Dynamical Systems chaotic dynamical system well known in engineering is solved using quantum-inspired evolutionary algorithm, differential evolution and genetic algorithms. The paper focuses on such combination of parameters that produce periodic responses instead of purely chaotic responses. The feature set used is a set of displacement values of the first five Poincare points, after ignoring transient effects. All approaches correctly identify the target set of parameters as producing the given response; however, depending on the fitness landscape some parameters are more difficult to identify than others especially when using the canonical genetic algorithm. This paper is also the first to investigate the quantum-inspired evolutionary algorithm for such parameter identification problems.

Conceptual Design and Damage Identification using genetic algorithm optimization methods requires the use of advanced representations. The implicit redundant representation (IRR) provides significant benefits for inverse problems in which the solution involves determining the optimal number of design variables, in addition to their values. The IRR encodes both variables and redundant segments in each individual. The encoded variable locations and values dynamically change and self-organize through crossover and mutation during optimization. In searching for optimal structural forms in conceptual design, the IRR provides the flexibility to represent designs having different numbers and locations of members and nodes, which supports the simultaneous optimization of topology, geometry, and member sizes. Therefore a broad range of designs can be evaluated during a single trial. The set of Pareto-optimal designs evolved by the IRR define the tradeoffs that occur in optimizing the objectives as the structural topology and geometry changes. In damage detection, optimization is often used to predict the location and extent of damages based on the structural response collected from measurement data. The IRR can work with a small subset of all possible damaged elements during the search process, which allows the method to scale well with problem size. The IRR genetic algorithm representation discussed holds significant promise in solving large-scale inverse problems by providing the benefit of working with a variable number of design variables. This flexibility is leveraged to reduce the implicit size of the problem domain searched and to compare designs having markedly different forms or topologies.

Forecast Chaotic Time Series nonlinear dynamics which have chaotic characteristics. Among these methods, data driven approaches such as Auto Regressive (AR) models, Nonlinear Auto Regressive (NAR) models, Radial Basis Function (RBF) networks, and Multi Layered Perceptron (MLP) neural networks have proven themselves to be powerful approaches in modeling and prediction of chaotic dynamics. However, the structure of these models should be known before the training phase, which is a very complicated problem. In this research, we introduce a co-evolutionary approach for modeling and system identification of chaotic dynamics. The proposed algorithm is composed of two co-evolving populations: candidate data driven models, and test data sets which either extract new information from the nonlinear chaotic system or elicit desirable behavior from it. The fitness of candidate models is their ability to explain behavior of the target chaotic system observed in response to tests carried out so far by predicting the future values of these data sets; the fitness of candidate test data sets is their ability to make the models disagree in their predictions. To check the performance of this algorithm, three case studies are considered. First, we apply this method to approximate a static function which has complicated behavior near zero. Then, we use this algorithm to predict two bench mark time series in chaos literature: Sunspot Number (SSN) and Mackey-Glass (MG) time series. Simulation results depict the power of proposed method in modeling and predicting complicated nonlinear systems.

Evaluation Costs straightforward, by distributing all fitness computations to slaves. The benefits of asynchronous steady-state approaches are well-known when facing a possible heterogeneity among the evaluation costs in term of runtime, be they due to heterogeneous hardware or non-linear numerical simulations. However, when this heterogeneity depends on some characteristics of the individuals being evaluated, the search might be biased, and some regions of the search space poorly explored. Motivated by a real-world case study of multi-objective optimization problem – the optimization of the combustion in a Diesel Engine – the consequences of different components of heterogeneity in the evaluation costs on the convergence of two Evolutionary Multi-objective Optimization Algorithms are investigated on artificially-heterogeneous benchmark problems. In some cases, better spread of the population on the Pareto front seem to result from the interplay between the heterogeneity at hand and the evolutionary search.

Cardinality Constraints belonging to a framed structure in order to minimize its weight while satisfying stress, displacement, stability, and other applicable constraints is often complicated by the requirement of considering non-linear structural behavior. The problem is further complicated if the members are to be chosen from a discrete set of commercially available sizes, which is frequently the

case. The solution of the commonly occurring case where the cardinality of the set of distinct values of the design variables (for instance, cross-sectional areas) should be smaller than a given value is still an open area for investigation. In this paper a genetic algorithm encoding, previously proposed in the literature, is used to directly enforce such cardinality constraint for design optimization of geometrically nonlinear truss structures. The impact of performing a more rigorous (geometrically nonlinear) structural analysis, on both safety and cost of the optimized structure is also pointed out.

Representation and Reinforcement Learning represent its chromosome. In the proposed algorithm, a probabilistic model is constructed from the promising individuals of the current generation using reinforcement learning, and used to produce the new population. The node connection probability is studied to develop the probabilistic model, therefore pairwise interactions can be demonstrated to identify and recombine building blocks in the proposed algorithm. The proposed algorithm is applied to a problem of agent control, i.e., autonomous robot control. The experimental results show the superiority of the proposed algorithm comparing with the conventional algorithms.

Scheduling Problems with Sequence-Dependent Setup Times metaheuristics and hyper-heuristics Estimation of Distribution Algorithms (EDAs). This algorithm has been used to solve different kinds of scheduling problems successfully. However, due to its probabilistic model does not consider the variable interactions, ACGA may not perform well in some scheduling problems, particularly the sequence-dependent setup times are considered because a former job influences the processing time of next job. It is not sufficient that probabilistic model just captures the ordinal information from parental distribution. As a result, this paper proposes a bi-variate probabilistic model added into the ACGA. The new algorithm is named extended artificial chromosomes with genetic algorithm (eACGA) and it is used to solve single machine scheduling problem with sequence-dependent setup times in a common due-date environment. Some heuristics are also employed with eACGA. The results indicate that the average error ratio of eACGA is one-half of the ACGA. In addition, when eACGA works with other heuristics, the hybrid algorithm achieves the best solution quality when it is compared with other algorithms in literature. Thus, the proposed algorithms are effective for solving this scheduling problem with setup consideration.

analysis and data mining search spaces and due to this ability, they were to some extent applied to Inductive Logic Programming (ILP) problem. Although Estimation of Distribution Algorithms (EDAs) perform better in most problems when compared to standard GAs, this kind of algorithm have not been applied to ILP. This work presents an ILP system based on EDA. Preliminary results show that the proposed system is superior when compared to a "standard"GA and it is very competitive when compared to the state of the art ILP system Aleph.

environments an inexpensive Gaussian mixture model with online learning, which will be employed in dynamic optimization. Here, the mixture model stores a vector of sufficient statistics of the best solutions, which is subsequently used to obtain the parameters of the Gaussian components. This approach is able to incorporate into the current mixture model potentially relevant information of the previous and current iterations. The online nature of the proposal is desirable in the context of dynamic optimization, where prompt reaction to new scenarios should be promoted. To analyze the performance of our proposal, a set of dynamic optimization problems in continuous domains was considered with distinct levels of complexity, and the obtained results were compared to the results produced by other existing algorithms in the dynamic optimization literature.

significant progress has been made in recent years, most notably in games such as Go, where the level of play is now competitive with expert human play on smaller boards. Recently, a significantly more complex class of games has received increasing attention: real-time video games. These games pose many new challenges, including strict time constraints, simultaneous moves and open-endedness. Unlike in traditional board games, computational play is generally unable to compete with human players. One driving force in improving the overall performance of artificial intelligence players are game competitions where practitioners may evaluate and compare their methods against those submitted by others and possibly human players as well. In this paper we introduce a new competition based on the popular arcade video game Ms Pac-Man: Ms Pac-Man versus Ghost Team. The competition, to be held at the Congress on Evolutionary Computation 2011 for the first time, allows participants to develop controllers for either the Ms Pac-Man agent or for the Ghost Team and unlike previous Ms Pac-Man competitions that relied on screen capture, the players now interface directly with the game engine. In this paper we introduce the competition, including a review of previous work as well as a discussion of several aspects regarding the setting up of the game competition itself.

Algorithm proposed for solving the flexible job shop scheduling problems. The total flow time criterion was considered. In the proposed algorithm, tabu search (TS) heuristic is introduced to perform local search for employed bee, onlookers, and scout bees. Meanwhile, an external Pareto archive set is employed to record enough non-dominated solutions for the problem considered. Experimental results on five well-known benchmarks show the efficiency of the proposed hybrid algorithm. It is concluded that the proposed algorithm is superior to the very recent algorithms in term of both search quality and computational efficiency.

Levenberq-Marquardt (LM) algorithm is introduced to train artificial neural networks (ANN). Training an ANN is an optimization task where the goal is to find optimal weight set of the network in training process. Traditional training algorithms might get stuck in local minima and the global search techniques might catch global minima very slow. Therefore, hybrid models combining global search algorithms and conventional techniques are employed to train neural networks. In this work, ABC algorithm is hybridized with the LM algorithm to apply training neural networks.

accompanies high demand for large capacities, high performance devices, high bandwidths etc.,. Therefore, image compression techniques are essential to reduce the computational or transmittal costs. Wavelet transform is one of the compression techniques especially used for images and multimedia files. In wavelet transform, approximation and detail coefficients are extracted from the signal by filtering. Both approximation and detail coefficients are re-decomposed up to some level to increase frequency resolution. Once coefficients are generated, the optimum threshold values are determined to obtain the best reconstructed image, which can be considered as an optimization task. In this study, Artificial Bee Colony algorithm which is a recent and successful optimization tool is used to determine the thresholds to produce the best compressed image in terms of both compression ratio and quality.

