approach for finding graph decompositions. We present the Markov Network Estimation of Distribution Algorithm (MN-EDA), an EDA that uses Kikuchi approximations to estimate the distribution, and Gibbs Sampling (GS) to generate new points. A systematic empirical evaluation of MN-EDA is done in comparison with different Bayesian network based EDAs. From our experiments we conclude that the algorithm can outperform other EDAs that use traditional methods of probability approximation in the optimization of functions with strong interactions among their variables.

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# DE/EDA: A new evolutionary algorithm for global optimization

Sun, JYZhang, QFTsang, EPK

Differential evolution (DE) was very successful in solving the global continuous optimization problem. It mainly uses the distance and direction information from the current population to guide its further search. Estimation of distribution algorithm (EDA) samples new solutions from a probability model which characterizes the distribution of promising solutions. This paper proposes a combination of DE and EDA (DE/EDA) for the global continuous optimization problem. DE/EDA combines global information extracted by EDA with differential information obtained by DE to create promising solutions. DE/EDA has been compared with the best version of the DE algorithm and an EDA on several commonly utilized test problems. Experimental results demonstrate that DE/EDA outperforms the DE algorithm and the EDA. The effect of the parameters of DE/EDA to its performance is investigated experimentally. (C) 2004 Elsevier Inc. All rights reserved.

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# Stock index modeling using EDA based Local Linear Wavelet Neural Network

Chen, YHDong, XHZhao, YO

Abstract no encontrado

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# Probabilistic distribution models for EDA-based GP

Yanai, KohsukeIba, Hitoshi

This paper proposes a novel technique for a program evolution based on probabilistic models. In the proposed method, two probabilistic distribution models with probabilistic dependencies between variables are used together. We empirically comfirm that our proposed method has higher search performance. Thereafter, we discuss the effectiveness of its distribution models.

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# MRI magnet design: Search space analysis, EDAs and a real-world problem with significant dependencies

Yuan, BoGallagher, MarcusCrozier, Stuart

This paper introduces the design of superconductive magnet configurations in Magnetic Resonance Imaging (MRI) systems as a challenging real-world problem for Evolutionary Algorithms (EAs). Analysis of the problem structure is conducted using a general statistical method, which could be easily applied to other problems. The results suggest that the problem is highly multimodal and likely to present a significant challenge for many algorithms. Through a series of preliminary experiments, a continuous Estimation of Distribution Algorithm (EDA) is shown to be able to generate promising designs with a small computational effort. The importance of utilizing problem-specific knowledge and the ability of an algorithm to capture dependencies in solving complex real-world problems is also highlighted.

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# On the convergence of an estimation of distribution algorithm based on linkage discovery and factorization

Wright, Alden H.Pulavarty, S. V. P. M. Sandeep

Estimation of distribution algorithms construct an explicit model of the problem to be solved, and then use this model to guide the search for good solutions. For an important class of fitness functions, namely those with k-bounded epistasis, it is possible to construct a complete explicit representation of the fitness function by sampling the fitness function. A very natural model of the problem to be solved is the Boltzmann distribution of the fitness function, which is an exponential of the fitness normalized to a probability distribution. As the exponentiation factor (inverse temperature) of the Boltzmann distribution is increased, probability is increasingly concentrated on the set of optimal points. We show that for fitness functions of k-bounded epistasis that satisfy an additional property called the running intersection property, an explicit computable exact factorization of the Boltzmann distribution with an arbitrary exponentiation factor can be constructed. This factorization allows the Boltzmann distribution to be efficiently sampled, which leads to an algorithm which finds the optimum with high probability.

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# Using a Markov network model in a univariate EDA: An empirical cost-benefit analysis

Shakya, SiddharthaMcCall, JohnBrown, Deryck

This paper presents an empirical cost-benefit analysis of an algorithm called Distribution Estimation Using MRF with direct sampling (DEUMd). DEUMd belongs to the family of Estimation of Distribution Algorithm (EDA). Particularly it is a univariate EDA. DEUMd uses a computationally more expensive model to estimate the probability distribution than other univariate EDAs. We investigate the performance of DEUMd in a range of optimization problem. Our experiments shows a better performance (in terms of the number of fitness evaluation needed by the algorithm to find a solution and the quality of the solution) of DEUMd on most of the problems analysed in this paper in comparison to that of other univariate EDAs. We conclude that use of a Markov Network in a univariate EDA can be of net benefit in defined set of circumstances.

