# Improving the artificial bee colony algorithm with a proprietary estimation of distribution mechanism for protein-ligand docking

Song, Shuangbao Tang, Cheng Song, Zhenyu Qu, Jia Chen, Xingqian

The protein-ligand docking problem plays an essential role in structure -based drug design. The challenge for a protein-ligand docking method is how to execute an efficient conformational search to explore a well -designed scoring function. In this study, we improved the artificial bee colony (ABC) algorithm and proposed an approach called ABC-EDM to solve the protein-ligand docking problem. ABC-EDM employs the scoring function of the classical AutoDock Vina to evaluate a solution during docking simulation. ABCEDM adopts the search framework of the canonical ABC algorithm to execute conformational search. By further investigating the characteristics of the protein-ligand docking problem, a proprietary search mechanism inspired by estimation of distribution algorithm, i.e., estimation of distribution mechanism (EDM), is designed to enhance the performance of ABC-EDM. To verify the effectiveness of the proposed ABC-EDM, we compare it with three variants of the ABC algorithm, three evolutionary computation algorithms, and AutoDock Vina. The experimental results show that ABC-EDM can effectively solve the protein-ligand docking problem, and it can achieve a success rate 5% higher than AutoDock Vina on the GOLD dataset. This study reveals that taking advantage of problem -specific information about the protein-ligand docking problem to enhance a docking method contributes to solving this problem.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001241590400001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# A knowledge-guided Estimation of Distribution Algorithm for energy-efficient Joint Robotic Assembly Line Balancing and Feeding Problem

Wu, Chu-ge Zhang, Ruochen Xia, Yuanqing

The assembly line serves as a fundamental system in discrete production. To address the challenges in balancing robotic assembly lines, timely part feeding, and the need for sustainable manufacturing, this paper studies an energy -efficient Joint Robotic Assembly Line Balancing and Feeding Problem (JRALB-FP) with the criteria of minimizing both cycle time and total fuel consumption cost. Considering the complexity of the multi -problem and multi -objective optimization, a knowledge -guided Estimation of Distribution Algorithm (KEDA) is proposed to solve energy -efficient JRALB-FP. First, a probability model of EDA for task -workstation allocation paired with a heuristic method -based sampling mechanism is created. Using this probability model, a specific encoding mechanism is designed for part -trailer allocation, and good initial solutions are produced. Second, several properties of the bi-objective problem are analyzed to guide the design of local search operators for both objectives optimization. Third, the updating mechanism of the probability model is designed to learn from the elite solutions. Fourth, two knowledge -guided local search operators are designed and implemented to exploit better non -dominated solutions sufficiently. A design of experiment is carried out to determine the parameters. Extensive computational tests and comparisons with the state-of-the-art multi -objective algorithms are carried out, which verify the effectiveness of the knowledge -guided local search operators, the problem -oriented heuristic -based sampling mechanism, and the special designs of the KEDA in solving the energy -efficient JRALB-FP.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001236832400001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# A hybrid estimation of distribution algorithm for solving assembly flexible job shop scheduling in a distributed environment

Du, Baigang Han, Shuai Guo, Jun Li, Yibing

This paper proposes a novel distributed assembly flexible job shop scheduling problem (DAFJSP), which involves three stages: production stage, assembly stage, and delivery stage. The production stage is accomplished in a few flexible job shops, the assembly stage is accomplished in a few single -machine factories, and the delivery stage is to deliver the obtained products to the corresponding customers. To address the problem, a hybrid estimation of distribution algorithm based on differential evolution operator and variable neighborhood search (HEDA-DEV) is proposed with the goal of minimizing the total cost and tardiness. Firstly, a new multidimensional coding method is designed based on the features of the DAFJSP. Secondly, two mutation operators and the similarity coefficient based on the probability matrix are put forward to implement the dynamic mutation. Thirdly, five types of neighborhood structures satisfying cooperative search strategies are employed to adequately improve the local exploitation ability. Finally, the comparison experiment results suggest that the proposed HEDA-DEV has competitive performance compared to the selected efficient algorithms. Moreover, a real case study is used to demonstrate that HEDA-DEV is an effective method for solving DAFJSP.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001235489000001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# An enhanced estimation of distribution algorithm with problem-specific knowledge for distributed no-wait flowshop group scheduling problems

Zhang, Zi-Qi Xu, Yan-Xuan Qian, Bin Hu, Rong Wu, Fang-Chun Wang, Ling

With the trend of economic globalization, distributed manufacturing widely exists in modern manufacturing systems. As an extension of the distributed flowshop scheduling problem, the distributed no -wait flowshop group scheduling problem with sequence -dependent setup times (DNFGSP\_SDSTs) is investigated in this article. To address DNFGSP\_SDSTs with the criterion of minimizing makespan, this study proposes an enhanced estimation of distribution algorithm &amp; sdot;(EEDA) with problem -specific knowledge. First, a mixed integer linear programming (MILP) model of DNFGSP\_SDSTs is established. Second, based on the characteristics of DNFGSP\_SDSTs, five problem -specific properties about local search operators are derived as prior knowledge to reduce computational cost. Third, two NEH-based two -stage heuristics are presented to construct a high -quality population with diversity. Fourth, a probability model with problem -specific knowledge and a family -based updating mechanism are developed to accumulate valuable pattern information from high -quality solutions, while a sampling strategy is designed to generate new populations with the accumulated information. Fifth, several local search operators are devised to refine the obtained solutions. Furthermore, perturbation and reinitialization methods are developed to avoid premature convergence. Finally, the validity of the MILP model is verified by using the Gurobi solver. The parameters of EEDA are tuned through a design of experiments. The effectiveness of key components in EEDA is confirmed through extensive experiments, and the computational comparisons with the state-of-theart algorithms indicate the effectiveness of the proposed EEDA for solving DNFGSP\_SDSTs.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001231623600001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Improving the estimation of distribution algorithm with a differential mutation for multilevel thresholding image segmentation

