A Hybrid Quantum Estimation of Distribution Algorithm (Q-EDA) for Flow-Shop Scheduling

Latif, Muhammad Shahid Zhou, Hong Amir, Muhammad

Intrinsically, the Permutation Flow-Shop Scheduling Problem (PFSSP) is a typical combinatorial optimization problem. It encompasses a strong scientific and engineering background and remains a NP-hard problem over decades. Scheduling and sequencing have played a vital role and had massive applications in modern industries and manufacturing systems. Therefore in order to improve and enhance the performance and efficiency of industrial manufacturing systems in present competitive era, it is worthwhile to develop effective scheduling techniques and approaches. In this paper, a hybrid approach is proposed which is based on standard Quantum Genetic Algorithm (QGA) and Estimation of Distribution Algorithm (EDA), aiming at permutation flow-shop scheduling problems (PFSSP). The quantum population is merged with population produced by EDA with a comparative criterion to ensure that the best individual will remain from both populations. The EDA is integrated with standard QGA to produced fitter populations and guide QGA to find promising solution space. Utilizing the advantages of both algorithms, a faster and efficient algorithm is developed, which has produced better results than previous similar approaches for medium scale problems.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000341627900116)

A fast estimation of distribution algorithm for dynamic fuzzy flexible job-shop scheduling problem

Liu, Bojun Fan, Yushun Liu, Yi

Due to the complicated circumstances in workshop, most of the conventional scheduling algorithms fail to meet the requirements of instantaneity, complexity, and dynamicity in job-shop scheduling problems. Compared with the static algorithms, dynamic scheduling algorithms can better fulfill the requirements in real situations. Considering that both flexibility and fuzzy processing time are common in reality, this paper focuses on the dynamic flexible job-shop scheduling problem with fuzzy processing time (DfFJSP). By adopting a series of transforming procedures, the original DfFJSP is simplified as a traditional static fuzzy flexible job-shop problem, which is more suitable to take advantage of the existing algorithms. In this paper, estimation of distribution algorithm (EDA) is brought into address the post-transforming problem. An improved EDA is developed through making use of several elements omitted in original EDA, including the historical-optimal solution and the standardized solution vectors. The improved algorithm is named as fast estimation of distribution algorithm (fEDA) since it performs better in convergence speed and computation precision, compared with the original EDA. To sum up, the ingenious transformation and the effective fEDA algorithm provide an efficient and practical way to tackle the dynamic flexible fuzzy job-shop scheduling problem. (C) 2015 Elsevier Ltd. All rights reserved.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000360772100018)

An effective estimation of distribution algorithm for the flexible job-shop scheduling problem with fuzzy processing time

Wang, Shengyao Wang, Ling Xu, Ye Liu, Min

Considering the fuzzy nature of the data in real-world scheduling, an effective estimation of distribution algorithm (EDA) is proposed to solve the flexible job-shop scheduling problem with fuzzy processing time. A probability model is presented to describe the probability distribution of the solution space. A mechanism is provided to update the probability model with the elite individuals. By sampling the probability model, new individuals can be generated among the search region with promising solutions. Moreover, a left-shift scheme is employed for improving schedule solution when idle time exists on the machine. In addition, some fuzzy number operations are used to calculate scheduling objective value. The influence of parameter setting is investigated based on the Taguchi method of design of experiment, and a suitable parameter setting is suggested. Numerical testing results and comparisons with some existing algorithms are provided, which demonstrate the effectiveness of the proposed EDA.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000320918900021)

An Energy-Based Sampling Technique for Multi-Objective Restricted Boltzmann Machine

Shim, Vui Ann Tan, Kay Chen Cheong, Chun Yew

Estimation of distribution algorithms are gaining increased research interest due to their advantage in exploiting linkage information. This paper examines the sampling techniques of a restricted Boltzmann machine-based multi-objective (MO) estimation of distribution algorithm (REDA). The behaviors of the sampling techniques in terms of energy levels are rigorously investigated, and a sampling mechanism that exploits the energy information of the solutions in a trained network is proposed to improve the search capability of the algorithm. The REDA is then hybridized, with a genetic algorithm and a local search based on an evolutionary gradient approach, to enhance the exploration and exploitation capabilities of the algorithm. Thirty-one benchmark test problems, which consist of different difficulties and characteristics, are used to examine the efficiency of the proposed algorithm. Empirical studies show that the proposed algorithm gives promising results in terms of inverted generational distance and nondominance ratio in most of the test problems.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000327970300003)