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# Using prior knowledge to improve the performance of an estimation of distribution algorithm applied to feature selection

Emmendorfer, LRTraleski, RPozo, ATR

Feature selection provides a great enhancement in the process of building a classifier model. A recent approach to feature selection is the use of Estimation of Distribution Algorithms (EDAs). Those algorithms's performance is greatly affected by the initial population, so prior knowledge about the problem is very important. The most important prior knowledge about the features is the relative order of importance observed among them, which can he obtained by some statistical measure. Based on the use of that kind of knowledge, some improvements are proposed and theoretically discussed. An experiment is presented, which evaluates potential benefits of those alternatives.

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# Continuous optimization based-on greedy estimation of GMM

Li, BZhong, RTWang, XJZhuang, ZQ

A new Estimation of Distribution Algorithms (EDAs) for continuous optimization based on greedy estimation of Gaussian Mixture Mode is proposed. By incrementally adding new components one by one, the new estimation method can approximate almost any complex probability density function efficiently, so it has the ability to learn the model structure and parameters automatically without any requirement for prior knowledge. Since for each estimation iteration the task is simplified to be a two-component mixture model learning problem, and a greedy strategy is adopted to guarantee the monotonous increasing of likelihood, the new EDA is very fast and efficient. A set of experiments has been implemented to evaluate, and to compare with other EDAs, the efficiency and performance of the new algorithm. The results show that, with a relative small number of generations, the new algorithm can perform very well on both uni-modal and multi-modal function optimization problems.

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# Biped gait optimization using estimation of distribution algorithm

Hu, LYZhou, CJSun, ZQ

This paper proposes a new biped gait optimization method based on Estimation of Distribution Algorithm (EDA). It is able to explicitly extract global statistical information from the selected solutions and build a posterior probability distribution model of promising solutions based on the extracted information. Biped gait for a nine-link robot is firstly formulated as a multi-objective optimization problem with consideration of multi-constraints including balance and torque. Optimization parameters are angles at transition poses. Instead of searching the joint space directly, EDA is applied to estimate the probability distribution of each joint degree. By this means, inherent mapping relationship between joint coordinates and cost function can be described in term of probability density. Compared to common intelligent learning method, the proposed optimization method can formulate a proper and feasible combination of impulses by tuning less parameters and visiting less states. The effectiveness of the proposed EDA based biped gait optimization method has been tested on a soccer-playing humanoid robot named Robo-Erectus. Experiment results demonstrate that the learned trajectory makes a good balance between stability and energy cost in short learning epochs.

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# Convergence of estimation of distribution algorithms in optimization of additively noisy fitness functions

Hong, YRen, QSZeng, JChang, YC

Noise is a common phenomenon in many real-world optimizations. It has long been argued that evolutionary algorithm (EA) should be relatively robust against it. As a novel computing model in evolutionary computations, Estimation of Distribution Algorithm (EDA) is also encountered with it. This paper initially presents three dynamic models of EDA under the additively noisy environment with three different selection methods (proportional selection method, truncation selection method and tournament selection method). We verify that when the population size is infinite, EDA can converge to the global optimal point. This concept establishes the theoretic foundation for optimization of noisy fitness functions with EDA.

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# Fitness approximation in estimation of distribution algorithms for feature selection

Chen, HXYuan, SMKai, JA

Estimation of distribution algorithms (EDAs) are popular and robust algorithms that combine two technical disciplines of soft computing methodologies, probabilistic reasoning and evolutionary computing, for optimization problems. Several algorithms have already been proposed by different authors. However, these algorithms may require huge computation power, which is seldom considered in those applications. This paper introduces a "fast estimation of distribution algorithm" (FEDA) for feature selection that does not evaluate all new individuals by actual fitness function, thus reducing the computational cost and improve the performance. Bayesian networks are used to model the probabilistic distribution and generate new individuals in the optimization process. Moreover, fitness value is assigned to each new individual using the extended Bayesian network as an approximate model to fitness function. Implementation issues such as individual control strategy, model management are addressed. Promising results are achieved in experiments on 5 UCI datasets. The results indicate that, as population-sizing requirements for building appropriate models of promising solutions lead to good fitness estimates, more compact feature subsets that give more accurate result can be found.

