# A Bayesian Network Approach to Program Generation

Hasegawa, Yoshihiko Iba, Hitoshi

Genetic programming (GP) is a powerful optimization algorithm that has been applied to a variety of problems. This algorithm can, however, suffer from problems arising from the fact that a crossover, which is a main genetic operator in GP, randomly selects crossover points, and so building blocks may be destroyed by the action of this operator. In recent years, evolutionary algorithms based on probabilistic techniques have been proposed in order to overcome this problem. In the present study, we propose a new program evolution algorithm employing a Bayesian network for generating new individuals. It employs a special chromosome called the expanded parse tree, which significantly reduces the size of the conditional probability table (CPT). Prior prototype tree-based approaches have been faced with the problem of huge CPTs, which not only require significant memory resources, but also many samples in order to construct the Bayesian network. By applying the present approach to three distinct computational experiments, the effectiveness of this new approach for dealing with deceptive problems is demonstrated.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:000261544100008&DestLinkType=FullRecord&DestApp=WOS_CPL)

# GAIT GENERATION AND OPTIMIZATION USING THE ESTIMATION OF DISTRIBUTION ALGORITHM FOR TEENSIZE HUMANOID SOCCER ROBOT RESr-1

Hu, Lingyun Zhou, Changjiu

This paper gives an overview of locomotion planning and control of a TeenSize humanoid soccer robot, Robo-Erectus Senior (RESr-1), which has been developed as an experimental platform for human-robot interaction and cooperative research in general and robotics soccer games in particular. The locomotion planning and control, along with an introduction of hierarchical control architecture, vision-based behavior and its application in the Humanoid TeenSize soccer challenge, are elaborated. The Estimation of Distribution Algorithm (EDA) is used in locomotion generation and optimization to achieves dynamically stable walk and a powerful kick. By setting different objective functions, smooth walking and powerful kicking can be generated quickly. RESr-1 made its debut at RoboCup 2007, and got fourth place in the Humanoid TeenSize penalty kick competition. In addition, some experimental results on RESr-1's walking, tracking and kicking are presented.

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# Protein folding in simplified models with estimation of distribution algorithms

Santana, Roberto Larranaga, Pedro Lozano, Jose A.

Simplified lattice models have played an important role in protein structure prediction and protein folding problems. These models can be useful for an initial approximation of the protein structure, and for the investigation of the dynamics that govern the protein folding process. Estimation of distribution algorithms (EDAs) are efficient evolutionary algorithms that can learn and exploit the search space regularities in the form of probabilistic dependencies. This paper introduces the application of different variants of EDAs to the solution of the protein structure prediction problem in simplified models, and proposes their use as a simulation tool for the analysis of the protein folding process. We develop new ideas for the application of EDAs to the bidimensional and tridimensional (2-d and 3-d) simplified protein folding problems. This paper analyzes the rationale behind the application of EDAs to these problems, and elucidates the relationship between our proposal and other population-based approaches proposed for the protein folding problem. We argue that EDAs are an efficient alternative for many instances of the protein structure prediction problem and are indeed appropriate for a theoretical analysis of search procedures in lattice models. All the algorithms introduced are tested on a set of difficult 2-d and 3-d instances from lattice models. Some of the results obtained with EDAs are superior to the ones obtained with other well-known population-based optimization algorithms.

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# Robust airfoil optimization with multi-objective estimation of distribution algorithm

Zhong Xiaoping Ding Jifeng Li Weiji Zhang Yong

A transonic airfoil designed by means of classical point-optimization may result in its dramatically inferior performance under off-design conditions. To overcome this shortcoming, robust design is proposed to find out the optimal profile of an airfoil to maintain its performance in an uncertain environment. The robust airfoil optimization is aimed to minimize mean values and variances of drag coefficients while satisfying the lift and thickness constraints over a range of Mach numbers. A multi-objective estimation of distribution algorithm is applied to the robust airfoil optimization on the base of the RAE2822 benchmark airfoil. The shape of the airfoil is obtained through superposing ten Hick-Henne shape functions upon the benchmark airfoil. A set of design points is selected according to a uniform design table for aerodynamic evaluation. A Kriging model of drag coefficient is constructed with those points to reduce computing costs. Over the Mach range from 0.7 to 0.8, the airfoil generated by the robust optimization has a configuration characterized by super-critical airfoil with low drag coefficients. The small fluctuation in its drag coefficients means that the performance of the robust airfoil is insensitive to variation of Mach number.