An Estimation of Distribution Algorithm for Solving Hybrid Flow-shop Scheduling Problem with Stochastic Processing Time

Wang, Shengyao Wang, Ling Xu, Ye

In this paper, an effective estimation of distribution algorithm (EDA) is proposed to solve the hybrid flow-shop scheduling problem with stochastic processing time. Considering the effectiveness and robustness of a schedule, the schedule objective is to minimize the makespan of the initial scenario as well as the deviation of the makespan between all stochastic scenarios and the initial one. In the proposed EDA, a bi-objective evaluation function is employed to evaluate the individuals of the population. A probability model is presented to describe the probability distribution of the solution space. A mechanism is provided to update the probability model with the superior individuals. By sampling the probability model, new individuals can be generated among the search region with the promising solutions. Numerical testing results based on some well known benchmark instances are provided. The comparisons with the existing genetic algorithm demonstrate the effectiveness and robustness of the proposed EDA.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000393046002111)

An Estimation of Distribution Algorithm for Steiner Tree Problem

Wang, Yaqing Wang, Hua Kong, Guohong

As one of the most well-known combinatorial optimization problems, Steiner tree problem is widely applied to optimization in transportation design, biological engineering, and communication networks. It has been proved to be NP complete, though. To solve this problem, researchers have provided many classic solutions. This paper proposes a new method of solving Steiner tree problem by using estimation of distribution algorithms (EDA). The basic idea is to initialize randomly n trees which contain the source node and the destination nodes. Some elites are selected by the selection operator. The algorithm then constructs a probabilistic model which attempts to estimate the probability distribution of the selected elites. Once the model is constructed, new trees are generated by sampling the distribution encoded by this model. These new trees are then incorporated back into the old population, possibly replacing it entirely. The process is repeated until some termination criteria are met. The algorithm constantly evolves trees to obtain a better solution tree with EDA ideas. This method leads to better performance, reduced time complexity, and optimized solution. Simulation results also show that the algorithm has better performance in searching and converging.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000356716900229)

An Estimation of Distribution Algorithm for the 3D Bin Packing Problem with Various Bin Sizes

Cai, Yaxiong Chen, Huaping Xu, Rui Shao, Hao Li, Xueping Tang, K Gao, Y Klawonn, F Lee, M Li, B Weise, T Yao, X

The 3D bin packing problem (3DBPP) is a practical problem modeled from modern industry application such as container ship loading and plane cargo management. Unlike traditional bin packing problem where all bins are of the same size, this paper investigates a more general type of 3DBPP with bins of various sizes. We proposed a modified univariate marginal distribution algorithm (UMDA) for solving the problem. A packing strategy derived from a deepest bottom left packing method was employed. The modified UMDA was experimentally compared with CPLEX and a genetic algorithm (GA) approach. The experimental study showed that the proposed algorithm performed better than GA and CPLEX for large-scale instances.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000329908900049)

An Intelligent Multi-Restart Memetic Algorithm for Box Constrained Global Optimisation

Sun, J. Garibaldi, J. M. Krasnogor, N. Zhang, Q.

In this paper, we propose a multi-restart memetic algorithm framework for box constrained global continuous optimisation. In this framework, an evolutionary algorithm (EA) and a local optimizer are employed as separated building blocks. The EA is used to explore the search space for very promising solutions (e. g., solutions in the attraction basin of the global optimum) through its exploration capability and previous EA search history, and local search is used to improve these promising solutions to local optima. An estimation of distribution algorithm (EDA) combined with a derivative free local optimizer, called NEWUOA (M. Powell, Developments of NEWUOA for minimization without derivatives. Journal of Numerical Analysis, 28:649-664, 2008), is developed based on this framework and empirically compared with several well-known EAs on a set of 40 commonly used test functions. The main components of the specific algorithm include: (1) an adaptive multivariate probability model, (2) a multiple sampling strategy, (3) decoupling of the hybridisation strategy, and (4) a restart mechanism. The adaptive multivariate probability model and multiple sampling strategy are designed to enhance the exploration capability. The restart mechanism attempts to make the search escape from local optima, resorting to previous search history. Comparison results show that the algorithm is comparable with the best known EAs, including the winner of the 2005 IEEE Congress on Evolutionary Computation (CEC2005), and significantly better than the others in terms of both the solution quality and computational cost.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000316061600005)