Ramos-Frutos, Jorge Armando Miguel-Andres, Israel Oliva, Diego Casas-Ordaz, Angel

Image segmentation consists of separating an image into regions that are entirely different from each other, and multilevel thresholding is a method used to perform this task. This article proposes an Estimation of Distribution Algorithms (EDA) combined with a Differential Evolution (DE) operator as a metaheuristic to solve the multilevel thresholding problem. The proposal is called the Differential Mutation Estimation of Distribution Algorithm (DMEDA), where the inclusion of the Differential Mutation increases the standard EDA's exploration capacity. The performance of the DMEDA for image segmentation is tested using Otsu's between-class variance and Kapur's entropy as objective functions applied separately over the Berkeley Segmentation Data Set 300 (BSDS300). Besides, a comparative study includes eight well-known algorithms in the literature. In this sense, statistical and non-parametric tests are performed to verify the efficiency of the DMEDA in solving the image segmentation problem from an optimization perspective. In terms of segmentation, different metrics are employed to verify the capabilities of the DMEDA to segment digital images properly. Regarding the two objective functions, the proposed DMEDA obtains better results in 97% of the experiments for Otsu's between-class variance and 85% for Kapur's entropy.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001217374900001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Maximizing Net Present Value for Resource Constraint Project Scheduling Problems with Payments at Event Occurrences Using Approximate Dynamic Programming

Phuntsho, Tshewang Gonsalves, Tad

Resource Constraint Project Scheduling Problems with Discounted Cash Flows (RCPSPDC) focuses on maximizing the net present value by summing the discounted cash flows of project activities. An extension of this problem is the Payment at Event Occurrences (PEO) scheme, where the client makes multiple payments to the contractor upon completion of predefined activities, with additional final settlement at project completion. Numerous approximation methods such as metaheuristics have been proposed to solve this NP-hard problem. However, these methods suffer from parameter control and/or the computational cost of correcting infeasible solutions. Alternatively, approximate dynamic programming (ADP) sequentially generates a schedule based on strategies computed via Monte Carlo (MC) simulations. This saves the computations required for solution corrections, but its performance is highly dependent on its strategy. In this study, we propose the hybridization of ADP with three different metaheuristics to take advantage of their combined strengths, resulting in six different models. The Estimation of Distribution Algorithm (EDA) and Ant Colony Optimization (ACO) were used to recommend policies for ADP. A Discrete cCuckoo Search (DCS) further improved the schedules generated by ADP. Our experimental analysis performed on the j30, j60, and j90 datasets of PSPLIB has shown that ADP-DCS is better than ADP alone. Implementing the EDA and ACO as prioritization strategies for Monte Carlo simulations greatly improved the solutions with high statistical significance. In addition, models with the EDA showed better performance than those with ACO and random priority, especially when the number of events increased.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001233477700001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# A novel differential evolution algorithm with multi-population and elites regeneration

Cao, Yang Luan, Jingzheng

Differential Evolution (DE) is widely recognized as a highly effective evolutionary algorithm for global optimization. It has proven its efficacy in tackling diverse problems across various fields and real-world applications. DE boasts several advantages, such as ease of implementation, reliability, speed, and adaptability. However, DE does have certain limitations, such as suboptimal solution exploitation and challenging parameter tuning. To address these challenges, this research paper introduces a novel algorithm called Enhanced Binary JADE (EBJADE), which combines differential evolution with multi-population and elites regeneration. The primary innovation of this paper lies in the introduction of strategy with enhanced exploitation capabilities. This strategy is based on utilizing the sorting of three vectors from the current generation to perturb the target vector. By introducing directional differences, guiding the search towards improved solutions. Additionally, this study adopts a multi-population method with a rewarding subpopulation to dynamically adjust the allocation of two different mutation strategies. Finally, the paper incorporates the sampling concept of elite individuals from the Estimation of Distribution Algorithm (EDA) to regenerate new solutions through the selection process in DE. Experimental results, using the CEC2014 benchmark tests, demonstrate the strong competitiveness and superior performance of the proposed algorithm.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001216879200008&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Online Ecological Energy Management for Plug-In HEVs Using Optimal SOC Prediction and Stochastic Optimization

Lim, Hansang

Optimizing power demand and distribution in real time is the primary challenge in the energy management of plug-in hybrid electric vehicles. To address this challenge, this study proposes an online ecological energy management strategy using the optimal state of charge (SOC) prediction and stochastic optimization. Future energy-consumption features at each location are computed from the traffic and route information of the entire remaining trip and the optimal SOC value at the next location is predicted from the computed features using a recurrent neural network. By considering the predicted optimal SOC and average speed as references, the speed and SOC values at the next location are optimized using a modified estimation of distribution algorithm (EDA). The process of generating initial and new populations in EDA is modified for fast and reliable convergence. The optimal SOC prediction considering the energy consumption for the entire remaining trip from the current to final locations ensures long-term optimality. Stochastic aspects of the modified EDA can compensate for potential neural-network errors. The prediction and optimization of driving only up to the next location enables to adapt to the changes in traffic conditions. Moreover, the energy efficiency is further improved by optimizing power demand based on the characteristics of the drivetrain, as well as traffic and route conditions. Because the traffic and route information are provided on a location basis, management is performed in a distance domain. The proposed management strategy is evaluated in diverse driving scenarios, and it exhibits good performance, comparable to that of the offline optimization.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001201960700001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Test Data Generation for Mutation Testing Based on Markov Chain Usage Model and Estimation of Distribution Algorithm