Shelf Space Optimization one of the most scarce resources in retail management. At this point, the efficient allocation of the limited shelf space carries critical importance for maximizing the financial performance. On the other hand, because of NP-Hard nature of the shelf space allocation problem, heuristic approaches are required to solve real world problems. In this paper, different from existing studies in the literature, a heuristic approach based on artificial bee colony algorithm is presented for shelf space allocation problem by using a model which considers the space and cross elasticity. In order to demonstrate the efficiency of the developed approach, another heuristic approach based on particle swarm optimization is proposed. The performance analysis of these approaches is realized with problem instances including different number of products, shelves and categories. Experimental results show that the developed artificial bee colony algorithm is efficient methodology through near-optimal solutions and reasonable solving time for large sized shelf space allocation problems.

to lossy compression. Recent NASA missions (such as Mars rovers Spirit and Opportunity) have used the ICER progressive wavelet image compressor to achieve state-of-the-art compression performance. The purpose of the research described in this paper was to demonstrate that it is possible to evolve wavelet and scaling numbers describing novel transforms that outperform the most commonly used ICER wavelet for the reconstruction of images of the Martian landscape that had previously been subjected to lossy compression. Because our technique only modifies the image reconstruction transform, it requires no modification of deployed mission hardware. We thus present a technique to provide improved reconstruction of images received from existing rover missions.

Facility Location Problems Multiobjective optimization location problem. In these models, the disservice caused by the facility is traditionally measured by distance-related objective functions. In this study, we modify the objective function representing the disservice using the Lorenz curve and the Gini coefficient. Both of these concepts are widely used in the economics literature to measure the discrepancy in wealth distribution within a population. The use of the Gini coefficient enables us to measure how the disservice caused by the facility varies across different Pareto optimal solutions. We use a bi-objective particle swarm optimizer (bi-PSO) to compare how the change in the objective function representing the disservice affects the recommended location of the facility. Results suggest that some solutions identified as "Pareto optimal"by traditional formulations are dominated by other solutions when the Gini coefficient is used. Additionally, the use of the Gini coefficient causes a change in the "optimal"location of a semi desirable facility for some other instances. Results are discussed in detail and directions for future work are provided.

computation theory fuzzy-time information. First, we present a formalism to represent specifications. This model exploits the concepts of fuzzy set theory and uses a mathematical framework to get a more flexible approach. As it is usually assumed in industrial case studies, we consider that the original

requirements of the specification may change. The implementation is built with respect to these changes but the specification is not upgraded. Thus, it may be outdated. In order to continue using the formal framework, the specification must be adapted with respect to these new requirements. We consider that this update process should be as non-intrusive as possible, that is, without using the source-code of the implementation. We present a novel methodology for self-evolving fuzzy-time systems, without interacting with the source code.

particles of Brownian particles. One of the most popular approaches in path planning is to use the artificial potential fields method which, due to its easiness in implementation, might attract the robot towards a local minimum configuration, thus preventing it from reaching the desired final destination. Although there are different approaches to deal with this drawback, their modeling lacks the simplicity of the potential fields, adding thus an extra complexity to the problem. The solution proposed here combines the strengths of both approaches: it is easy to analyze and to implement, just like in the potentials method, while it preserves the robustness against local minima of more complex particle swarm models. An approximate analysis for the deterministic version of the selected model was performed and it was observed, via simulations, that the results obtained after this simplification were consistent with the behavior of the stochastic system.

Multi-robot studied the problem of odor source localization and presented a modified particle swarm optimization algorithm for odor source localization of multi- robot. The algorithm dynamically adjusts two learning factors in the velocity update equation based on the effect of wind on self-cognition and social cognition of a particle. In addition, an artificial potential field method is employed to improve the performance of our algorithm. We conducted various experiments in time-varying environments, and the experimental results confirm the superiority of our algorithm.

early application for mobile robots, and commercial robots designed for this purpose have become available. We consider the problem of using a single mobile robot to simultaneously direct multiple groups of visitors through a museum or exhibition, and formulate an objective function for this task. We show that an evolutionary robotics approach using a simple, low-fidelity simulator and genetic programming can automatically generate robot controllers which can perform this task better than hand-coded controllers as well as humans in both simulation and on a real robot.

for an system operator. This work presents a population-based optimization to create sets of functions to approximate a locally optimal input as an operator selects an output. Output and cost functions are modeled by neural networks. Neural network gradients are used to optimize a population of agents by minimizing the cost for the agent's current output. When an agent reaches an optimal input for its current output, additional agents are generated to step in the output gradient directions. The agent then settles to the local optimum for the new output value. The set of associated optimal points forms a inverse function, via spline interpolation, from a desired output to an optimal input. In this manner, a locally optimal function is created for each settled agent. These functions are naturally clustered in input and output spaces allowing for a continuous optimal function. The best cluster over the anticipated range of desired outputs can be chosen and the process optimized on-the-fly to respond to different set points. Results are shown for a diverse set of functions.

Locomotion generator (CPG) to generate rhythmic signals for fish-like locomotion of robotic fish. The robotic fish's wave form approximates fish's traveling wave. Since each joint angle of the robotic fish is modeled by a periodic function, it can be easily produced by a CPG. A CPG consists of biological neural oscillators, which can produce coordinated rhythmic signals by using simple input signals. The proposed CPG uses a neural oscillator for each joint of a robotic fish. To optimize the parameters of the CPG which determine the output signals, particle swam optimization (PSO) is employed. The effectiveness of the proposed CPG is demonstrated by computer simulation and real experiment with the robotic fish Fibo, developed in the Robot Intelligence Technology Lab., KAIST.

optimization is the possibility of convergence into bad local optima. Many techniques address this problem, mostly through restarting the search. However, deciding the new start location is nontrivial since neither a good location nor a good scale for sampling a random restart position are known. A black box search algorithm can nonetheless obtain some information about this location and scale from past exploration. The method proposed here makes explicit use of such experience, through the construction of an archive of \emph{novel solutions} during the run. Upon convergence, the most "novel" individual found so far is used to position the new start in the least explored region of the search space, actively looking for a new basin of attraction. We demonstrate the working principle of the method on two multi-modal test problems.

named the distance-weighted exponential natural evolution strategies (DX-NES). DX-NES remedies two problems of a conventional method, the exponential natural evolution strategies (xNES), that shows good performance when it does not need to move the distribution for sampling individuals down the slope to the optimal point. The first problem of xNES is that the search efficiency deteriorates while the distribution moves down the slope of an ill-scaled function because it degenerates before reaching the optimal point. The second problem is that the settings of learning rates are inappropriate because they do not taking account of some factors affecting the estimate accuracy of the natural gradient. We compared the performance of DX-NES with that of xNES and CMA-ES on typical benchmark functions and confirmed that DX-NES outperformed the xNES on all the benchmark functions and that DX-NES showed better performance than CMA-ES on the almost all functions except the k-tablet function.

Heuristics for Combinatorial Optimization Problems Genetic algorithms progress of an evolutionary algorithm (and possibly other heuristic search techniques) to manipulate and make use of the relationship between runtime and solution quality. The paper examines the idea that very rapid increases in initial fitness may lead to premature convergence and a reported solution that is less than optimal. We examine the advantages provided by this metaheuristic selection technique in solving two different combinatorial optimization problems: including a “toy"problem of finding magic squares and a more realistic vehicle routing problem (VRP) benchmark. The method is found to be useful for finding both higher quality solutions with a marginally longer algorithm run time and for obtaining lower quality solutions in a shorter time. Furthermore, the impact on the search results is similar for both the magic square and the VRP problem providing evidence the method is scalable to other problem domains, and therefore is potentially a relatively straight forward addition to many heuristic approaches that can add value by improving both runtime and solution quality.

Soccer Simulation humanoid model in the RoboCup 3D Soccer Simulation environment. A gait pattern of this humanoid is generated by a desired foot trajectory, joint control systems and nonlinear oscillators. To build a good gait pattern, the parameters of the walking system should be adjusted suitably. In this paper, a usage of evolution strategies that is depending on only a performance evaluation of the robot, is considered for adjusting the parameters. We apply two type evolution strategies in order to tune the parameters. The one is an evolution strategy with mask operation where the portion of individual to avoid mutation. The other is a covariance matrix adaptation evolution strategy. Numerical simulation studies are carried out to evaluate the performance of the proposed approaches by using the RoboCup 3D Soccer Simulator.

games in which traders continuously evaluate a complete set of trading strategies with different memory lengths using the strategies' past performance, weighted by a discount factor, and choose the strategy with the best past performance. Based on the chosen trading strategy they determine their prediction of the movement of each individual asset for the following time period. We find empirically using stocks from the SP500 that our prediction model yields a success rate and trading return that is increasing the smaller the discount factor becomes. We hypothesize that this result is driven by the existence of complex patterns of returns that are constantly changing and thus cannot be captured by relying on long-lasting experiences or static trading strategies.