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# Unified eigen analysis on multivariate Gaussian based estimation of distribution algorithms

Dong, Weishan Yao, Xin

Multivariate Gaussian models are widely adopted in continuous estimation of distribution algorithms (EDAs), and covariance matrix plays the essential role in guiding the evolution. In this paper, we propose a new framework for multivariate Gaussian based EDAs (MGEDAs), named eigen decomposition EDA (ED-EDA). Unlike classical EDAs, ED-EDA focuses on eigen analysis of the covariance matrix, and it explicitly tunes the eigenvalues. All existing MGEDAs can be unified within our ED-EDA framework by applying three different eigenvalue tuning strategies. The effects of eigenvalue on influencing the evolution are investigated through combining maximum likelihood estimates of Gaussian model with each of the eigenvalue tuning strategies in ED-EDA. In our experiments, proper eigenvalue tunings show high efficiency in solving problems with small population sizes, which are difficult for classical MGEDA adopting maximum likelihood estimates alone. Previously developed covariance matrix repairing (CMR) methods focusing on repairing computational errors of covariance matrix can be seen as a special eigenvalue tuning strategy. By using the ED-EDA framework, the computational time of CMR methods can be reduced from cubic to linear. Two new efficient CMR methods are proposed. Through explicitly tuning eigenvalues, ED-EDA provides a new approach to develop more efficient Gaussian based EDAs. (c) 2008 Elsevier Inc. All rights reserved.

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# RM-MEDA: A regularity model-based multiobjective estimation of distribution algorithm (vol 12, pg 41, 2008)

Zhang, Qingfu Zhou, Aimin Jin, Yaochu

Abstract no encontrado

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# A HYBRID ESTIMATION OF DISTRIBUTION ALGORITHM FOR CDMA CELLULAR SYSTEM DESIGN

Sun, Jianyong Zhang, Qingfu Li, Jin Yao, Xin

This paper proposes a hybrid estimation of distribution algorithm (HyEDA) to address the design problem of code division multiple access cellular system configuration. Given a service area, the problem is to find a set of optimal locations of base stations, associated with their corresponding powers and antenna heights in the area, in order to maximize call quality and service coverage, at the same time, to minimize the total cost of the system configuration. HyEDA is a two-stage hybrid approach which integrates an estimation of distribution algorithm, a K-means clustering method, and a simple local search algorithm. We have compared HyEDA with a simulated annealing method on a number of instances. Our simulation results have demonstrated that HyEDA outperforms the simulated annealing method in terms of the solution quality and computational cost.

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# Estimating biped gait using spline-based probability distribution function with Q-learning

Hu, Lingyun Zhou, Changjiu Sun, Zengqi

This paper studies the probability distribution functions of the parameters to be learned and optimized in biped gait generation. By formulating the gait pattern generation into a multiobjective optimization problem with consideration of geometric and state constraints, dynamically stable and low energy cost biped gaits are generated and optimized by the proposed method, namely Spline-based Estimation of Distribution Algorithm (EDA) with Q-learning updating rule (EDA\_S\_Q). Instead of assuming variables as independent ones, the relationship between them is exploited by formulating the corresponding probability models with the Catmull-Rom cubic spline function. Such kind of function is proved to be a suboptimal and adaptive realization of the cubic spline function and is capable of providing high-precision description. Moreover, the probability models are updated autonomously by Q-learning method, which is model-free and adaptive. Thus, EDA\_S\_Q can deal with complex probability distribution functions without a prior knowledge about the distribution. The biped gait generated by EDA\_S\_Q has been verified using the simulation model of a humanoid soccer robot Robo-Erectus. It also shows that EDA\_S\_Q can generate the desired biped gaits autonomously in short learning epochs. An interpretation of the transition probability distribution achieved by EDA\_S\_Q provides us easy understanding for biped locomotion and better control in humanoid robots.