Wei, Changqing Yao, Xiangjuan Gong, Dunwei Liu, Huai

Mutation testing, a mainstream fault-based software testing technique, can mimic a wide variety of software faults by seeding them into the target program and resulting in the so-called mutants. Test data generated in mutation testing should be able to kill as many mutants as possible, hence guaranteeing a high fault-detection effectiveness of testing. Nevertheless, the test data generation can be very expensive, because mutation testing normally involves an extremely large number of mutants and some mutants are hard to kill. It is thus a critical yet challenging job to find an efficient way to generate a small set of test data that are able to kill multiple mutants at the same time as well as reveal those hard-to-detect faults. In this paper, we propose a new approach for test data generation in mutation testing, through the novel applications of the Markov chain usage model and the estimation of distribution algorithm. We first utilize the Markov chain usage model to reduce the so-called mutant branches in weak mutation testing and generate a minimal set of extended paths. Then, we regard the problem of generating test data as the problem of covering extended paths and use an estimation of distribution algorithm based on probability model to solve the problem. Finally, we develop a framework, TAMMEA, to implement the new approach of generating test data for mutation testing. The empirical studies based on fifteen object programs show that TAMMEA can kill more mutants using fewer test data compared with baseline techniques. In addition, the computation overhead of TAMMEA is lower than that of the baseline technique based on the traditional genetic algorithm, and comparable to that of the random method. It is clear that the new approach improves both the effectiveness and efficiency of mutation testing, thus promoting its practicability.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001188302300003&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Shared manufacturing-based distributed flexible job shop scheduling with supply-demand matching

Wei, Guangyan Ye, Chunming Xu, Jianning

Shared Manufacturing (sharedMfg) is a peer-to-peer (P2P) paradigm for sharing manufacturing resources, derived from the sharing economy. In sharedMfg, manufacturing service resources are integrated into a large set with defined service types. Based on its resource organization structure, we build a model for the shared manufacturing-based distributed flexible job shop scheduling problem (SM-DFJSP) with supply-demand matching. The goal is to minimize both the total cost and the makespan. The SM-DFJSP model enables the scheduling of jobs requiring different manufacturing services across distributed, heterogeneous, and flexible service resource units (SRUs) with diverse manufacturing functions. To solve the SM-DFJSP, we propose a hybrid estimation of distribution algorithm and Tabu search (EDA-TS), including EDA and TS components. Additionally, a multi-populations strategy and non-dominated solutions memory mechanism are designed to improve the exploration ability of the algorithm. Within the EDA component, three probability distribution models and some dispatching rules are designed to generate a new population. In the TS component, three neighborhood search structures are built that adopt hybrid short and long memory tabu strategy. Finally, comparison and ablation experiments on 25 instances demonstrate the superior performance of the EDA-TS algorithm in solving the SM-DFJSP, highlighting the effectiveness of the multi-population strategy and non-dominated solutions memory mechanism.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001181562300001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# An enhanced Kalman filtering and historical learning mechanism driven estimation of distribution algorithm

Zhu, Ningning Zhao, Fuqing Wang, Ling Dong, Chenxin

As a representative evolutionary algorithm based on probabilistic models, the estimation of distribution algorithm (EDA) is widely applied in complex continuous optimization problems based on remarkable characteristics of modeling with macro-dominant information. However, the success of EDA depends on the quality of dominant solutions, modeling, sampling methods, and the efficiency of searching. An enhanced Kalman filtering and historical learning mechanism-driven EDA (KFHLEDA) is proposed to adjust the search direction and enlarge the search range of classical EDA in this paper. The enhanced Kalman filtering is designed in allusion to specific problems during the search through the prediction, observation, and the first and second revision stages. A historical archive is integrated into KFHLEDA to store the elite individuals with specific knowledge and diverse solutions from Kalman filtering. The elite strategy is embedded in the revision improvement matrix to revise modeling data, which is fed back to the probabilistic model through the historical learning mechanism with previous promising solutions to estimate the covariance matrix. The population adaptive adjustment strategy is introduced to reduce the number of invalid iterations. The effectiveness of the proposed KFHLEDA is proved through theoretical analysis. The evaluation results on benchmark functions of the CEC 2017 test suit validate that the KFHLEDA is efficient and competitive compared with fifteen classical metaheuristic algorithms and state-of-the-art EDA variants.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001181725600001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# A coevolutionary estimation of distribution algorithm based on dynamic differential grouping for mixed-variable optimization problems

Huang, Shijia Wang, Zhe Ge, Yang Wang, Feng

The mixed variable optimization problems (MVOPs), which involves both continuous and discrete decision variables, are difficult to be solved due to the complex search space. Recently, many EA-based algorithms have been designed to address MVOPs. However, due to the mixed variables with different evolutionary operators and complex search space, it is difficult to handle the mixed variables effectively and the search efficiency cannot be guaranteed. How to solve MVOPs efficiently has been a challengeable issue. In this paper, we propose a mixed-variable optimization algorithm called coevolutionary estimation of distribution algorithm (CoEDAmv). First, a dynamic differential grouping (DDG) method is employed to improve the search efficiency of CoEDAmv, in which both the interaction of variables and search performance on the current search region are considered simultaneously. Second, two probabilistic models, i.e. fitness rank based continuous histogram (FRCH) and fitness rank based discrete histogram (FRDH), are proposed to handle continuous and discrete variables respectively, which can benefit from elite individuals obtained during the fitness ranking strategy and enhance the convergence performance with the elite neighborhood-based updating probability strategy. Compared with eight state -of -the -art algorithms, the experimental results on 28 artificial MVOPs show that CoEDAmv is effective and efficient.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001152737000001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Efficient Surrogate Model Assisted Estimation of Distribution Algorithm for Expensive Optimization