Single-Objective economics. One area of study is its use to discover effective rules for technical trading in the context of a portfolio of equities (or an index). Early work used GP to find rules that were profitable, but were outperformed by the simple buy and hold strategy. Attempts since then report similar findings, except a handful of cases where GP has been found to outperform BH. Recent work has clarified that robust outperformance of BH depends on, mainly, the adoption of a relatively infrequent trading strategy (e.g. monthly), as well as a range of other factors. Here we add a comprehensive study of multiobjective approaches to this investigation, and find that multiobjective strategies provide even more robustness in outperforming BH, even in the context of more frequent (e.g. weekly) trading decisions.

mining an example when building a classification model. It is given by a credibility function, estimated according to a series of factors that influence the credibility of the examples, and is context-dependent. Here we deal with automatic document classification, and study the credibility of a document according to three factors: content, authorship and citations. We propose a genetic programming algorithm to estimate the credibility of training examples, which is then added to a credibility-aware classifier. For that, we model the authorship and citation data as a complex network, and select a set of structural metrics that can be used to estimate credibility. These metrics are then merged with other

content-related ones, and used as terminals for the GP. The GP was tested in a subset of the ACM-DL, and results showed that the credibility-aware classifier obtained results of micro and macroF_1 from 5% to 8% better than the traditional classifiers.

Processing Associative Memory hetero-associative recall. Our proposed Protein Processor Associative Memory (PPAM) is fundamentally different from the traditional processing methods which use arithmetic operations and consequently Arithmetic and Logic Units (ALUs). In this paper, we improve on our initial work addressing concerns surrounding hardware implementation. We present the improved computational architecture, coupled with a corresponding hardware architecture for implementation. Results of applying the hardware implementation on a small dataset are included, along with reports from synthesis tools about hardware utilisation.

Hardware Architecture solution or optimization of some technical or mathematical problems. But for some technical tasks, such as localization, nature seem to provides optimal solutions. This paper discusses how the barn owl auditory system can be conceptually realized on a digital system, such as a fieldprogrammable gate array. This adapted system yields a time resolution as small as 20 ps, even though it is clocked at only 85 MHz, which corresponds to a duty cycle of about 12 ns. The system achieves this result by copying the natural role model's core principles, i.e., employing a large number of simple, slowly operating processing elements, which are all connected to two passive wires, which induce only a very small additional time delay; these properties are the result of a natural evolutionary process that has taken millions of years.

Improvement deterministic test pattern generator. In contrast to conventional methods, the proposed evolutionary-based approach reduces the gate count of a built-in self-test structure, which is used for the automatic fault detection. The reduced-gate-count structure is needed to achieve the test structure with a smaller hardware area overhead, while still satisfying the reliability constraints. The presented optimization approach searches concurrently for the optimal combination of the register cells structure, the test patterns order in the generated test sequence, and the bit order of the test patterns. A comparison of the results with similar studies shows the efficiency of the proposed evolutionary approach, which is therefore very useful in the design of robust and fault-tolerant systems, while maintaining the minimum size of the hardware overhead.

Gate Array for Swarm System Simulations with each other to afford a complex behaviour. Such swarm systems are inherently parallel but as yet little work has focussed on the development of specific hardware platforms that might take advantage of such parallelism. This paper proposes a hardware platform for the implementation of swarm system simulations, using a case study of Reynolds' boids. Our platform provides a flexible decentralised intelligent bus communication architecture designed to provide effective communication between agents on a hardware platform.

Extraction for Image Classification problem of domain-independent image feature extraction and classification. We propose a new GP-based image classification system that extracts image features autonomously, and compare its performance against a baseline GP-based classifier system that uses human-extracted features. We found that the proposed system has a similar performance to the baseline system, and that GP is capable of evolving a single program that can both extract useful features and use those features to classify an image.

Noisy Images mages. We propose an algorithm based on discrete particle swarm optimisation (PSO) to detect continuous edges in noisy images. A constrained PSO-based algorithm with a new objective function is proposed to address noise and reduce broken edges. The localisation accuracy of the new algorithm is compared with that of a modified version of the Canny algorithm as a Gaussian-based edge detector, the robust rank order (RRO)-based algorithm as a statistical based edge detector, and our previously developed PSO-based algorithm. Pratt's figure of merit is used as a measure of localisation accuracy for these edge detection algorithms. Experimental results show that the performance of the new algorithm is higher than the Canny and RRO algorithms in the images corrupted by two different types of noise (impulsive and Gaussian noise). The new algorithm also detects edges more accurately and smoothly than our previously developed algorithm in noisy images.

a global approach to edge detection using genetic programming (GP). Unlike most traditional edge detection methods which use local window filters, this approach directly uses an entire image as input and classifies pixels directly as edges or non-edges without preprocessing or postprocessing. Shifting operations and common standard operators are used to form the function set. Precision, recall and true negative rate are used to construct the fitness functions. This approach is examined and compared with the Laplacian and Sobel edge detectors on three sets of images providing edge detection problems

of varying difficulty. The results suggest that the detectors evolved by GP outperform the Laplacian detector and compete with the Sobel detector in most cases.

optimization (PSO) with two improved fitness functions. The PSO clustering algorithm can be used to find centroids of a user specified number of clusters. Two new fitness functions are proposed in this paper. The PSO-based image clustering algorithm with the proposed fitness functions is compared to K-means clustering. Experimental results show that the PSO-based image clustering approach, using the improved fitness functions, can perform better than K-means by generating more compact clusters and larger inter-cluster seperation.

engineering problems. One of the areas in which this approach succeeds is digital image processing. Impulse noise represents a basic type of non-linear noise typically affecting a single pixel in different regions of the image. In order to eliminate this type noise median filters have usually been applied. However, for higher noise intensity or wide range of the noise values this approach leads to corrupting non-noise pixels as well which results in images that are smudged or lose some details after the filtering process. Therefore, advanced filtering techniques have been developed including a concept of noise detection or iterative filtering algorithms. In case of the high noise intensity, a single filtering step is insufficient to eliminate the noise and obtain a reasonable quality of the filtered image. Therefore, iterative filters have been introduced. In this paper we apply an evolutionary algorithm combined with Cartesian Genetic Programing representation to design image filters for the impulse noise that are able to compete with some of the best conventionally used iterative filters. We consider the concept of noise detection to be designed together with the filter itself by means of the evolutionary algorithm. Finally, it will be shown that if the evolved filter is applied iteratively on the filtered image, a high-quality results can be obtained utilizing lower computational effort of the filtering process in comparison with the conventional iterative filters.

Recognition mapping out eukaryotic DNA. While this task is key to understanding the regulation of differential transcription, the gene-specific architecture of promoter sequences does not readily lend itself to general strategies. To date, the best approaches are based on Support Vector Machines (SVMs) that employ standard "spectrum"features and achieve promoter region classification accuracies from a low of 84% to a high of 94% depending on the particular species involved. In this paper, we propose a general and powerful methodology that uses Genetic Programming (GP) techniques to generate more complex and more gene-specific features to be used with a standard SVM for promoter region identification. We evaluate our methodology on three data sets from different species and observe consistent classification accuracies in the 94-95% range. In addition, because the GP-generated features are gene-specific, they can be used by biologists to advance their understanding of the architecture of eukaryotic promoter regions.

Polycephalum of attention in renowned journals recently, for their ability to construct fault tolerant connection networks. Previous work experiments with a real slime mold Physarum Polycephalum as well as computer simulations based on a tube model in order to construct a fault tolerant and efficient transport network for the Tokyo rail system [1] showed, that networks have been found that are similar to the existing rail system of Tokyo, however the quality of the solutions of the real slime mold show big variations, and the tubular computer simulation does not seem to reproduce the natural slime mold very well, since the constructed networks of the simulated slime mold show heavy dependence of one simulation parameter. Thus in our work we present an agent based simulation approach for construction of fault tolerant connection networks for the Tokyo rail system using the agent based simulation of Physarum Polycephalum. Analysis of the results show that the agent based simulation reproduces the variance in the behavior of the natural slime mold much better. Analysing the cost benefit ratio of bio-inspired network construction we however conclude that it might be worth to consider classical efficient computational algorithms for the problem of constructing minimal fault tolerant networks. Index Terms–slime mold; physarum polycephalum;nature inspired algorithms

Evolutionary Algorithms with Variable Size Individuals problem that seeks to discover the evolutionary relationship between different genomes, and is one of the many challenging problems in Bioinformatics. Solving the problem optimally has been proved to be NP-Hard and so a selection of approximation algorithms have been developed. In this paper a new mapping order is introduced to solve the problem of sorting unsigned permutations using a specialized multi- objective genetic algorithm. Our modified genetic algorithm uses a population with variable length individuals to maintain a worst time running time complexity of O(n4 log2 n); where n is the problem size. The results show that this approach is more effective than the 3=2 heuristic method and previous genetic algorithm approaches.