An Novel Estimation of Distribution Algorithm for TSP

Yu, Fahong Liao, Weizhi Chen, Meijia Kim, YH

Estimation of distribution algorithms (EDAs) is a method for solving NP-hard problem. But it is hard to find global optimization quickly for some problems, especially for traveling salesman problem (TSP) that is a classical NP-hard combinatorial optimization problem. To solve TSP effectively, a novel estimation of distribution algorithm (NEDA) is provided, which can solve the conflict between population diversity and algorithm convergence. The experimental results show that the performance of NEDA is effective.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000339362300209)

EDA with Switching Distributions for Long-Short Portfolio Replication Problems

Shibata, Shunsuke Orito, Yukiko Hanada, Yoshiko Yamamoto, Hisashi

It is desired to replicate the benchmark portfolio when it has delivered good performances. In this paper, our focus is on the portfolio replication problem that the total return of the benchmark portfolio is opened to the public but the proportion-weighted combination is closed to the public. It is difficult to solve this replication problem because we cannot have any techniques to solve the simultaneous equations when the number of unknown valuables is more than the number of equations. In order to solve such a problem, we propose the new Estimation of Distribution Algorithm with the operation switching two distributions in this paper. In the numerical experiments, we show that the portfolios replicated by our proposing algorithm have delivered good performances even in the future periods.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000332201900072)

Effect of Model Complexity for Estimation of Distribution Algorithm in NK Landscapes

Liaw, Rung-Tzuo Ting, Chuan-Kang

Evolutionary algorithms (EAs) have been widely proved to be effective in solving complex problems. Estimation of distribution algorithm (EDA) is an emerging EA, which manipulates probability models instead of genes for evolution EDA creates probability models based on the promising solution in the population and generates offspring by sampling from these models. The model complexity is a key factor in the performance of EDA. Complex models can express the relations among variables more accurately than simple models. However, for some problems with strong interaction among variables, building a model for all the relations becomes unrealistic and impractical due to its high computational cost and requirement for a large population size. This study aims to understand the behaviors of EDAs with different model complexities in NK landscapes. Specifically, this study compares the solution quality and convergence speed of univariate marginal distribution algorithm (UMDA), bivariate marginal distribution algorithm (BMDA), and estimation of Bayesian network (EBNA) in the NK landscapes with different parameter settings. The comparative results reveal that high complexity does not imply high performance: Simple model such as UMDA and BMDA can outperform complex mode like EBNA on the tested NK landscape problems. The results also show that BMDA achieves a stable high probability of generating the best solution and satisfactory solution quality; by contrast, the probability for EBNA drastically declines after some generations.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000332876700011)

Efficient Sampling in Fragment-Based Protein Structure Prediction Using an Estimation of Distribution Algorithm

Simoncini, David Zhang, Kam Y. J.

Fragment assembly is a powerful method of protein structure prediction that builds protein models from a pool of candidate fragments taken from known structures. Stochastic sampling is subsequently used to refine the models. The structures are first represented as coarse-grained models and then as all-atom models for computational efficiency. Many models have to be generated independently due to the stochastic nature of the sampling methods used to search for the global minimum in a complex energy landscape. In this paper we present EdaFold(AA), a fragment-based approach which shares information between the generated models and steers the search towards native-like regions. A distribution over fragments is estimated from a pool of low energy all-atom models. This iteratively-refined distribution is used to guide the selection of fragments during the building of models for subsequent rounds of structure prediction. The use of an estimation of distribution algorithm enabled EdaFold(AA) to reach lower energy levels and to generate a higher percentage of near-native models. EdaFold(AA) uses an all-atom energy function and produces models with atomic resolution. We observed an improvement in energy-driven blind selection of models on a benchmark of 20 in comparison with the Rosetta AbInitioRelax protocol.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000322433300018)

Estimation of Distribution Algorithm for Resource Allocation in Green Cooperative Cognitive Radio Sensor Networks

Naeem, Muhammad Pareek, Udit Lee, Daniel C. Anpalagan, Alagan

Due to the rapid increase in the usage and demand of wireless sensor networks (WSN), the limited frequency spectrum available for WSN applications will be extremely crowded in the near future. More sensor devices also mean more recharging/replacement of batteries, which will cause significant impact on the global carbon footprint. In this paper, we propose a relay-assisted cognitive radio sensor network (CRSN) that allocates communication resources in an environmentally friendly manner. We use shared band amplify and forward relaying for cooperative communication in the proposed CRSN. We present a multi-objective optimization architecture for resource allocation in a green cooperative cognitive radio sensor network (GC-CRSN). The proposed multi-objective framework jointly performs relay assignment and power allocation in GC-CRSN, while optimizing two conflicting objectives. The first objective is to maximize the total throughput, and the second objective is to minimize the total transmission power of CRSN. The proposed relay assignment and power allocation problem is a non-convex mixed-integer non-linear optimization problem (NC-MINLP), which is generally non-deterministic polynomial-time (NP)-hard. We introduce a hybrid heuristic algorithm for this problem. The hybrid heuristic includes an estimation-of-distribution algorithm (EDA) for performing power allocation and iterative greedy schemes for constraint satisfaction and relay assignment. We analyze the throughput and power consumption tradeoff in GC-CRSN. A detailed analysis of the performance of the proposed algorithm is presented with the simulation results.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000318036400052)