Shang, Jin Li, Guiying Hao, Hao Zhang, Yufang

In recent years, several surrogate assisted evolutionary algorithms (SAEAs) have been proposed to solve expensive optimization problems. These problems lack explicit expressions and are characterized by high invocation costs. SAEAs leverage surrogate models to accelerate convergence towards the optimal region and reduce the number of function evaluations. While Gaussian Processes (GPs) are widely used due to their robustness and capability of providing uncertainty estimates, their applicability becomes limited in scenarios involving a large number of samples or high-dimensional spaces. This is due to their cubic time complexity in relation to the number of samples, which results in prohibitive computational demands for large-scale problems. To address the challenge, this work presents an efficient surrogate model-assisted estimation of the distribution algorithm (ESAEDA). This method employs a random forest as a surrogate model and combines it with a GP-hedge acquisition strategy to ensure the efficiency and accuracy of model-assisted selection. An improved EDA model called the variable-width histogram model with some unevaluated solutions is used to generate new solutions. To demonstrate the benefits of the proposed method, we compared ESAEDA with several state-of-the-art surrogate-assisted evaluation algorithms and the Bayesian optimization method. Experimental results demonstrate the superiority of the proposed algorithm over these comparison algorithms for two well-known test suites.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001242890700001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Distortion Tolerant Method for Fiber Bragg Grating Sensor Network Using Estimation of Distribution Algorithm and Convolutional Neural Network

Luo, Yuemei Huang, Chenxi Lin, Chaohui Li, Yuan Chen, Jing Miao, Xiren Jiang, Hao

In this article, we proposed a distortion-tolerant method for fiber Bragg grating (FBG) sensor networks based on the estimation of distribution algorithm (EDA) and convolutional neural network (CNN). Addressing the parameter reconstruction of the reflection spectrum, an objective function is formulated to pinpoint the Bragg wavelength detection problem, with the optimal solution acquired via EDA. By incorporating spectral distortion into the objective function, the EDA-based method effectively manages distorted spectrums, ensuring the fidelity of wavelength data. Further, CNN aids in extracting features from the entire FBG sensor network's wavelength information, facilitating the creation of the localization model. By sending the reliable wavelength data obtained by EDA to the trained model, swift identification of the load position is achieved. Testing revealed that under conditions of spectral distortion, EDA can adeptly detect the Bragg wavelength. Additionally, the CNN-trained localization model outperforms other machine-learning techniques. Notably, experimental results demonstrate that the proposed EDA surpasses the second-ranked method, i.e., the maximum method, achieving a root mean square error (RMSE) of merely 1.4503 mm which is substantially lower than the 6.2463 mm achieved by the maximum method. The average localization error remains under 2 mm when 5 out of 9 FBGs' reflection spectra are distorted. Furthermore, Bragg wavelength detection error stays below 1 pm amid spectral distortion. Consequently, our method offers promising application prospects for long-term FBG sensor network monitoring, ensuring high accuracy and robustness in detecting structural damage.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001230668400010&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Bayesian Network-Based Multi-objective Estimation of Distribution Algorithm for Feature Selection Tailored to Regression Problems

Lopez, Jose A. Morales-Osorio, Felipe Lara, Maximiliano Velasco, Jonas Sanchez, Claudia N.

Feature selection is an essential pre-processing step in Machine Learning for improving the performance of models, reducing the time of predictions, and, more importantly, identifying the most significant features. Sometimes, this identification can reduce the time and cost of obtaining feature values because it could imply buying fewer sensors or spending less human time. This paper proposes an Estimation of Distribution Algorithm (EDA) for feature selection tailored to regression problems with a multi-objective approach. The objective is to maximize the performance of learning models and minimize the number of selected features. We use a Bayesian Network (BN) as the EDA distribution probability model. The main contribution of this work is the process used to create this BN structure. It aims to capture the redundancy and relevance among features. Also, the BN is used to create the initial EDA population. We test and compare the performance of our proposal with other multi-objective algorithms: an EDA with a Bernoulli distribution probability model, NSGA II, and AGEMOEA, using different datasets. The experimental results show that the proposed algorithm found solutions with a considerably fewer number of features. Additionally, the proposed algorithm achieves comparable results on models' performance compared with the other algorithms. Our proposal generally expended less time and had fewer objective function evaluations.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001150274100023&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Maximal coverage problems with routing constraints using cross-entropy Monte Carlo tree search

Lin, Pao-Te Tseng, Kuo-Shih

Spatial search, and environmental monitoring are key technologies in robotics. These problems can be reformulated as maximal coverage problems with routing constraints, which are NP-hard problems. The generalized cost-benefit algorithm (GCB) can solve these problems with theoretical guarantees. To achieve better performance, evolutionary algorithms (EA) boost its performance via more samples. However, it is hard to know the terminal conditions of EA to outperform GCB. To solve these problems with theoretical guarantees and terminal conditions, in this research, the cross-entropy based Monte Carlo Tree Search algorithm (CE-MCTS) is proposed. It consists of three parts: the EA for sampling the branches, the upper confidence bound policy for selections, and the estimation of distribution algorithm for simulations. The experiments demonstrate that the CE-MCTS outperforms benchmark approaches (e.g., GCB, EAMC) in spatial search problems.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001150930500001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Scheduling optimization of underground mine trackless transportation based on improved estimation of distribution algorithm