the possibility of achieving practical processing time through the use of GPUs for parallel processing in the application of genetic computation to problems for which the use of genetic computing has not been investigated before because of the processing time problem. To increase accuracy, we propose a genetic operation that takes building- block linkage into account. As a parallel processing model for higher performance, we use a multiple- population coarse-grained GA model to counter initial value dependence under the condition of a limited number of individuals. Specifically, we show that it is possible to reach a solution in a few seconds of processing time with a correct solution rate of 100%, even for extremely difficult problems by parallel processing of genetic computation on a GeForce GTX 460, a commercial GPU produced by the NVIDIA Corporation.

evolutionary algorithms scalability and complexity analysis uses to perform compute-intensive tasks. In particular, cloud storage is an easy and convenient way of storing files that will be accessible over the Internet, but can also be used for distributing those files for performing computation on them. In this paper we describe how such a service commercial- ized by Dropbox is used for pool-based evolutionary algorithms. A prototype system is described and its performance measured over deceptive combinatorial optimization problems using two different substrates: WiFi and wired, finding that, for some type of problems and using commodity hardware, cloud storage systems can profitably be used as a platform for distributed evolutionary algorithms; however, performance is influenced by the type of underlying network. After introducing the method in a previous paper, in this paper we focus on measuring this influence, finding that wired is faster than WiFi for any number of nodes. We have also performed an experiment with a few more computers to see whether speedup keeps up with the number of nodes.

millions of cores expected to be installed on around 2018. Such massive parallelism makes programming difficult. Inherent parallel nature of evolutionary computation is a promising factor in designing optimization algorithms that adapt to such massively parallel architecture although there are some problems to be solved to realize robust algorithm that can analyze complex interactions among genes. This paper discusses current status and future trend in realizing robust and scalable evolutionary computation on such extreme-scale supercomputers.

computation for GPGPU (General-Purpose Graphic Processing Unit) to solve non-convex Mixed Integer Non-Linear Programming (MINLP) and non-convex Non Linear Programming (NLP) problems using a stochastic algorithm. Stochastic algorithms being random in their behavior are difficult to implement over GPU like architectures. In this paper we not only succeed in implementation of a stochastic algorithm over GPU but show considerable speedups over CPU implementations. The stochastic algorithm considered for this paper is an adaptive resolution approach to genetic algorithm (arGA), developed by the authors of this paper. The technique uses the entropy measure of each variable to adjust the intensity of the genetic search around promising individuals. Performance is further improved by hybridization with adaptive resolution local search (arLS) operator. In this paper, we describe the challenges and design choices involved in parallelization of this algorithm to solve complex MINLPs over a commodity GPU using Compute Unified Device Architecture (CUDA) programming model. Results section shows several numerical tests and performance measurements obtained by running the algorithm over an nVidia Fermi GPU. We show that for difficult problems we can obtain a speedup of up to 20x with double precision and up to 42x with single precision.

Colony Algorithm Wireless Sensor Network (WSN) structures having many application areas such as military, medical, meteorology, and geology. In this paper, the performance of Artificial Bee Colony Algorithm (ABC) on routing operations in WSNs is studied. Obtained performance result shows that the used protocol provides longer network life time by saving more energy. Complexity analysis of cluster-based routing strategy using ABC algorithm is made. Performance and analysis results approve that ABC algorithm presents promising solutions on WSN routings.

Algorithm problems, including the optimization of synaptic weights from an Artificial Neural Network (ANN). However, this is not enough to generate a robust ANN. For that reason, some authors have proposed methodologies based on so-called metaheuristics that automatically allow designing an ANN, taking into account not only the optimization of the synaptic weights as well as the ANN's architecture, and the transfer function of each neuron. However, those methodologies do not generate a reduced design (synthesis) of the ANN. In this paper, we present an ABC based methodology, that maximizes its accuracy and minimizes the number of connections of an ANN by evolving at the same time the synaptic weights, the ANN's architecture and the transfer functions of each neuron. The methodology is tested with several pattern recognition problems.

artificial bee colony algorithm that illustrates a number of courses assigned to the classrooms. In this study, a hybrid algorithm composed of a heuristic graph node coloring and artificial bee colony algorithm (ABC) is proposed to solve CSP. The study is one of the few applications of ABC on discrete optimization problems and to our best knowledge it is the first application on CSP. A basic heuristic algorithm of node coloring problem takes part initially to develop some feasible solutions of CSP. Those feasible solutions correspond to the food sources in ABC algorithm. The ABC is then is used to improve the feasible solutions. The employed and onlooker bees are directed or controlled in a specific manner in order to avoid the conflicts in the course timetable. Proposed solution procedure is tested using real data from a university in Turkey. The experimental results demonstrate that the proposed hybrid algorithm yields efficient solutions

Problem to solve the economic lot scheduling problem (ELSP) under extended basic period (EBP) approach and power-of-two (PoT) policy. In specific, our algorithm provides a cyclic production schedule of n items to be produced on a single machine such that the production cycle of each item is an integer multiple of a fundamental cycle. All the integer multipliers are in the form of power-of-two, and under EBP approach feasibility is guaranteed with a constraint that checks if the items assigned in each period can be produced within the length of the period. For this problem, which is NP-hard, our DABC algorithm employs a multi-chromosome solution representation to encode power-of-two multipliers and the production positions separately. Both feasible and infeasible solutions are maintained in the population through the use of some sophisticated constraint handling methods. A variable neighborhood search (VNS) algorithm is also fused into DABC algorithm to further enhance the solution quality. The experimental results show that the proposed algorithm is very competitive to the best performing algorithms from the existing literature under the EBP and PoT policy

for Coastal Surveillance planing craft is presented. The proposed framework consists of a surface information retrieval module, a geometry manipulation module and an optimization module backed by standard naval architectural performance estimation tools. Total resistance comprising calm water resistance and added resistance in waves is minimized subject to constraints on displacement and stability requirements. Infeasibility Driven Evolutionary Algorithm (IDEA) is incorporated in the optimization module. A scenario-based hydrodynamic optimization problem using an example of United States Coast Guard (USCG) WPB-110ft vessel is presented in this work. The concepts presented in this paper is an extension of the works of [15] [16] where instead of only performing total resistance minimization of high speed planing craft at a single operational speed, a set of collective speed spanning over a predefined lifetime is illustrated. The proposed framework is capable of generating the optimum hull form while at the same time enabling a provision for ship designers to evaluate the candidate designs' performance over various operating scenarios.

conventional bin packing, and develop an algorithm called Reordering Grouping Genetic Algorithm (RGGA) to assign VMs to servers. We first test RGGA on conventional bin packing problems and show that it yields excellent results but much more efficiently. We then generate a multi-constraint test set, and demonstrate the effectiveness of RGGA in this context. Lastly, we show the applicability of RGGA in its desired context by using it to develop an assignment of real virtual machines to servers.

Agents in Web service research area. There are numerous methods to achieve Web service composition. This paper describes the use of Asynchronous Teams (A-Teams) algorithm with genetic agents to compose semantic Web services. Specific agents realize the composition of sequential, parallel and synchronization control flow patterns. Other agents, based on genetic algorithms, perform the crossover and mutation over these patterns. The composition is described through semantic logic rules that take into account the input and output parameters obtained from OWL-S files. The quality of the composition is also evaluated. A system was implemented and typical test scenarios are also presented.

Representation and operators customised polymer microstructured optical fibres play a more significant role in many diverse new short-distance applications. Our prototyping process involves drilling an array of holes in a cylindrical preform. That preform is subsequently heated and pulled into a narrow fibre. The size and position of the holes create an effective refractive index profile, which in turn determines the optical transmission properties of the fibre. In this paper, a new variable-length genotype is introduced which controls the coordinates of the centres of 'potential' holes. The genotype-to-phenotype mapping carefully determines which holes are 'activated' and the final radius of each hole, consistent with manufacturing constraints. Two manufacturing constraints are: a minimum spacing between adjacent holes and that the drill bits are only available in a discrete range of radii. A cross-over operator is designed that works with variable-length genotypes and its effect on the distribution

of genome lengths is explored in detail. An implementation of NSGA-II is used to perform a multi-objective optimisation with four objectives. One of these objectives (wanting a parabolic index profile) is the same as in our previous work. Two are new: minimising the deformability of the design and minimising the detrimental effects of surface roughness. The final objective is not optical but related to the efficiency of the GA and is to minimise the number of inactive genes. The behaviour of the genetic algorithm and a number of interesting designs are discussed.