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# RM-MEDA: A regularity model-based multiobjective estimation of distribution algorithm

Zhang, Qingfu Zhou, Aimin Jin, Yaochu

Under mild conditions, it can be induced from the Karush-Kuhn-Tucker condition that the Pareto set, in the decision space, of a continuous multiobjective optimization problem is a piecewise continuous (m - 1)-D manifold, where m Is the number of objectives. Based on this regularity property, we propose a regularity model-based multiobjective estimation of distribution algorithm (RM-MEDA) for continuous multiobjective optimization problems with variable linkages. At each generation, the proposed algorithm models a promising area in the decision space by a probability distribution whose centroid is a (m - 1) -D piecewise continuous manifold. The local principal component analysis algorithm is used for building such a model. New trial solutions are sampled from the model thus built. A nondominated sorting-based selection is used for choosing solutions for the next generation. Systematic experiments have shown that, overall, RM-MEDA outperforms three other state-of-the-art algorithms, namely, GDE3, PCX-NSGA-II, and MIDEA, on a set of test instances with variable linkages. We have demonstrated that, compared with GDE3, RM-MEDA is not sensitive to algorithmic parameters, and has good scalability to the number of decision variables in the case of nonlinear variable linkages. A few shortcomings of RM-MEDA have also been identified and discussed in this paper.

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# Dynamic search space transformations for software test data generation

Sagana, Ramon Lozano, Jose A.

Among the tasks in software testing, test data generation is particularly difficult and costly. In recent years, several approaches that use metaheuristic search techniques to automatically obtain the test inputs have been proposed. Although work in this field is very active, little attention has been paid to the selection of an appropriate search space. The present work describes an alternative to this issue. More precisely, two approaches which employ an Estimation of Distribution Algorithm as the metaheuristic technique are explained. In both cases, different regions are considered in the search for the test inputs. Moreover, to depart from a region near to the one containing the optimum, the definition of the initial search space incorporates static information extracted from the source code of the software under test. If this information is not enough to complete the definition, then a grid search method is used. According to the results of the experiments conducted, it is concluded that this is a promising option that can be used to enhance the test data generation process.

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# Adding Probabilistic Dependencies to the Search of Protein Side Chain Configurations Using EDAs

Santana, Roberto Larranaga, Pedro Lozano, Jose A.

The problem of finding an optimal positioning for the side chain residues of a protein is called the side chain placement or side chain prediction problem. It can be posed as an optimization problem in the discrete domain. In this paper we use an estimation of distribution algorithm to address this optimization problem. Using a set of 50 difficult protein instances, it is shown that the addition of dependencies between the variables in the probabilistic model can improve the quality of the solutions achieved for most of the instances considered. However, we also show that only when information about the known interactions between the residues is considered in the creation of the probabilistic model, the addition of the dependencies contributes to improve the quality of the solutions obtained.

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# Preventing Premature Convergence in a Simple EDA Via Global Step Size Setting

Posik, Petr

When a simple real-valued estimation of distribution algorithm (EDA) (EDA) with Gaussian model and maximum likelihood estimation of parameters is used, it converges prematurely even on the slope of the fitness function. The simplest way of preventing premature convergence multiplying the variance estimate by a constant factor k each generation is studied. Recent works have shown that when increasing the dimensionality of the search space, such an algorithm becomes at the same time. In this paper it is shown that when isotropic distributions with Gaussian or Cauchy distributed norms are used, the simple constant setting of k is able to ensure a reasonable behaviour of the EDA on the slope and in the valley of the fitness function at the same time.

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# A Generalized Differential Evolution Combined with EDA for Multi-objective Optimization Problems

Chen, Wang Shi, Yan-jun Teng, Hong-fei

This paper proposed a multi-objective evolutionary algorithm (called by GDE-EDA hereinafter). The proposed algorithm combined a generalized differential evolution (DE) with an estimation of distribution algorithm (EDA). This combination can simultaneously use global information of population extracted by EDA and differential information by DE. Thus, GDE-EDA can obtain a better distribution of the solutions by EDA while keeping the fast convergence exhibited by DE. The experimental results of the proposed GDE-EDA algorithm were reported on a suit of widely used test functions, and compared with GDE and NSGA-II in the literature.

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# An Orthogonal hybrid algorithm for the resource-constrained project scheduling problem

Huang, Zhiyu

As an effective method, the generation-based heuristic algorithm gets information from the history search at one generation, and then uses this information to generate some other solutions as the next generation so that a near optimum solution can be found. To do this effectively, how to represent a solution is a fundamental problem. After providing a new representation for a solution, a hybrid algorithm was given. The algorithm used the ideal of orthogonal design to make the solutions generating more reasonable, and used the ideal of Estimation of Distribution Algorithm to elicit the information about activity linking in a population so that the solutions with history linking information can be generated, and used the ideal of Scatter Search to keep the search process strolling in divers parts, and used the ideal of reverse schedule to improve the fitness of found solutions. The simulation results reveal the efficiency of the algorithm.