Li, Ning Wu, Yahui Ye, Haiwang Wang, Liguan Wang, Qizhou Jia, Mingtao

The trend in underground mine development is trackless transportation, and the scheduling optimization of underground mine trackless transportation is a current research hotspot. This paper proposes a truck scheduling optimization method for underground mine trackless transportation based on an improved estimation of distribution algorithm to address the truck scheduling problem in the underground mine trackless transportation process. The transportation process of transport trucks in underground mines is analyzed. The dispatching model of transport trucks in underground mines is constructed based on the requirements of reducing transportation costs and increasing transportation efficiencies, taking into account the truck meeting situation in the ramp section and minimizing the total shift transportation distance and the total waiting time of transport trucks as the objective functions. The improved estimation of distribution algorithm is used to solve the truck scheduling model, resulting in the optimal ore blending and scheduling schemes. The comparative analysis employs a genetic algorithm, particle swarm optimization algorithm, and immune algorithm. The results demonstrate that, compared to other algorithms, the improved estimation of distribution algorithm proposed in this paper has superior performance in terms of convergence speed and the search for the optimal solution. The total number of transportation tasks associated with the optimal ore allocation scheme is at least 82, and the waiting time associated with the optimal scheduling scheme is reduced to 7.5 min. The operation time chart of transport trucks calculated by the optimal dispatching scheme can clearly depict the location of each transport truck at any time during a shift's working time, which has significant guiding significance for the actual truck transportation in the mine.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001155973100001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# A Reinforcement-Learning-Based 3-D Estimation of Distribution Algorithm for Fuzzy Distributed Hybrid Flow-Shop Scheduling Considering On-Time-Delivery

Deng, Libao Di, Yuanzhu Wang, Ling

With the increasing level of mass-customization and globalization of competition, environmentally friendly production scheduling for distributed manufacturing considering customer satisfaction has received growing attention. Meanwhile, uncertain scheduling is becoming a force to be considered within intelligent manufacturing industries. However, little research has been found that surveyed the uncertain distributed scheduling considering both energy consumption and customer satisfaction. In this article, the fuzzy distributed hybrid flow-shop scheduling problem considering on-time delivery (FDHFSP-OTD) is addressed, and a 3-D estimation of distribution algorithm (EDA) with reinforcement learning (RL) is proposed to minimize the makespan and total energy consumption while maximizing delivery accuracy. First, two heuristics and a random method are designed and used cooperatively for initialization. Next, an EDA with a 3-D probability matrix is innovated to generate offspring. Then, a biased decoding method based on Q-learning is proposed to adjust the direction of evolution self-adaptively. Moreover, a local intensification strategy is employed for further enhancement of elite solutions. The effect of major parameters is analyzed and the best combination of values is determined through extensive experiments. The numerical results prove the effectiveness of each specially designed strategy and method, and the comparisons with existing algorithms demonstrate the high-potential of the 3D-EDA/RL in solving the FDHFSP-OTD.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001129721600001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Choosing the right algorithm with hints from complexity theory

Wang, Shouda Zheng, Weijie Doerr, Benjamin

Choosing a suitable algorithm from the myriads of different search heuristics is difficult when faced with a novel optimization problem. In this work, we argue that the purely academic question of what could be the best possible algorithm in a certain broad class of black-box optimizers can give fruitful indications in which direction to search for good established heuristics. We demonstrate this approach on the recently proposed DLB benchmark. Our finding that the unary unbiased black-box complexity is only O (n2) suggests the Metropolis algorithm as an interesting candidate and we prove that it solves the DLB problem in quadratic time. We also prove that better runtimes cannot be obtained in the class of unary unbiased algorithms. We therefore shift our attention to algorithms that use the information of more parents to generate new solutions and find that the significance-based compact genetic algorithm can solve the DLB problem in time O (n log n).(c) 2023 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons .org /licenses /by-nc -nd /4 .0/).

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001129841200001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# An Estimation of Distribution Algorithm With Resampling and Local Improvement for an Operation Optimization Problem in Steelmaking Process

Tang, Lixin Liu, Chang Liu, Jiyin Wang, Xianpeng

This article studies an operation optimization problem in a steelmaking process. Shortly before the tapping of molten steel from the basic oxygen furnace (BOF), end-point control measures are applied to achieve the required final molten steel quality. While it is difficult to build an exact mathematical model for this process, the control inputs and the corresponding outputs are available by collecting production data. We build a data-driven model for the process. To optimize the control parameters, an improved estimation of distribution algorithm (EDA) is developed using a probabilistic model comprising different distributions. A resampling mechanism is incorporated into the EDA to guide the new population to a broader and more promising area when the search becomes ineffective. To further enhance the solution quality, we add a local improvement to update the current best individual through simplified gravitational search and information learning. Experiments are conducted using real data from a BOF steelmaking process. The results show that the algorithm can help to achieve the specified molten steel quality. To evaluate the proposed algorithm as a general optimization algorithm, we test it on some complex benchmark functions. The results illustrate that it outperforms other state-of-the-art algorithms across a wide range of problems.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001078412000001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# An improved estimation of distribution algorithm for rescue task emergency scheduling considering stochastic deterioration of the injured