Imputation still a relevant and challenging problem nowadays. Data can be missing for a variety of reasons, and there are several techniques capable of processing missing data. A parcel of them tries to estimate the missing values. This technique is called imputation. Recently, it was proposed a biclustering algorithm, based on Swarm Intelligence, named SwarmBCluster, to impute missing data. As it is a novel and promising algorithm, this paper intends to investigate the influence of its parameters on the performance. To achieve this objective, this paper will compare SwarmBCluster with other two imputation algorithms and, after that, it will perform a sensitivity analysis. The quality of the imputations is measured with the Root Mean Squared Error (RMSE). The experiments showed that SwarmBCluster presents good results concerning the RMSE metric and that the proper choice of parameters can considerably improve the performance of the algorithm.

Clustering and data mining number of classes in the face recognition. As a result, the recognition accuracy of the traditional subspace face recognition algorithm is unsatisfactory. This paper presents a sequential subspace face recognition framework using an effective genetic-based clustering algorithm (GCA). Firstly, the facial database is decomposed into a double layer database using a face recognition oriented GCA. Then, the face recognition is realized by minimizing the distance measures in a specific cluster as in the traditional subspace face recognition algorithms. The contributions of this study are summarized as follows: 1) The class, i.e., person is regarded as an element in the clustering rather than an image. 2) The proposed GCA uses a novel distance to measure the similarity between a class and the cluster centroids of different clusters. 3) The proposed GCA uses a balance factor to achieve balanced clustering results. Experimental results on the extended Yale-B database indicate that the proposed sequential subspace face recognition framework has higher accuracy compared with the traditional subspace methods and K-mean+traditional subspace methods.

Genetic Algorithms mining, Data mining that is multivariate in nature. This means that one or more of the attributes is in the form of a sequence. The notion of similarity or distance, used in time series data, is significant and affects the accuracy, time, and space complexity of the classification algorithm. There exist numerous similarity measures for time series data, but each of them has its own disadvantages. Instead of relying upon a single similarity measure, our aim is to find the near optimal solution to the classification problem by combining different similarity measures. In this work, we use genetic algorithms to combine the similarity measures so as to get the best performance. The weightage given to different similarity measures evolves over a number of generations so as to get the best combination. We test our approach on a number of benchmark time series datasets and present promising results.

Genetic algorithms algorithms such as classifiers. Recently,researchers have proposed evolutionary-based feature extraction methods that aim to find a good feature set by combining the original features with new features generated by mathematical transformations of the original features. In this paper, we propose dynamically collecting past performance information on promising features and operators to use in our mutation method. We consider how to make our evolutionary algorithm more reliable by reducing overfitting. Preliminary results using UCI data show that our dynamic mutation method only slightly enhances the classification accuracy but it produces more reliable results.

Insect-Scale Flapping-Wing Micro Air Vehicle online, in-flight, adaptation of a rigorous controller for hovering in an insect-scale flapping- wing micro air vehicle based on the Harvard RoboFly. That particular evolvable hardware oscillator, however, was a proof- of-concept prototype and is incapable of supporting the types of signal adaptation necessary to support on-line correction for other flight modes (E.G. roll, pitch, forward translation, etc.). This paper introduces a new oscillator design capable of supporting signal adaptation for all possible flight modes of the vehicle. It will also present preliminary experimental results demonstrating the adaptive oscillator to be capable of correcting for vehicle faults in a two degree of freedom (2DOF) control task requiring simultaneous regulation of vehicle altitude and roll. The paper will conclude with discussion of application of this adaptive, evolvable oscillator to full vehicle control.

Scale Flapping-Wing Micro Air Vehicle applications of a Flapping-Wing Micro Air Vehicle (FW-

MAV) has been presented which meets the various needs of such a device. Unique challenges posed by the small size of such a device include accounting for process variation during the manufacturing of small scale wings and effectors, damage accumulation during the operation of the device, as well as weight and power restrictions limiting the computational power available on-board the device have been overcome with a cycle-average controller which preserves mathematical rigor while still allowing computational power for evolvable hardware on-board the device. This paper will describe an attempt to optimize altitude control learning times on a controller which has been shown to support single DOF flight with the intent to shorten learning times of a multiple DOF flight controller which is much more computationally intense.

Software Architecture Design Multiobjective optimization modern component-based software development which is based on the idea that develop software systems by assembling appropriate off-the-shelf components with a well-defined software architecture. Component-based software development has achieved great success and been extensively applied to a large range of application domains from realtime embedded systems to online web-based applications. In contrast to traditional approaches, it requires software architects to address a large number of non-functional requirements that can be used to quantify the operation of system. Moreover, these quality attributes can be in conflict with each other. In practice, software designers try to come up with a set of different architectural designs and then identify good architectures among them. With the increasing scale of architecture, this process becomes time-consuming and error-prone. Consequently architects could easily end up with some suboptimal designs because of large and combinatorial search space. In this paper, we introduce AQOSA (Automated Quality-driven Optimization of Software Architecture) toolkit, which integrates modeling technologies, performance analysis techniques, and advanced evolutionary multiobjective optimization algorithms (i.e. NSGA-II, SPEA2, and SMS-EMOA) to improve non-functional properties of systems in an automated manner.

programming optimisation to Cartesian genetic programming (CGP) when used for evolution of cell-array configurations. A cell-array is a proposed type of custom FPGA, where digital circuits can be formed from interconnected configurable cells; thus, the CGP nodes are more complex than in its standard implementation. We have described modifications to a previously described optimisation algorithm that has led to significant improvements in performance; circuits close to a hand designed equivalent have been found, in terms of the optimised objectives. Additionally we have investigated the effect of circuit decomposition techniques on evolutionary performance. We found that using a hybrid of input and output decomposition techniques substantial reductions in evolution time were observed. Further, while the number of circuit inputs is the key factor for functional evolution time, the number of circuit outputs is the key factor for optimisation time.

Algorithm Although evolutionary algorithms (EAs) have been successfully applied to unconstrained real-parameter optimization problems, it is sometimes difficult for these methods even to find feasible solutions in constrained ones. In this study, we thus propose a technique that makes EAs possible to solve function optimization problems with several inequality and a single equality constraints. The proposed technique simply forces individuals newly generated to satisfy the equality constraint. In order to generate these individuals, this study utilizes a Markov chain Monte Carlo (MCMC) method and crossover kernels. While the proposed technique can be applied to any EA, this study applies it to a relatively simple one, UNDX/MGG. Experimental results show that UNDX/MGG with the proposed technique has an ability to solve unimodal and multimodal function optimization problems with constraints. Finally, we show that, although our approach cannot solve function optimization problems with multiple equality constraints, we can convert some of them into those with a single equality constraint.

and combinatorial optimization. for improving the quality of these algorithms' result when solving optimization problems. The difficulty lies in determining when to assign individual values to specific parameters during the run. This paper investigates the possible implications of a generic and computationally cheap approach towards parameter analysis for population-based algorithms. The effect of parameter settings was analyzed in the application of a genetic algorithm to a set of traveling salesman problem instances. The findings suggest that statistics about local changes of a search from iteration i to iteration i+1 can provide valuable insight into the sensitivity of the algorithm to parameter values. A simple method for choosing static parameter settings has been shown to recommend settings competitive to those extracted from a state-of-the-art parameter tuner, paramILS, with major time and setup advantages.

collected into a fitness landscape. Often these landscapes are huge, making an exhaustive search for the best solution impractical. Stochastic search algorithms work best if the search operators are tailored to the fitness landscape structure. Some researchers claim this structure is induced by the search operator itself. In this paper we show structural information obtained from operator-induced neighborhoods can be completely misleading unless special ordering has prevailed during the mapping process and appropriate isomorphic proofs have been made.

Policy Search under an Episodic Goal Seeking Task collective behavior, Genetic programming generally fall into policy search as opposed to value function optimization approaches. Various recent results have made the claim that the policy search approach is at best inefficient at solving episodic 'goal seeking' tasks i.e., tasks under which the reward is limited to describing properties associated with a successful outcome have no qualification for degrees of failure. This work demonstrates that such a conclusion is due to a lack of diversity in the training scenarios. We therefore return to the Acrobot 'height' task domain originally used to demonstrate complete failure in evolutionary policy search. This time a very simple stochastic sampling heuristic for defining a population of training configurations is introduced. Benchmarking two recent evolutionary policy search algorithms – Neural Evolution of Augmented Topologies (NEAT) and Symbiotic Bid-Based (SBB) Genetic Programming – under this condition demonstrates solutions as effective as those returned by advanced value function methods. Moreover this is achieved while remaining within the evaluation limit imposed by the original study.

development vital area of research in the study of general human competence. Recently in artificial intelligence, formalizations of the mental attitudes of intentional agents have been extended to include agent capabilities with respect to artifacts or tools. We consider understanding how these individual capabilities are learned and how they evolve as important steps towards formally defining, representing and implementing complex group capabilities. In this paper, a theoretical model for artifact capability is extended to incorporate evolution and learning through exploratory methods. A representation of artifacts and the cognition of a rational agent that can learn artifact use are provided. Supervised learning is assumed and combined with historical knowledge and genetic algorithms to provide an implementation of a multi-agent simulation. The simulation is built to support an agent with the ability to learn an artifact capability through observations of its own behavior, as well as through observations of other agents in a social environment. Results obtained from the simple yet practical approach, show that learned use of artifacts outperforms random use and rational agents can learn artifact use more efficiently as a social species than on their own.