Hybrid Estimation of Distribution Algorithm for solving Single Row Facility Layout Problem

Ou-Yang, Chao Utanilma, Amalia

The layout positioning problem of facilities on a straight line is known as Single Row Facility Layout Problem (SRFLP). The objective of SRFLP, categorized as NP Complete problem, is to arrange the layout so that the sum of distances between all facilities' pairs can be minimized.|Estimation of Distribution Algorithm (EDA) efficiently improves the solution quality in first few runs, but the diversity loss grows rapidly as more iterations are run. To maintain the diversity, hybridization with metaheuristic algorithms is needed. This research proposes Hybrid Estimation of Distribution Algorithm (EDAhybrid), an algorithm which consists of hybridization of EDA, Particle Swarm Optimization (PSO), and Tabu Search. Another hybridization algorithm, extended Artificial Chromosomes Genetic Algorithm (eACGA), is also built as benchmark. EDAhybrid's performance is tested in 15 benchmark problems of SRFLP and it successfully achieves optimum solution. Moreover, the mean error rates of EDAhybrid always get the lowest value compared to other algorithms.|SRFLP can be enhanced by considering more constraints, so it becomes enhanced SRFLP. Computational results show that EDAhybrid can also solve Enhanced SRFLP effectively. Therefore, we can conclude that EDAhybrid is a promising metaheuristic algorithm which can be used to solve the basic and enhanced SRFLP. (C) 2013 Elsevier Ltd. All rights reserved.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000324084300009)

A Hybrid Estimation of Distribution Algorithm for the Quay Crane Scheduling Problem

Perez-Rodriguez, Ricardo

The aim of the quay crane scheduling problem (QCSP) is to identify the best sequence of discharging and loading operations for a set of quay cranes. This problem is solved with a new hybrid estimation of distribution algorithm (EDA). The approach is proposed to tackle the drawbacks of the EDAs, i.e., the lack of diversity of solutions and poor ability of exploitation. The hybridization approach, used in this investigation, uses a distance based ranking model and the moth-flame algorithm. The distance based ranking model is in charge of modelling the solution space distribution, through an exponential function, by measuring the distance between solutions; meanwhile, the heuristic moth-flame determines who would be the offspring, with a spiral function that identifies the new locations for the new solutions. Based on the results, the proposed scheme, called QCEDA, works to enhance the performance of those other EDAs that use complex probability models. The dispersion results of the QCEDA scheme are less than the other algorithms used in the comparison section. This means that the solutions found by the QCEDA are more concentrated around the best value than other algorithms, i.e., the average of the solutions of the QCEDA converges better than other approaches to the best found value. Finally, as a conclusion, the hybrid EDAs have a better performance, or equal in effectiveness, than the so called pure EDAs.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000699722100001)

Improving the performance of the BioHEL learning classifier system

Xia, Xiao-Lei Xing, Huanlai

The identification of significant attributes is of major importance to the performance of a variety of Learning Classifier Systems including the newly-emerged Bioinformatics-oriented Hierarchical Evolutionary Learning (BioHEL) algorithm. However, the BioHEL fails to deliver on a set of synthetic datasets which are the checkerboard data mixed with Gaussian noises due to the fact the significant attributes were not successfully recognised. To address this issue, a univariate Estimation of Distribution Algorithm (EDA) technique is introduced to BioHEL which primarily builds a probabilistic model upon the outcome of the generalization and specialization operations. The probabilistic model which estimates the significance of each attribute provides guidance for the exploration of the problem space. Experiment evaluations showed that the proposed BioHEL systems achieved comparable performance to the conventional one on a number of real-world small-scale datasets. Research efforts were also made on finding the optimal parameter for the traditional and proposed BioHEL systems. (C) 2013 Elsevier Ltd. All rights reserved.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000322051600024)

Multi-objective optimization with an adaptive resonance theory-based estimation of distribution algorithm