Xu, Ying Li, Xiaobo Li, Qian Zhang, Weipeng

Efficient allocating and scheduling emergency rescue tasks are a primary issue for emergency management. This paper considers emergency scheduling of rescue tasks under stochastic deterioration of the injured. First, a mathematical model is established to minimize the average mathematical expectation of all tasks' completion time and casualty loss. Second, an improved multi-objective estimation of distribution algorithm (IMEDA) is proposed to solve this problem. In the IMDEA, an effective initialization strategy is designed for obtaining a superior population. Then, three statistical models are constructed, which include two tasks existing in the same rescue team, the probability of first task being processed by a rescue team, and the adjacency between two tasks. Afterward, an improved sampling method based on referenced sequence is employed to efficiently generate offspring population. Three multi-objective local search methods are presented to improve the exploitation in promising areas around elite individuals. Furthermore, the parameter calibration and effectiveness of components of IMEDA are tested through experiments. Finally, the comprehensive comparison with state-of-the-art multi-objective algorithms demonstrates that IMEDA is a high-performing approach for the considered problem.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001035544000005&DestLinkType=FullRecord&DestApp=WOS_CPL)

# A hybrid estimation of distribution algorithm for the offline 2D variable-sized bin packing problem

Borgulya, Istvan

In this paper we present an evolutionary heuristic for the offline two-dimensional variable-sized bin packing problem. In this problem we have to pack a set of rectangles into two-dimensional variable-sized rectangular bins. The bins are divided into types, and the bins in different types have different sizes and possibly different weights (costs). There are (sufficiently) many bins from each type, and any rectangle fits into at least one bin-type. The goal is to pack the rectangles into the bins without overlap, parallel to the sides, so that the total area of the used bins (or total cost) is minimized. Our algorithm is a hybrid heuristic. It uses two different techniques to generate the descendants: either estimation of distribution algorithm and sampling the resulting probability model, or applying the usual operators of evolutionary algorithms (selection, mutation). To pack the rectangles into the bins the algorithm uses the strategy of randomly choosing one of two placement heuristics, that pack always only one group (one to three) of rectangles. It improves the quality of the solutions with three local search procedures. The algorithm has been tested on benchmark instances from the literature and has been compared with other heuristics and metaheuristics. Our algorithm outperformed the previously published results.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:001002493900001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Knowledge-based multi-objective estimation of distribution algorithm for solving reliability constrained cloud workflow scheduling

Li, Ming Pi, Dechang Qin, Shuo

With the rapid development of cloud computing, numerous large-scale workflow are executed in the cloud environment. Therefore, the workflow scheduling in cloud environment has become an emerging topic. This paper focuses on a reliability constrained multi-objective workflow scheduling problem (RCMOWSP) with the objectives of minimum execution cost and time. To solve the RCMOWSP, this paper proposes a knowledge-based multi-objective estimation of distribution algorithm (KMOEDA) with several problem-specific operators. First, an idle time-based decoding scheme is applied to sort the permutation of tasks greedily. In the global search strategy, a probability model is constructed to improve the diversity of population. Based on the problem-specific knowledge, a reliability-aware local search strategy is designed to performs local search around the solutions that violate reliability constraint. An elite enhancement strategy with a task perturbation operator and a resource perturbation operator is introduced to further improve the elite non-dominated solutions in the external archive. A comprehensive experiment is conducted to verify the performance of KMOEDA. The comparative results show that the KMOEDA significantly outperforms several relative multi-objective workflow scheduling approaches in solving the RCMOWSP.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:000986472800001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# A roadmap for solving optimization problems with estimation of distribution algorithms

Ceberio, Josu Mendiburu, Alexander Lozano, Jose A.

In recent decades, Estimation of Distribution Algorithms (EDAs) have gained much popularity in the evolutionary computation community for solving optimization problems. Characterized by the use of probabilistic models to represent the solutions and the interactions between the variables of the problem, EDAs can be applied to either discrete, continuous or mixed domain problems. Due to this robustness, these algorithms have been used to solve a diverse set of real-world and academic optimization problems. However, a straightforward application is only limited to a few cases, and for the general case, an efficient application requires intuition from the problem as well as notable understanding in probabilistic modeling. In this paper, we provide a roadmap for solving optimization problems via EDAs. It is not the aim of the paper to provide a thorough review of EDAs, but to present a guide for those practitioners interested in using the potential of EDAs when solving optimization problems. In order to present a roadmap which is as useful as possible, we address the key aspects involved in the design and application of EDAs, in a sequence of stages: (1) the choice of the codification, (2) the choice of the probability model, (3) strategies to incorporate knowledge about the problem to the model, and (4) balancing the diversification-intensification behavior of the EDA. At each stage, first, the contents are presented together with common practices and advice to follow. Then, an illustration is given with an example which shows different alternatives. In addition to the roadmap, the paper presents current open challenges when developing EDAs, and revises paths for future research advances in the context of EDAs.