several ellipses or circles presented on a same image and with the presence of outliers. Each geometric form is extracted by means of a robust fitting, that is a nonlinear optimization problem, solved with two different heuristics: differential evolution and RANSAC. Once the geometric form is fitted, its points are extracted by calculating their statistics. Several tests with synthetic and real images are performed to show its effectiveness.

in fields such as security, animation, and human computer interaction (HCI). In this paper, we introduce a previously-unexplored swarm intelligence approach to multi-object monocular tracking by using Bacterial Foraging Optimization (BFO) swarms to drive a novel part-based pedestrian appearance tracker. We show that tracking a pedestrian by segmenting the body into parts outperforms popular blob-based methods and that using BFO can improve performance over traditional Particle Swarm Optimization and Particle Filter methods.

computerized. Conventional motion detection methods in machine vision can differentiate moving objects from background, but cannot directly handle different types of motions. In this paper, we present Genetic Programming (GP) as a method which not only removes relatively stationary background, but also can be selective on what kind of motions to capture. Programs can be evolved to select a certain type of moving objects and ignore other motions. That is to select fast moving target and ignore slowing moving ones. Furthermore programs can be evolved to handle these tasks even when the camera itself is in relatively arbitrary motion. This general GP method does not require additional process to differentiate various types of motions.

method by using a novel evolutionary clustering technique, namely multiagent genetic clustering algorithm (MAGAc). In MAGAc, the clustering problem is considered from an optimization viewpoint. Each agent is a matrix of real numbers representing the cluster centers. Agents interact with others under the pressure of environment to search the best partition of data. After extracting texture features from an image, MAGAc determines the partition of feature vectors using evolutionary search. In experiments, six UCI datasets and four artificial textural images are used to test the performance

of MAGAc. The experimental results show that in terms of cluster quality, MAGAc outperforms the K-means algorithm and a genetic algorithm-based clustering technique.

environments. uncertainties, among which a significant number belong to the dynamic optimization problem (DOP) category in which the fitness function changes through time. In this study, we propose the cultural based particle swarm optimization (PSO) to solve DOP problems. A cultural framework is introduced that incorporates the required information from the PSO into five sections of the belief space, namely situational knowledge, temporal knowledge, domain knowledge, normative knowledge and spatial knowledge. The stored information will be adopted to detect the changes in the environment and assists response to the change through a diversity based repulsion among particles and migration among swarms in the population space, also helps in selecting the leading particles in three different levels, personal, swarm and global level. Comparison of the proposed cultural based dynamic PSO demonstrates the better or equal performance with respect to other selected state-of-the-art dynamic PSO heuristics.

metaheuristics and hyper-heuristics mixed-integer programming problem. It has been solved by using optimization techniques such as dynamic programming, integer programming, and mixed-integer non-linear programming. On the other hand, a broad class of meta-heuristics has been developed for reliability-redundancy optimization. Recently, a new meta-heuristics called firefly algorithm (FA) algorithm has emerged. The FA is a stochastic metaheuristic approach based on the idealized behavior of the flashing characteristics of fireflies. In FA, the flashing light can be formulated in such a way that it is associated with the objective function to be optimized, which makes it possible to formulate the firefly algorithm. This paper introduces a modified FA approach combined with chaotic sequences (FAC) applied to reliability-redundancy optimization. In this context, an example of mixed integer programming in reliability-redundancy design of an overspeed protection system for a gas turbine is evaluated. In this application domain, FAC was found to outperform the previously best-known solutions available.

coefficient during freezing treatment by inverse analysis branch is the differential evolution (DE). DE is a powerful population-based algorithm of evolutionary computation field designed for solving global optimization problems which only has a few control parameters. With an eye to improve the performance of DE, in this paper, a DE approach combined with a cultural algorithm technique based on normative knowledge (NDE) is investigated to estimate the heat transfer coefficient during freezing treatment by inverse analysis. Numerical results for inverse heat transfer problem demonstrate the applicability and efficiency of the NDE algorithm. In this application, NDE approach outperforms a classical DE approach in terms of quality of solution.

applications Guillotine Two-Dimensional Cutting Stock Problem. The single-objective formulation of the problem has been widely studied in the related literature, so a large number of heuristics, meta-heuristics, and exact algorithms have been proposed in order to optimise the total profit obtainable from the available surface. However, in some industries, where the material is cheap enough or easily recycled, a faster generation of pieces and a minimum usage of the machinery could be more decisive aspects in determining the efficiency of the production process. For this reason, we have focused on a multi-objective formulation of the problem which seeks to maximise the total profit, as well as minimise the number of cuts to achieve the pieces. To solve this multi-objective problem we have applied Multi-objective Optimisation Evolutionary Algorithms given its great effectiveness with other types of real-world multi-objective problems. For the application of this kind of algorithms it has been necessary to define an encoding scheme which allows to deal with the problem intrinsic features. In this case, we have defined two encoding schemes which are based on a post-fix notation, thus simplifying the representation of guillotine patterns. The first encoding scheme controls the pieces included in the solution in order to generate valid builds. The second one generates a full solution, including all the available pieces, although the final values for the objectives are limited by the available surface. The computational results demonstrate that, in both cases, the multi-objective approach provides solutions with good compromise between the two objectives.

Heterogeneous ab initio Atomic Clusters algorithms search of the lowest-energy structures of heterogeneous atomic clusters. A new and improved crossover operator is proposed in order to always ensure the creation of new clusters with the same number of atomic elements. The approach proposed proved to be efficient and fast as all cluster calculations were performed by an ab initio quantum mechanics method, which is computationally expensive. Results of our search, obtained using the proposed approach, have been compared with previous calculations, and the efficiency has been confirmed,

as we were able to find the global minimum and propose a wide number of new isomers of low-energy. Specifically, we addressed the problem to deal with clusters of lithium and fluorine atoms. However, the proposed algorithm can be extended to all kind of atomic and molecular clusters.

Using Discretization Process discretization process (improved generator coordinate Hartree-Fock (IGCHF) and polynomial expansion) is proposed and evaluated for all first-row atoms. A Genetic Algorithm is used to vary and find the exponents values for the sets of basis functions that provide the lowest energies for all first-row atoms. Most of the difficulties to the development of efficient basis functions are related to the large number of exponents parameters to be optimized as well as the nonlinear nature of these functions. Ground state Hartree-Fock calculations for the first-row atoms using the new generated Gaussian basis set are carried out to demonstrate the improvement offered by this optimization technique. An improvement compared to the conventional optimization was verified when the Genetic Algorithm was applied.

Metaheuristics Using Multiple Topologies that has been demonstrated to be competitive with other metaheuristic algorithms such as Genetic Algorithms (GA), Particle Swarm Optimization (PSO), and Group Search Optimization (GSO). While CFO often shows superiority in terms of functional evaluations and solution quality, the algorithm is complex and often requires increased computational time. In order to decrease CFO's computational time, we have implemented the concept of local neighborhoods and implemented CFO on a Graphics Processing Unit (GPU) using the NVIDIA Compute Unified Device Architecture (CUDA) extensions for C/C++. Two different versions of CFO, Pseudo-Random CFO (PR-CFO) and Parameter Free CFO (PF-CFO), are examined using four test problems ranging from 30 to 100 dimensions. Results are compared and analyzed across four unique implementations of the PR-CFO and PF-CFO algorithm: Standard, Ring, CUDA, and CUDA-Ring. Decreases in computational time along with superiority in terms of solution quality are demonstrated.

Bilevel Linear Programming optimization problem involving two levels, and at least one level has multiple objectives. This paper mainly studies a special kind of MBLP with one objective at the lower level. With primal and dual theory, the lower level problem is transformed into a part of constraints of the upper level problem, then by handling the feasible set of the transformed problem, several equivalent problems of MBLP are obtained. Furthermore, by designing three feasible genetic operators, a new genetic algorithm for solving MBLP is presented. The simulations on several designed multiobjective bilevel linear programming problems are made, and the performance of the proposed algorithm is verified by comparing with the existing algorithms. The results show that the proposed algorithm is effective for MBLP.

difficult, including the Light Up. Although, recently, such single-player games have received considerable attention from the scientific community, only a few papers address the Light Up. This paper presents a two phase Ant Colony Optimization algorithm to solve this puzzle. In the first phase, logical rules are applied to the game grid in order to restrict the space searched by the algorithm in the second phase. The approach was applied to thirty-two game instances with grids ranging from 7x7 to 40x30 solving them efficiently.

applications, Genetic algorithms will be used as inputs of a classifier. The selection of these features is one of the most crucial parts, because they will design the search space, and, therefore, will determine the difficult of the classification. Usually, these features are selected by using some prior knowledge about the signals, but there is no method that can determine that they are the most appropriate to solve the problem. This paper proposes a new technique for signal classification in which a Genetic Algorithm is used in order to automatically select the best feature set for signal classification, in combination with a kNN as classifier system. This method was used in a well known problem and its results improve those already published in other works.