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# Discovering gene-gene interactions by inferring dags of Bayesian networks with EDA

Dai, CLiu, J

More and more experimental results have shown that genes do not function independently; instead they act on each other. To find the interactions among genes is one of the hottest topics in current genome research. The Bayesian Network (BN), which is a graph-based representation of a joint probability distribution that captures properties of conditional independence between variables, is a desirable tool to find the interaction between genes. However, how to find appropriate BNs that most fit to the data is very difficult since the number of possible BNs on n variables is the super-exponential of n. To avert the combinational explosion, in this paper, we use Estimation of Distribution Algorithm (EDA) to search the BN space. Also, in order to make the individuals of EDA meaningful, we also propose a depth-first search method to cut circles in the graph. We have tested our method on cell-cycle gene expression data, the results show that the constructed BNs can not only discover some existing relationships in other literatures and Gene Ontology, but also reveal some previously unknown interactions.

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# Estimating the distribution in an EDA

Shakya, SMcCall, JBrown, DF

This paper presents an extension to our work on estimating the probability distribution by using a Markov Random Field (MRF) model in an Estimation of Distribution Algorithm (EDA) (1). We propose a method that directly samples a MRF model to generate new population. We also present a new EDA, called the Distribution Estimation Using MRF with direct sampling (DELTMd), that uses this method, and iteratively refines the probability distribution to generate better solutions. Our experiments show that the direct sampling of a MRF model as estimation of distribution provides a significant advantage over other techniques on problems where a univariate EDA is typically used.

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# A study on the global convergence time complexity of estimation of distribution algorithms

Rastegar, RMeybodi, MR

The Estimation of Distribution Algorithm is a new class of population based search methods in that a probabilistic model of individuals are estimated based on the high quality individuals and used to generate the new individuals. In this paper we compute 1) some upper bounds on the number of iterations required for global convergence of EDA 2) the exact number of iterations needed for EDA to converge to global optima.

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# Parallel island-based estimation of distribution algorithms for wireless network planning

Liu, FZeng, YHZou, YSLiu, JZhou, HB

Wireless network planning is an important problem to the communication companies. To solve this problem, many models were proposed, which overlooked different profits on the same acreage in different regions. Genetic algorithms (GAs) and similar algorithms were put forward by many papers based on those models. However, those models cannot reflect the companies' aims that make maximum profit with minimum cost. In this paper, we put forward a novel model with profit weight and penalty factor and design a new simulation experiment about the model, In order to gain the optimal solution quickly, a kind of novel algorithms-parallel island-based estimation of distribution algorithms (PEDA)--is proposed based on [5]. Through simulation tests, we find that our algorithms outperform other stochastic heuristic search algorithms.

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# A new estimation of distribution algorithm based on learning automata

Rastegar, RMeybodi, MR

In this paper we introduce an estimation of distribution algorithm based on a team of learning automata. The proposed algorithm is a model based search optimization method that uses a team of learning automata as a probabilistic model of high quality solutions seen in the search process. Simulation results show that the proposed algorithm is a good candidate for solving optimization problems.

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# Empirical studies on parallel network construction of Bayesian optimization algorithms

Munetomo, MMurao, NAkama, K

This paper discusses a parallel optimization algorithm based on evolutionary algorithms with probabilistic model-building in order to design a robust search algorithm that can be applicable to a wide-spectrum of application problems effectively and reliably. Probabilistic model building genetic algorithm, which is also called estimation of distribution algorithm, is a promising approach in evolutionary computation and its parallelization has been investigated. We propose an improvement of parallel network construction in distributed Bayesian optimization algorithms which estimate distribution of promising solutions as Bayesian networks. Through numerical experiments on an actual parallel architecture, we show the effectiveness of our approach compared to the conventional parallelization. Also we perform experiments on a real-world application problem: protein structure predictions.

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