[Paper](https://www.webofscience.com/api/gateway?GWVersion=2&SrcApp=edas&SrcAuth=WosAPI&KeyUT=WOS:000850379900001&DestLinkType=FullRecord&DestApp=WOS_CPL)

# Trainability maximization using estimation of distribution algorithms assisted by surrogate modelling for quantum architecture search

Soloviev, Vicente P. Dunjko, Vedran Bielza, Concha Larrañaga, Pedro Wang, Hao

Quantum architecture search (QAS) involves optimizing both the quantum parametric circuit configuration but also its parameters for a variational quantum algorithm. Thus, the problem is known to be multi-level as the performance of a given architecture is unknown until its parameters are tuned using classical routines. Moreover, the task becomes even more complicated since well-known trainability issues, e.g., barren plateaus (BPs), can occur. In this paper, we aim to achieve two improvements in QAS: (1) to reduce the number of measurements by an online surrogate model of the evaluation process that aggressively discards architectures of poor performance; (2) to avoid training the circuits when BPs are present. To detect the presence of the BPs, we employed a recently developed metric, information content, which only requires measuring the energy values of a small set of parameters to estimate the magnitude of cost function's gradient. The main idea of this proposal is to leverage a recently developed metric which can be used to detect the onset of vanishing gradients to ensure the overall search avoids such unfavorable regions. We experimentally validate our proposal for the variational quantum eigensolver and showcase that our algorithm is able to find solutions that have been previously proposed in the literature for the Hamiltonians; but also to outperform the state of the art when initializing the method from the set of architectures proposed in the literature. The results suggest that the proposed methodology could be used in environments where it is desired to improve the trainability of known architectures while maintaining good performance.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:001337417700002)

The Compact Genetic Algorithm Struggles on Cliff Functions

Neumann, Frank Sudholt, Dirk Witt, Carsten

The compact genetic algorithm (cGA) is a non-elitist estimation of distribution algorithm which has shown to be able to deal with difficult multimodal fitness landscapes that are hard to solve by elitist algorithms. In this paper, we investigate the cGA on the Cliff function for which it has been shown recently that non-elitist evolutionary algorithms and artificial immune systems optimize it in expected polynomial time. We point out that the cGA faces major difficulties when solving the Cliff function and investigate its dynamics both experimentally and theoretically around the Cliff. Our experimental results indicate that the cGA requires exponential time for all values of the update strength... We show theoretically that, under sensible assumptions, there is a negative drift when sampling around the location of the cliff. Experiments further suggest that there is a phase transition for.. where the expected optimization time drops from n Theta((n)) to 2 Theta((n)).

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000847380200161)

Semiparametric Estimation of Distribution Algorithms for Continuous Optimization

Soloviev, Vicente P. Bielza, Concha Larranaga, Pedro

Traditional estimation of distribution algorithms (EDAs) often use Gaussian densities to optimize continuous functions, such as the estimation of Gaussian network algorithms (EGNAs) which use Gaussian Bayesian networks (GBNs). However, this assumes a parametric density function, and, in GBNs, linear dependencies between variables. Furthermore, the EGNA baseline learns a GBN at each iteration based on the best individuals in the last iteration, which may lead to local optimum convergence or large variance between solutions across multiple independent runs of the algorithm. In this work, we propose a semiparametric EDA in which the restriction of assuming Gaussianity in the variables is relaxed using semiparametric Bayesian networks (SPBNs), in which nodes estimated by kernels coexist with nodes that assume Gaussianity, and the algorithm itself is able to determine where to use each type of node. Additionally, our approach takes into account information from several past iterations to learn the SPBN from which the new solutions are sampled in each iteration. The empirical results show that semiparametric EDAs are a useful tool for continuous scenarios compared to different kinds of EDAs and other optimization techniques in continuous environments.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:001283906100008)

Parameterless Gene-pool Optimal Mixing Evolutionary Algorithms

Dushatskiy, Arkadiy Virgolin, Marco Bouter, Anton Thierens, Dirk Bosman, Peter A. N.

When it comes to solving optimization problems with evolutionary algorithms (EAs) in a reliable and scalable manner, detecting and exploiting linkage information, that is, dependencies between variables, can be key. In this paper, we present the latest version of, and propose substantial enhancements to, the gene-pool optimal mixing evolutionary algorithm (GOMEA): an EA explicitly designed to estimate and exploit linkage information. We begin by performing a large-scale search over several GOMEA design choices to understand what matters most and obtain a generally best-performing version of the algorithm. Next, we introduce a novel version of GOMEA, called CGOMEA, where linkage-based variation is further improved by filtering solution mating based on conditional dependencies. We compare our latest version of GOMEA, the newly introduced CGOMEA, and another contending linkage-aware EA, DSMGA-II, in an extensive experimental evaluation, involving a benchmark set of nine black-box problems that can be solved efficiently only if their inherent dependency structure is unveiled and exploited. Finally, in an attempt to make EAs more usable and resilient to parameter choices, we investigate the performance of different automatic population management schemes for GOMEA and CGOMEA, de facto making the EAs parameterless. Our results show that GOMEA and CGOMEA significantly outperform the original GOMEA and DSMGA-II on most problems, setting a new state of the art for the field

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:001368000000001)

Minimum-Fuel Low-Thrust Trajectory Optimization via a Direct Adaptive Evolutionary Approach

Shirazi, Abolfazl

Space missions with low-thrust propulsion systems are of appreciable interest to space agencies because of their practicality due to higher specific impulses. This research proposes a technique to the solution of minimum-fuel noncoplanar orbit transfer problem. A direct adaptive method via fitness landscape analysis (FLA) is coupled with a constrained evolutionary technique to explore the solution space for designing low-thrust orbit transfer trajectories. Taking advantage of the solution for multi-impulse orbit transfer problem, and parameterization of thrust vector, the orbital maneuver is transformed into a constrained continuous optimization problem. A constrained estimation of distribution algorithms (EDA) is utilized to discover optimal transfer trajectories, while maintaining feasibility of the solutions. The low-thrust trajectory optimization problem is characterized via three parameters, referred to as problem identifiers, and the dispersion metric is utilized for analyzing the complexity of the solution domain. Two adaptive operators including the kernel density and outlier detection distance threshold within the framework of the employed EDA are developed, which work based on the landscape feature of the orbit transfer problem. Simulations are proposed to validate the efficacy of the proposed methodology in comparison with the nonadaptive approach. Results indicate that the adaptive approach possesses more feasibility ratio and higher optimality of the obtained solutions.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:001233499100061)