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

The introduction of learning to the search mechanisms of optimization algorithms has been nominated as one of the viable approaches when dealing with complex optimization problems, in particular with multi-objective ones. One of the forms of carrying out this hybridization process is by using multi-objective optimization estimation of distribution algorithms (MOEDAs). However, it has been pointed out that current MOEDAs have an intrinsic shortcoming in their model-building algorithms that hamper their performance. In this work, we put forward the argument that error-based learning, the class of learning most commonly used in MOEDAs is responsible for current MOEDA underachievement. We present adaptive resonance theory (ART) as a suitable learning paradigm alternative and present a novel algorithm called multi-objective ART-based EDA (MARTEDA) that uses a Gaussian ART neural network for model-building and a hypervolume-based selector as described for the HypE algorithm. In order to assert the improvement obtained by combining two cutting-edge approaches to optimization an extensive set of experiments are carried out. These experiments also test the scalability of MARTEDA as the number of objective functions increases.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000330232900004)

Novel Particle Swarm Optimization for Unconstrained Problems

Wu, Peifeng Zhang, Jianhua

Estimation of Distribution Algorithm (EDA) is a class of evolutionary algorithms which construct the probabilistic model of the search space and generate new solutions according to the probabilistic model. Particle Swarm Optimization (PSO) is an algorithm that simulates the behavior of birds flocks and has good local search ability. This paper proposes a combination (EDAPSO) of EDA with PSO for the global optimization problems. The EDAPSO proposed in this paper combines the exploration of EDA with the exploitation of PSO. EDAPSO can perform a global search over the entire search space with faster convergence speed. EDAPSO has two main steps. First, the algorithm generates new solutions according to the probabilistic model. Then, EDAPSO updates the whole population according to improved velocity updating equation. EDAPSO has been evaluated on a series of benchmark functions. The results of experiments show that EDAPSO can produce a significant improvement in terms of convergence speed, solution accuracy and reliability.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000326977300067)

Regularized continuous estimation of distribution algorithms

Karshenas, Hossein Santana, Roberto Bielza, Concha Larrañaga, Pedro

Regularization is a well-known technique in statistics for model estimation which is used to improve the generalization ability of the estimated model. Some of the regularization methods can also be used for variable selection that is especially useful in high-dimensional problems. This paper studies the use of regularized model learning in estimation of distribution algorithms (EDAs) for continuous optimization based on Gaussian distributions. We introduce two approaches to the regularized model estimation and analyze their effect on the accuracy and computational complexity of model learning in EDAs. We then apply the proposed algorithms to a number of continuous optimization functions and compare their results with other Gaussian distribution-based EDAs. The results show that the optimization performance of the proposed RegEDAs is less affected by the increase in the problem size than other EDAs, and they are able to obtain significantly better optimization values for many of the functions in high-dimensional settings. (C) 2012 Elsevier B. V. All rights reserved.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000319205200019)

Scaling Up Estimation of Distribution Algorithms for Continuous Optimization

Dong, Weishan Chen, Tianshi Tino, Peter Yao, Xin

Since estimation of distribution algorithms (EDAs) were proposed, many attempts have been made to improve EDAs' performance in the context of global optimization. So far, the studies or applications of multivariate probabilistic model-based EDAs in continuous domain are still mostly restricted to low-dimensional problems. Traditional EDAs have difficulties in solving higher dimensional problems because of the curse of dimensionality and rapidly increasing computational costs. However, scaling up continuous EDAs for large-scale optimization is still necessary, which is supported by the distinctive feature of EDAs: because a probabilistic model is explicitly estimated, from the learned model one can discover useful properties of the problem. Besides obtaining a good solution, understanding of the problem structure can be of great benefit, especially for black box optimization. We propose a novel EDA framework with model complexity control (EDA-MCC) to scale up continuous EDAs. By employing weakly dependent variable identification and subspace modeling, EDA-MCC shows significantly better performance than traditional EDAs on high-dimensional problems. Moreover, the computational cost and the requirement of large population sizes can be reduced in EDA-MCC. In addition to being able to find a good solution, EDA-MCC can also provide useful problem structure characterizations. EDA-MCC is the first successful instance of multivariate model-based EDAs that can be effectively applied to a general class of up to 500-D problems. It also outperforms some newly developed algorithms designed specifically for large-scale optimization. In order to understand the strengths and weaknesses of EDA-MCC, we have carried out extensive computational studies. Our results have revealed when EDA-MCC is likely to outperform others and on what kind of benchmark functions.

[Paper](https://www.webofscience.com/wos/alldb/full-record/WOS:000327970300005)