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# Solution of Cannonball Dispersion Evenness Based on Estimation of Distribution Algorithm

Wang, Gaopeng Dou, Lihua Zhang, Juan Chen, Chen

Cannonball dispersion evenness is the main parameter for the design and optimization of future air window. The key of solution of cannonball dispersion evenness is the computations of the biggest value and smallest value of a 2-dimensional continuous function, which has many maximum values and minimum values. Moreover, as it need to compute the biggest value and smallest value for many times in the design and parameter computation of FAW, the solution algorithm is required global convergence and quick convergence speed. Many randomly generated individuals are introduced in each generation to avoid local convergence, and in order to speed up the convergence speed, probability distribution models are founded to guide the searching process. By computer simulation verifying, the algorithm has the advantages of quick convergence speed and high precision of solution in certain generations compared to conventional genetic algorithm. The algorithm is also suitable for other optimizing solutions of 2-dimentional continuous function.

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# Estimation of Distribution Algorithm Applied to Dynamic Model in Ecology

Wang, Jie Wu, Yanghui

Estimation of Distribution Algorithm based on Markov Random Fields (DEUM) is applied to solve a bio-control Dynamic Optimal Model in Mushroom growing. A chain structure is used to indicate the relation among variables, then a probability distribution model is built based on fitness function, Gibbs Distribution is utilized as sampling to generate new generations. Our experiment's results show a better performance of DEUM in term of the quality of the solution in comparison to Genetic Algorithms. We concluded that this approach can be as an effective method to other Dynamic Optimal problems.

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# A linear estimation-of-distribution GP system

Poli, Riccardo McPhee, Nicholas F.

We present N-gram GP, an estimation of distribution algorithm for the evolution of linear computer programs. The algorithm learns and samples a joint probability distribution of triplets of instructions (or 3-grams) at the same time as it is learning and sampling a program length distribution. We have tested N-gram GP on symbolic regressions problems where the target function is a polynomial of up to degree 12 and lawn-mower problems with lawn sizes of up to 12 x 12. Results show that the algorithm is effective and scales better on these problems than either linear GP or simple stochastic hill-climbing.

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# FPGA implementation of a cellular compact genetic algorithm

Jewajinda, Yutana Chongstitvatana, Prabhas

This paper presents a cellular compact genetic algorithm (CCGA.) for evolvable and adaptive hardware. The CCGA has cellular-like structure which is suitable for hardware implementation. The CCGA is developed from compact genetic algorithm (CGA) and parallel estimation of distribution algorithm (EDA). The concept and algorithm of the CCGA are presented. The standard test functions are selected to measure the effectiveness of the CCGA. The experimental results significantly shows that the CCGA outperforms the normal compact GA and deliver compatible results to the cooperative compact genetic algorithm while employs only one type of cell. The implemented hardware in FPGA demonstrates the feasibility to use this new kind of genetic algorithm to evolvable and adaptive hardware.

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# Optimal genes selection with a new multi-objective evolutional algorithm hybriding NSGA-II with EDA

Fei, Luo Juan, Liu

Recent studies on molecular level classification of tissues with DNA microarray technology have produced remarkable results. It is believed that the subtypes of cancer can be distinguished by a set of discriminative genes. To achieve this goal, it not only requires high enough classification accuracy, but also a minimal number of genes as much as possible to lower cost. Meanwhile, the number of samples from different tissues may differ greatly. Therefore, it should also avoid classification bias due to unbalance sample number in different classes. In this paper, we propose a new multi-objective evolutional algorithm (MOEA) framework to select optimal genes, which has both advantages of the non-dominated sorting genetic algorithm II (NSGA-II) and the estimation of distribution algorithm (EDA). Finally, experiment on the data is done, The result shows that our method has good performance.