applications in recent years, as proven by the large number of papers published. To accomplish this task, a lot of classification systems such as Support Vector Machines (SVMs) or Artificial Neural Networks (ANNs) are used. However, Recurrent Artificial Neural Networks (RANNs) that allow using the previously computed results to generate the actual output have hardly been used, although intuitively they may seem to be very useful in this field. This article proposes the use of RANNs to solve a well-known problem: the detection of epileptic seizures in EEG signals. The results show that RANNs can work it out satisfactorily, with a higher accuracy than other techniques previously used.

with applications in optimization of scheduling of rental cars and transport systems in general. This paper defines the problem and proposes a Transgenetic Algorithm for it. The proposed algorithm is

compared to a Memetic Algorithm presented in a previous work. In order to focus on differences between the evolutionary strategies of each algorithm, the algorithm proposed here share several elements with the memetic algorithm. Results of a computational experiment performed on twenty instances indicate that the cooperative evolutionary process of the transgenetic algorithm produces high quality solutions outperforming the comparison algorithm.

optimization better with Machine Learning tasks. Recently, the well-known Bagging approach was adapted to solve biclustering problems, where the objective is to find large sub-groups of samples and attributes of the data matrix with the samples showing high correlation over the attributes. In this paper, aiming at the generation of more diverse and high-quality biclusters to be fused through an ensemble perspective, we have adopted a well-known multimodal Particle Swarm Optimization algorithm, namely NichePSO. In particular, the study brings a preliminary comparative assessment of the biclustering results delivered by NichePSO operating alone and by two ensemble settings (one of which is Bagging) operating on the biclusters produced by NichePSO. The assessment was done based on bioinformatics and collaborative filtering datasets, and the results achieved so far reveal the usefulness of ensembling the repertory of biclusters produced by NichePSO.

Schemes problems. importance for three main reasons: (i) a well designed dEA can outperform a 'standard' EA in terms of reliability, solution quality, and speed; (ii) they can (of course) be implemented on parallel hardware, and hence combine efficient utilization of parallel resources with very fast and reliable optimization; (iii) parallel hardware resources are increasingly common. A dEA operates as separate evolving populations with occasional interaction between them via 'migration'. A specific dEA is characterized by the topology and nature of these interactions. The performance of alternative topologies and migration mechanisms in this field remains under-explored. In this paper we continue an investigation of two simple, novel dEA topologies, comparing with the cube-based topology that underpins Alba et al's GD-RCGA (a state of the art dEA). The focus in this paper is on testing a novel adaptive migration scheme, in which the frequency of migration events adapts dynamically in response to the current balance between exploration and exploration. We also focus on high dimensional versions of a selection of hard function optimization problems. We find that the adaptive migration scheme is promising, and that overall results marginally favour a simple three-level treebased topology and adaptive migration with a longer window, especially as dimensionality increases.

with Viz3D and some of its variants when submitted to benchmark continuous optimization problems to reveal whether and how such variants change the patterns of search behavior exhibited by the canonical version. For this purpose, a new Visual Mining tool based on the Viz3D algorithm was developed to aid in the visualization of how the HS algorithms effectively explore the search space. The results achieved provide evidence that the gains in performance usually promoted by the HS variants are indeed related to noticeable modifications in the search behavior as displayed by the original version.

been proposed to overcome the problem of software behavior comprehension. If the code of a program is available, combining symbolic and concrete execution has been shown to provide an effective method to derive logic formulae that describe a program's behavior. However, symbolic execution does not work very well with loops, and thus such methods are not able to derive useful descriptions of programs containing loops. In this paper, we present a preliminary approach that aims to integrate genetic programming to synthesize a logic formula that describes the behavior of a loop. Such formula could be integrated in a symbolic execution based approach for invariant detection to synthesize a complex program behavior. We present a specific representation of formulae that works well with loops manipulating arrays. The technique has been validated with a set of relevant examples with increasing complexity. The preliminary results are promising and show the feasibility of our approach.

intelligence rows and columns from a given dataset expressing a relationship. Each subset is a bicluster and corresponds to a sub-matrix whose elements tend to present a high degree of coherence with each other, that may lead to novel discoveries regarding the objects in the dataset. This coherence leads to the possibility of obtaining representative values for rows (subset of objects) and columns (subset of attributes) of each bicluster. In the literature, it is usually studied the additive coherence among elements, i.e. each element is represented by the sum of its respective representative values. But in a given dataset, it is also possible to find multiplicative relations, i.e. each element being represented by the multiplication of its respective representative values, and that may reveal distinct knowledge contained in the objects of the dataset. So, in this paper, a swarm-based approach, named

SwarmBcluster, is adapted to find both additive and multiplicative coherent biclusters from a dataset, in an attempt to enrich the amount of information provided by the biclusters. Experiments are performed considering two well-known datasets and it is found that the multiplicative coherence biclusters improve the quality of the data analysis and may contribute to reduce the influence of noise.

matching tool to search for structures in a set of objects, like files, text documents or folders. Pattern matching can be used to look for files whose name contains a given string, to search files that contain a specific pattern within them, or simply to extract text in a set of documents. It is very popular to apply regexes to detect and extract patterns that represent phone numbers, URLs, email addresses, etc. These kind of information can be characterized because it has a well defined structure. Nevertheless, regexes are not very frequently used because its high complexity in both, syntax and grammatical rules, makes regexes difficult to understand. For this reason, the development of programs able to automatically generate, and evaluate, regexes has become a valuable task. This work analyzes the performance of different grammatical evolutionary approaches in the generation of regexes able to extract URL patterns. Four different types of grammars have been evaluated: a context-free grammar, a context-free grammar with a penalized fitness function, an extensible context-free grammar, and a Christiansen grammar. For the considered problem, the experimental results show that the best performance of the system, measured as cumulative success rate, is achieved using Christiansen grammars.

Classifier System Convergence, scalability and complexity analysis improve adaptive rule based systems designed to efficiently react in changing environments is the idea behind the problem studied in this paper. In this framework, the aim of this research is studying the benefits of using relational learning in combination with an evolutionary propositional learning system as XCS. The proposed method starts by learning a first order relational decission tree using a set of simplified instances of a problem. The learned relational model is then used to help a learning classifier system to deal with a more complex instance of the task. The researched strategy is based on injecting rules derived from the relational model in the discovering subsystem of the XCS. Results show that this method can be used to automatically adapt the behaviour of a learning rule based system when the environment increases its complexity.

Modeling and hybrid algorithms The ability to identify a shape with good performance is largely dependent on the underlying shape representation scheme. In this paper, a novel shape representation scheme is presented based on B-splines, wherein the control points representing the shape are repaired and subsequently evolved within the framework of a memetic algorithm. The underlying memetic algorithm is a multi-feature hybrid that combines the strength of a real coded genetic algorithm, differential evolution and a local search. Two test problems on shape matching are presented and solved using a mere 5000 function evaluations to illustrate the efficiency of the proposed scheme.

Optimization optimization a framework of multi-starting optimization methods based on scalarization for solving multiobjective function optimization problems. The experiments in the proposal show that AWA outperforms conventional multi-starting descent methods at coverage of solutions. However, the suitable termination condition for AWA have not been understood. Coverage of AWA's solutions and computational cost of AWA strongly depends on the termination condition. In this paper, we derive the necessary and sufficient iteration count to achieve high coverage and the number of approximate solutions generated until AWA stops. Numerical experiments show that AWA still achieves better coverage than the conventional methods under the derived termination condition.

solving a wide range of optimization problems. Cuckoo Search Algorithm (CS) is a novel meta-heuristic based on the obligate brood parasitic behaviour of some cuckoo species in combination with the Levy flight behavior of some birds and fruit flies. This algorithm has been applied in a wide range of optimization problems; nonetheless, their promising results suggest its application in the field of artificial neural networks, specially during the adjustment of the synaptic weights. On the other hand, spiking neurons are neural models that try to simulate the behavior of biological neurons when they are excited with an input current (input pattern) during a certain period time. Instead of generating a response in its output every iteration, as classical neurons do, this model generates a response (spikes or spike train) only when the model reaches a specific threshold. This response could be coded into a firing rate and perform a pattern classification task according to the firing rate generated with the input current. To perform a classification task the model ought to exhibit the next behavior: patterns from the same class must generate similar firing rates and patterns from other classes have to generate

firing rates sufficiently dissimilar to differentiate among the classes. The model needs of a training phase aimed to adjust their synaptic weights and exhibit the desired behavior. In this paper, we describe how the CS algorithm can be useful to train a spiking neuron to be applied in a pattern classification task. The accuracy of the methodology is tested using several pattern recognition problems.

much research interest in recent years. Parallel computation can be applied to genetic algorithms (GAs) in terms of the processes of individuals in a population. This paper describes the implementation of GAs in the compute unified device architecture (CUDA) environment. CUDA is a general-purpose computation environment for GPUs. The major characteristic of this study is that a steady-state GA is implemented on a GPU based on concurrent kernel execution. The proposed implementation is evaluated through four test functions; we find that the proposed implementation method is 3.0-6.0 times faster than the corresponding CPU implementation.