Maximizing Nash Social Welfare Based on Greedy Algorithm and Estimation of Distribution Algorithm

Liao, Weizhi Jin, Youzhen Wang, Zijia Wang, Xue Xia, Xiaoyun

The Nash social welfare (NSW) problem is relevant not only to the economic domain but also extends its applicability to the field of computer science. However, maximizing Nash social welfare is an APX-hard problem. In this study, we propose two approaches to enhance the maximization of Nash social welfare. First, a general greedy algorithm (GA) capable of addressing the Nash social welfare problem for both agents with identical and differing valuations was presented. It is proven that the proposed algorithm aligns with the previous greedy algorithm when all agents possess identical valuations. Second, an innovative method for solving the Nash social welfare problems using evolutionary algorithms was developed. This approach integrates the Estimation of Distribution Algorithms (EDAs) with neighborhood search techniques to improve the maximization process of Nash social welfare. Finally, the proposed algorithms were implemented across a range of instances with the objective of maximizing Nash social welfare. The experimental results indicate that the approximation solutions derived from the Estimation of Distribution Algorithm outperform those obtained via the greedy algorithm.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:001366893000001)

Estimation-of-distribution algorithms for multi-valued decision variables

Ben Jedidia, Firas Doerr, Benjamin Krejca, Martin S.

With apparently all research on estimation-of-distribution algorithms (EDAs) concentrated on pseudo-Boolean optimization and permutation problems, we undertake the first steps towards using EDAs for problems in which the decision variables can take more than two values, but which are not permutation problems. To this aim, we propose a natural way to extend the known univariate EDAs to such variables. Different from a naive reduction to the binary case, it avoids additional constraints.Since understanding genetic drift is crucial for an optimal parameter choice, we extend the known quantitative analysis of genetic drift to EDAs for multi-valued variables. Roughly speaking, when the variables take r different values, the time for genetic drift to become critical is r times shorter than in the binary case. Consequently, the update strength of the probabilistic model has to be chosen r times lower now.To investigate how desired model updates take place in this framework, we undertake a mathematical runtime analysis on the.. -valued LeadingOnes problem. We prove that with the right parameters, the multi-valued UMDA solves this problem efficiently in O (r log(r)(2) n(2) log(n)) function evaluations. Overall, our work shows that EDAs can be adjusted to multi-valued problems and gives advice on how to set their parameters.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:001031455100029)

**Estimation of Distribution Algorithms in Machine Learning: A Survey**

Larranaga, Pedro Bielza, Concha

The automatic induction of machine learning models capable of addressing supervised learning, feature selection, clustering, and reinforcement learning problems requires sophisticated intelligent search procedures. These searches are usually performed in the possible model structure spaces, leading to combinatorial optimization problems, and in the parameter spaces, where it is necessary to solve continuous optimization problems. This article reviews how the estimation of distribution algorithms, a kind of evolutionary algorithm, can be used to address these problems. Topics include preprocessing, mining association rules, selecting variables, searching for the optimal supervised learning model (both probabilistic and nonprobabilistic models), finding the best hierarchical, partitional, or probabilistic clustering, obtaining the optimal policy in reinforcement learning, and performing inference and structural learning in Bayesian networks for association discovery. Interesting guidelines for future work in this area are also provided.

[**Paper**](https://www.webofscience.com/wos/alldb/full-record/WOS:001328314100006)

**Estimation of Distribution Algorithm for Grammar-Guided Genetic Programming**

Criado, Pablo Ramos Rolania, D. Barrios de la Hoz, David Manrique, Daniel

Genetic variation operators in grammar-guided genetic programming are fundamental to guide the evolutionary process in search and optimization problems. However, they show some limitations, mainly derived from an unbalanced exploration and local-search trade-off. This paper presents an estimation of distribution algorithm for grammar-guided genetic programming to overcome this difficulty and thus increase the performance of the evolutionary algorithm. Our proposal employs an extended dynamic stochastic context-free grammar to encode and calculate the estimation of the distribution of the search space from some promising individuals in the population. Unlike traditional estimation of distribution algorithms, the proposed approach improves exploratory behavior by smoothing the estimated distribution model. Therefore, this algorithm is referred to as SEDA, smoothed estimation of distribution algorithm. Experiments have been conducted to compare overall performance using a typical genetic programming crossover operator, an incremental estimation of distribution algorithm, and the proposed approach after tuning their hyperparameters. These experiments involve challenging problems to test the local search and exploration features of the three evolutionary systems. The results show that grammar-guided genetic programming with SEDA achieves the most accurate solutions with an intermediate convergence speed.

[**Paper**](https://www.webofscience.com/wos/alldb/full-record/WOS:001368000000004)

EDAspy: An extensible python package for estimation of distribution Algorithms

Soloviev, Vicente P. Larranaga, Pedro Bielza, Concha

Estimation of distribution algorithms (EDAs) are a type of evolutionary algorithms where a probabilistic model is learned and sampled in each iteration. EDAspy provides different state-of-the-art implementations of EDAs including the recent semiparametric EDA. The implementations are modularly built, allowing for easy extension and the selection of different alternatives, as well as interoperability with new components. EDAspy is totally free and open-source under the MIT license.

[**Paper**](https://www.webofscience.com/wos/alldb/full-record/WOS:001362095300001)