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# QoS-based service provision schemes and plan durability in service composition

Pichanaharee, Koramit Senivongse, Twittie

In service composition, quality of service is a major criterion for selecting services to collaborate in a process flow to satisfy a certain quality goal. This paper presents an approach for service composition which considers QoS-based service provision schemes and variability of the QoS when planning. The QoS of a service can be stated in terms of complex service provision schemes, e.g. its service cost is offered at different rates for different classes of processing time, or its partnership with another service gives a special class of QoS when they operate in the same plan. We also address that it is desirable for service planning to result in a plan that is durable and reusable since change in the plan, e.g. by deviation of the actual QoS, would incur overheads. Our planning approach takes into account these dynamic situations and is demonstrated by using the Estimation of Distribution Algorithm.

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# Optimizing scheduling problem using an estimation of distribution algorithm and genetic algorithm - art. no. 67943Y

Jiang, Qun Ou, Yang Shi-Du, Dong

This paper presents a methodology for using heuristic search methods to optimize scheduling problem. Specifically, an Estimation of Distribution Algorithm (EDA) - Population Based Incremental Learning (PBIL), and Genetic Algorithm (GA) have been applied to finding effective arrangement of curriculum schedule of Universities. To our knowledge, EDAs have been applied to fewer real world problems compared to GAs, and the goal of the present paper is to expand the application domain of this technique. The experimental results indicate a good applicability of PBIL to optimize scheduling problem.

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# Scalable continuous multiobjective optimization with a neural network-based estimation of distribution algorithm

Marti, Luis Garcia, Jesas Berlanga, Antonio Molina, Jose M.

To achieve a substantial improvement of MOEDAs regarding MOEAs it is necessary to adapt their model building algorithm to suit this particular task. Most current model building schemes used so far off-the-shelf machine learning methods. However, the model building problem has specific requirements that those methods do not meet and even avoid.

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# Histogram-based estimation of distribution algorithm: A competent method for continuous optimization

Ding, Nan Zhou, Shu-De Sun, Zeng-Qi

Designing efficient estimation of distribution algorithms for optimizing complex continuous problems is still a challenging task. This paper utilizes histogram probabilistic model to describe the distribution of population and to generate promising solutions. The advantage of histogram model, its intrinsic multimodality, makes it proper to describe the solution distribution of complex and multimodal continuous problems. To make histogram model more efficiently explore and exploit the search space, several strategies are brought into the algorithms: the surrounding effect reduces the population size in estimating the model with a certain number of the bins and the shrinking strategy guarantees the accuracy of optimal solutions. Furthermore, this paper shows that histogram-based EDA (Estimation of distribution algorithm) can give comparable or even much better performance than those predominant EDAs based on Gaussian models.

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# Optimization and Stabilization of Networked Control Systems: an Estimation of Distribution Algorithm approach\

Li, HongBo Chow, Mo-Yuen Sun, ZengQi

This paper addresses the optimization and stabilization problem for networked control systems (NCSs). The memoryless state feedback controller is considered, and the resulting closed-loop NCS is modeled as a discrete-time switch system. By defining a state-dependent Lyapunov function, the stability conditions are derived for NCSs in terms of linear matrix inequalities (LMIs). Based on the obtained stability conditions, the corresponding controller design problem is solved, and Estimation of Distribution Algorithm (EDA) is used to select the optimal state feedback stabilizing gain. It is shown that the proposed method can be easily implemented to various applications, since it is simple and has no assumptions on time delays and packet losses. Simulation results are given to demonstrate the effectiveness of the proposed approach.

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# An Improved Regularity Model-Based Multi-Objective Estimation of Distribution Algorithm

Wang, Jianwen Dai, Guangming Zheng, Wei

Based on the study and analysis of A Regularity Model-Based Multi-Objective Estimation of Distribution Algorithm (RM-MEDA), we propose An Improved Regularity Model-Based Multi-Objective Estimation of Distribution Algorithm (IRM-MEDA). The IRM-MEDA had some features. 1) generate initial population with orthogonal design so that the individuals make a more representative distribution of the feasible solutions. 2)introduce a new convergence criterion to determine when the genetics-based method, i.e. crossover, mutation and when the EDA-based method should be used to generate offspring.3)combine genetics-based and model-based offspring generation instead of only model-based method in RM-MEDA. The experiment result on a number of test problems proved that An Improved Regularity ModeI-Based Multi-Objective Estimation of Distribution Algorithm is able to find much better convergence near the the true Pareto-optimal solutions and better spread of solutions than RM-MEDA.

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# Linkages Detection in Histogram-Based Estimation of Distribution Algorithm

Ding, Nan Zhou, Shude

In this chapter, we review two methods that deal with the linkage detection in the Histogram-based Estimation of Distribution Algorithms; one is based on probabilistic graphical models, and the other is based on space transformation. The two methods deal with the linkage in the optimization problem with different accuracy and with different computational complexity. Probabilistic graphical model is generally more accurate but always associated to high-cost, while transformation is the opposite. In the following, we will mainly discuss the way to reduce the complexity of the method based on probabilistic graphical model and the way to obtain the transformation which captures the dominant linkage of the problem.

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# Online Transportation and Logistics Using Computationally Intelligent Anticipation

Bosman, Peter A. N. La Poutre, Hall

With advances in technology in communication and navigation, the ability to make decisions online (i.e. as time goes by) becomes increasingly important in transportation and logistics. In this chapter, we focus oil online decision making in these areas. First, we point out the importance of anticipation when optimizing decision processes online. Anticipation is the possibility to take into account future events and the influence of decisions taken now on those future events. Second, we discuss)low computational intelligence (CI) call be used to design approaches that perform anticipation. We illustrate this particular use of CI techniques in two different applications: dynamic vehicle routing (transportation) and inventory management (logistics). In both cases the use of anticipation is found to lead to substantial improvements. This demonstrates our main conclusion that the ability to perform anticipation in online transportation and logistics is very important.

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# A Differential Ant-Stigmergy Approach to Continuous Optimization

Korosec, Peter Silc, Jurij

The paper presents an extension of the antcolony optimization metaphor for continuous domain. This new approach was named a Differential Ant-Stigmergy Algorithm (DASA) and was studied on a set of benchmark suite of real-parameter optimization problems defined in 2005 at the IEEE Congress of Evolutionary Computation.

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# An Improved Estimation of Distribution Algorithm in Dynamic Environments

Liu, Xiaoxiong Wu, Yan Ye, Jimin

In dynamic environments, the optimal solution changes over time. To track the solution, an improved univariate marginal distribution algorithm(UMDA) is proposed A transfer model is introduced to increase the diversity of population. The current information is used to avoid being trapped into the local optimization for dynamic optimization problems. The scheme is illustrated through simulations applying dynamic moving peaks benchmark. The results show that the proposed algorithm is effective and can accommodate the dynamic environments rapidly.

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# Improved Prediction of Nitrogen Oxides Using GRNN with K-means Clustering and EDA

Zheng, Ligang Yu, Shuijun Wang, Wei Yu, Minggao

The current study presented a generalized regression neural network (GRNN) based approach to predict nitrogen oxides (NOx) emitted from coal-fired boiler. A novel 'mulliple' smoothing parameters, which is different from the standard algorithm in which only single smoothing parameter was adopted (Matlab neural network toolbox, for example), were assigned to GRNN model. K-means clustering algorithm was developed so as to reduce the number of smoothing parameters. The training data was firstly partitioned into groups (the number of groups was much smaller than that of training samples) using K-means clustering. A smoothing parameter was then assigned to this group. A recently emerging estimation of distribution algorithm (EDA) was employed to optimize the multiple smoothing parameters. EDA presented in this paper was a kind of optimization algorithm based on Gaussian probability distribution. As a case study, the proposed approach was applied to establish a non-linear model between the parameters of the coal-fired boiler and the NOx emissions. The results showed that the number of cluster has significant effect on the predictive accuracy of GRNN model. GRNN model with multiple smoothing parameters showed better agreement than that with only one smoothing parameter. The modeling errors on the testing subset were 1.24% and 1.62% for GRNN models trained by the present algorithm and the standard algorithm, respectively.

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# Asynchronous Distributed Parallel Gene Expression Programming based on Estimation of Distribution Algorithm

Du, Xin Ding, Lixin Jia, Liyuan

In order to reduce the computation time and improve the quality of solutions of Gene Expression Programming (GEP), a new asynchronous distributed parallel gene expression programming based on Estimation of Distribution Algorithm (EDA) is proposed. The idea of introducing EDA into GEP is to accelerate the convergence speed. Moreover the improved GEP is implemented by an asynchronous distributed parallel method based on the island parallel model on a message passing interface (MPI) environment. Some experiments are done on distributed network connected by twenty computers. The best results of sequential and parallel algorithms are compared, speedup and performance influence of some important parallel control parameters to this parallel algorithm are discussed. The experimental results show that it may approach linear speedup and has better ability to find optimal solution and higher stability than sequential algorithm.

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# An Island Based Hybrid Evolutionary Algorithm for Optimization

Li, Changhe Yang, Shengxiang

Evolutionary computation has become an important problem Solving methodology among the Set of search and Optimization techniques. Recently, more and more different evolutionary techniques have been developed, especially hybrid evolutionary algorithms. This paper proposes an island based hybrid evolutionary algorithm (IHEA) for optimization, which is based on Particle swarm optimization (PSO), Past Evolutionary Programming (FEP) and Estimation of Distribution Algorithm (EDA). Within IHEA, an island model is designed to cooperatively search for the global optima in search space. By combining the strengths of the three component algorithms, IHEA greatly improves the optimization performance of the three basic algorithms. Experimental results demonstrate that IHEA outperforms all the three component algorithms on the test problems.

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# A Bi-level Blocked Estimation of Distribution Algorithm with Local Search for Maximum Clique Problems

Zhang, Yan Dang, Qun Jiang, Zhu Huang, YongXuan

Maximum Clique Problem (MCP) is a complicated deceptive problem for estimation of distribution algorithms (EDAs). The univariate EDAs cannot utilize the correlations of the variables and the advanced EDAs perform poor due to the expensive computational cost in building the appropriate probability models. In this paper, by utilizing the special structure of MCP, a new Bi-level Blocked Probability model (BBP) is constructed, which achieves the relationships utilizing in a bivariate probability model at the computational cost of univariate probability model. Integrating promising neighborhood search techniques, a new EDA algorithm, called Bi-level Blocked Estimation of Distribution Algorithm (BBEDA) is proposed for MCP. Comparative experiments on extensive DIMACS Benchmark instances show that the proposed BBEDA can be competitive with the evolutionary algorithm with guided mutation (the best evolutionary algorithm reported so far) in terms of solution quality and computational performance.

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# A Restart Univariate Estimation of Distribution Algorithm: Sampling under Mixed Gaussian and Levy probability Distribution

Wang, Yu Li, Bin

A univariate EDA denoted as "LSEDA-gl" for large scale global optimization (LSGO) problems is proposed in this paper. Three efficient strategies: sampling under mixed Gaussian and Levy probability distribution, Standard Deviation Control strategy and restart strategy are adopted to improve the performance of classical univariate EDA on LSGO problems. The motivation of such work is to extend EDAs to LSGO domain reasonably. Comparison among LSEDA-gl, EDA with standard deviation control strategy only (EDA-STDC) and similar EDA version "continuous univariate marginal distribution algorithm" UMDAc is carried out on classical test functions. Based on the general comparison standard, the strengths and weaknesses of the algorithms are discussed. Besides, LSEDA-gl is tested on 7 functions with 100, 500, 1000 dimensions provided in the CEC'2008 Special Session on LSGO. This work is also expected to provide a comparison result for the CEC'2008 special session.

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# FPGA Implementation of a Cellular Univariate Estimation of Distribution Algorithm and Block-Based Neural Network as an Evolvable Hardware

Jewajinda, Yutana Chongstitvatana, Prabhas

This paper presents a hardware implementation of evolvable block-based neural network (BBNN) amd a kind of EDAs called cellular compact genetic algorithm (CCGA) in FPGA. The CCGA and BBNN have cellular-like and array-like structures which are suitable for hardware implementation. The implemented hardware demonstrates the completely intrinsic online evolution in hardware without software running on microprocessors. This work contributes to the field of evolvable hardware by proposing CCGA and a layer-based architecture to an integration of BBNN and CCGA as a kind of evolvable hardware. In addition, the proposed CCGA efficiently solves the scalable issues by scaling up to the size of BBNN. The presented approach demonstrates a new kind of evolvable hardware.

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# Bio-control in Mushroom Farming using a Markov Network EDA

Wu, Yanghui McCall, John Godley, Paul Brownlee, Alexander Cairns, David Cowie, Julie

In this paper we present an application of an Estimation of Distribution Algorithm (EDA) that uses a Markov network probabilistic model. The application is to the problem of bio-control in mushroom farming, a domain which admits bang-bang-control solutions. The problem is multi-objective and uses a weighted fitness function. Previous work on this problem has applied genetic algorithms (GA) with directed intervention crossover schemes aimed at effective biocontrol at an efficient level of intervention. Here we compare these approaches with the EDA Distribution Estimation Using Markov networks (DEUMd). DEUMd constructs a probabilistic model using Markov networks. Our experiments compare the quality of solutions produced by DEUMd with the GA approaches and also reveal interesting differences in the search dynamics that have implications for algorithm design.

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# Approaches to Selection and their Effect on Fitness Modelling in an Estimation of Distribution Algorithm

Brownlee, Alexander E. I. McCall, John A. W. Zhang, Qingfu Brown, Deryck F.

Selection is one of the defining characteristics of an evolutionary algorithm, yet inherent in the selection process is the loss of some information from a population. Poor solutions may provide information about how to bias the search toward good solutions. Many Estimation of Distribution Algorithms (EDAs) use truncation selection which discards all solutions below a certain fitness, thus losing this information. Our previous work on Distribution Estimation using Markov networks (DEUM) has described an EDA which constructs a model of the fitness function; a unique feature of this approach is that because selective pressure is built into the model itself selection becomes optional. This paper outlines a series of experiments which make use of this property to examine the effects of selection on the population. We look at the impact of selecting only highly fit solutions, only poor solutions, selecting a mixture of highly fit and poor solutions, and abandoning selection altogether. We show that in some circumstances, particularly where some information about the problem is already known, selection of the fittest only is suboptimal.

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# An Estimation of Distribution Algorithm for Motif Discovery

Li, Gang Chan, Tak-Ming Leung, Kwong-Sak Lee, Kin-Hong

The problem of Transcription Factor Binding Sites identification or motif discovery is to identify the motif binding sites in the cis-regulatory regions of DNA sequences. The biological experiments are expensive and the problem is NP-hard computationally. We have proposed Estimation of Distribution Algorithm for Motif Discovery (EDAMD). We use Bayesian analysis to derive the fitness function to measure the posterior probability of a set of motif instances, which can be used to handle a variable number of motif instances in the sequences. EDAMD adopts a Gaussian distribution to model the distribution of the sets of motif instances, which is capable of capturing the bivariate correlation among the positions of motif instances. When a new Position Frequency Matrix (PFM) is generated from the Gaussian distribution, a new set of motif instances is identified based on the PFM via the Greedy Refinement operation. At the end of a generation, the Gaussian distribution is updated with the sets of motif instances. Since Greedy Refinement assumes a single motif instance on a sequence, a Post Processing operation based on the fitness function is used to find more motif instances after the evolution. The experiments have verified that EDAMD is comparable to or better than GAME and GALF on the real problems tested in this paper.

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# Discrete Quantum-Behaved Particle Swarm Optimization Based on Estimation of Distribution for Combinatorial Optimization

Wang, Jiahai Zhang, Yunong Zhou, Yalan Yin, Jian

Particle swarm optimization (PSO) is a population-based swarm intelligence algorithm. A quantum-behaved particle swarm optimization (QPSO) is also proposed by combining the classical PSO philosophy and quantum mechanics. These algorithms have been very successful in solving the global continuous optimization, but their applications to combinatorial optimization have been rather limited. Estimation of distribution algorithm (EDA) samples new solutions from a probability model which characterizes the distribution or promising solutions. This paper proposes a novel discrete QPSO based on EDA for the combinatorial optimization problem. The proposed algorithm combines global statistical information extracted by EDA with local information obtained by discrete QPSO to create promising solutions. To demonstrate the performance of the proposed algorithm, experiments are carried out on the unconstrained binary quadratic programming problem which numerous hard combinatorial optimization problems can be formulated as. The results show that the discrete QPSO based on EDA have superior performance to other algorithms.

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# Optimal Design for 2-DOF PID Controller Based on Maximum Entropy Estimation of Distribution Algorithm

Lin, Lu

Estimation of Distribution Algorithms (EDAs) is new kinds of colony evolution algorithms. It produces its new generation by constructing probability distribution model through counting excellent information of individuals of present colony EDAs first, and then sampling the model. To solve the NP-Hard question as EDAs searching optimum network structure, a new Maximum Entropy Estimation of Distribution Algorithm (MEEDA) is proposed; and the paper puts forward the MEEDA to optimize two degree of freedom PID controller parameters. The simulation results show that the optimal 2-DOF PID controller has simultaneously both the characteristics of command tracking and disturbance rejection, so we can see the simulation verifies the effectiveness of the EDA algorithm.

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