data mining, Heuristics, metaheuristics and hyper-heuristics confident classifier ensemble to predict the class of a particular test pattern. The overproduce-and-choose strategy is a dynamic classifier ensemble selection method which is divided into optimization and dynamic selection phases. The first phase involves the test of different candidate ensembles in order to produce a population composed of the highest performing candidate ensembles. Then, the second phase calculates the domain of expertise of each candidate ensemble to pick up the solution with highest degree of certainty of its decision to classify the unknown test samples. It has been shown that the optimization phase decreases oracle, the upper bound of dynamic selection processes. In this paper we propose a hybrid algorithm to perform the optimization phase of overproduce-and-choose strategy. The proposed algorithm combines stochastic initialization of candidate ensembles of different sizes, with the traditional forward search greedy method. The objective is to apply oracle as search criterion during the optimization phase. We show experimentally that choosing the population of classifier ensembles taking into account the population oracle leads to increase the upper bound of the dynamic selection phase. Moreover, experimental results conducted to compare the proposed method to a multi-objective genetic algorithm (MOGA), demonstrate that our method outperforms MOGA on generating population of candidate ensembles with higher oracle rates.

multimodal data. The proposed method uses a population code (hypernetwork representation), i.e. a collection of codewords (hyperedges) and associated weights, which is adapted by evolutionary computation based on observations of positive and negative examples. The goal of evolution is to find the best compositions and weights of hyperedges to estimate the underlying distribution of the target concepts. We discuss the relationship of this method with estimation of distribution algorithms (EDAs), classifier systems, and %% modif ensemble learning methods. We evaluate the method on a suite of image/text benchmarks. The experimental results demonstrate that the evolutionary process successfully discovers salient codewords representing multi-modal feature combinations for describing and distinguishing different concepts. We also analyze how the complexity of the population code evolves as learning proceeds.

of Random 3-CNFs by Simple Crossover optimization., Genetic algorithms randomized hard problems such as that of finding Hamiltonian cycles in random graphs. We introduce a simple polynomial reduction of the problem of computing satisfiability assignments for random 3-CNFs to a constrained variant of the problem of computing simple paths in undirected graphs. We provide experimental results evidencing that the simple crossover technique, incorporated into the framework of a memetic model, inspired by Sexual Selection and Elitist/Evolution Strategy principles, is effective in practice to solve the satisfiability problem (for 3-CNF random instances satisfiable by hidden assignments).

optimization which has been used in a wide range of applications, due to its simple implementation, fast convergence, parallel behavior, and versatility in working with continuous and discrete domains. In this paper, we consider its application to the load balancing problem, in green smart homes. Specifically, an adapted version of the Binary PSO has been used to determine the optimal distribution of energy resources, accross different green energy sources in a green smart home. The case study of interest considers the usage of solar and wind energy, as green energy sources for the green smart home. Results demonstrate the effectiveness of the algorithm, in terms of the optimal outcome (efficient distribution of energy resources), finding installation material surplus, and the execution speed of the algorithm.

Inverse Dynamics been studied over the past decade. The path control of the tip of the two link manipulator is a challenging problem due to the coupled and non-linear dynamics. In addition, parameter variations in terms of moments of inertia/ mass provide additional challenge to control engineers. This paper considers the positioning of the end-effector based on inverse dynamics, without

specifying a particular path. Fuzzy Logic Control (FLC) and Genetic Fuzzy Logic Control (GFLC) based controllers are designed and compared with the conventional Proportional-Derivative (PD) controller. Hybrid cost function is used in the Genetic Algorithm (GA) to achieve better performance. The membership functions of the FLC along with the scaling gains of the hybrid cost function are optimized using the GA algorithm. Numerical simulations show the improvements in the performance and robustness to parameter variations and noise.

Multi-agent Control System of Smart Building proposed for the intelligent control of smart buildings. A multi-agent control system is applied for the energy management and building operation. Particle Swarm Optimization (PSO) is applied to optimize the set points based on the comfort zone. Integrating a grey predictor to predict outdoor temperature with the FACT model shows great promise in systematically determining the customer temperature comfort zone for smart buildings. With the application of the FACT model and other intelligent technologies, the multi-agent control system has successfully provided a high-level of temperature comfort with low power consumption to customers in smart building environments. Case studies and corresponding simulation results are presented and discussed in this paper.

Filter and Wrapper algorithms such as classifiers. Feature extraction selects and transforms original features to find information hidden in data. Due to the huge search space of selection and transformation of features, exhaustive search is computationally prohibitive and randomized search such as evolutionary algorithms (EA) are often used. In our prior work on evolutionary-based feature extraction, an individual, which represents a set of features, is evaluated by estimating the accuracy of a classifier when the individual's feature set is used for learning. Although incorporating a learning algorithm during evaluation, which is called the wrapper approach, generally performs better than evaluating an individual simply by the statistical properties of data, which is called the filter appproach, our EA based on a wrapper approach suffers from overfitting, so that a slight enhancement of fitness in training can dramatically reduce the classification accuracy for unseen testing data. To cope with this problem, this paper proposes a two-population EA for feature extraction (TEAFE) that combines filter and wrapper approaches, and shows the promising preliminary results.

Constrained Optimization Problems models, Coevolutionary systems relatively new field of research in evolutionary computation (EC). At present, few EC works have been published to handle problems plagued with constraints that are expensive to compute. This paper presents a surrogate-assisted memetic co-evolutionary framework to tackle both facets of practical problems, i.e. the optimization problems having computationally expensive objectives and constraints. In contrast to existing works, the cooperative coevolutionary mechanism is adopted as the backbone of the framework to improve the efficiency of surrogate-assisted evolutionary techniques. The idea of randomproblem decomposition is introduced to handle interdependencies between variables, eliminating the need to determine the decomposition in an ad-hoc manner. Further, a novel multi-objective ranking strategy of constraints is also proposed. Empirical results are presented for a series of commonly used benchmark problems to validate the proposed algorithm.

Algorithm For Real World Optimization Problems, Real-world applications, Intelligent systems applications Differential Evolution algorithm (SACWIDE), where the cluster number is dynamically changed by the suitable learning strategy during evolution and also the algorithm strategically determines whether a particular cluster will perform Differential Evolution (DE) or new weeds to be generated for avoiding the shrinking. The performance of SACWIDE is reported on the set of 22 benchmark problems of CEC-2011.

Global Optimization metaheuristics and hyper-heuristics nature-inspired algorithms for real parameter optimization at present. In this article, we introduce a new variant of PSO referred to as Hierarchical D-LPSO (Dynamic Local Neighborhood based Particle Swarm Optimization). In this new variant of PSO the particles are arranged following a dynamic hierarchy. Within each hierarchy the particles search for better solution using dynamically varying sub-swarms i.e. these sub-swarms are regrouped frequently and information is exchanged among them. Whether a particle will move up or down the hierarchy depends on the quality of its sofar best-found result. The swarm is largely influenced by the good particles that move up in the hierarchy. The performance of Hierarchical D-LPSO is tested on the set of 25 numerical benchmark functions taken from the competition and special session on real parameter optimization held under IEEE Congress on Evolutionary Computation (CEC) 2005. The results have been compared to those obtained with a few best-known variants of PSO as well as a few significant existing evolutionary algorithms.

with Fuzzy Dominance areas based on decomposition, with fuzzy dominance (MOEA/DFD). The algorithm introduces a fuzzy Pareto dominance concept to compare two solutions and uses the scalar decomposition method only when one of the solutions fails to dominate the other in terms of a fuzzy dominance level. The diversity is maintained through the uniformly distributed weight vectors. In addition, Dynamic Resource Allocation (DRA) is used to distribute the computational effort based on the utilities of the individuals. To assess the performance of the proposed algorithm, experiments were conducted on two general benchmarks and ten unconstrained benchmark problems taken from the competition on real parameter MOEAs held under the 2009 IEEE Congress on Evolutionary Computation (CEC). As per the IGD metric, MOEA/DFD outperforms other major MOEAs in most cases.

algorithm for single-hidden layer feedforward neural network (SLFN) much faster than the traditional gradient-based learning strategies. However, ELM random determination of the input weights and hidden biases may lead to non-optimal performance, and it might suffer from the overfitting as the learning model will approximate all training samples well. In this paper, a hybrid approach is proposed based on Group Search Optimizer (GSO) strategy to select input weights and hidden biases for ELM algorithm, called GSO-ELM. In addition, we evaluate the influence of different forms of handling members that fly out of the search space bounds. Experimental results show that GSO-ELM approach using different forms of dealing with out-bounded members is able to achieve better generalization performance than traditional ELM in real benchmark datasets.

Minimization directly to the distribution network or on the customer site of the meter. It is related with the use of small capacity units installed in strategic points of electric distribution system and mainly close to the load centres. An optimal placement of DC can minimize the losses in the system, improve voltage profiles and increase load factors of distribution system. This paper proposes an accurate method for optimal allocation of DC in the distribution systems based on intelligent technique namely particle swarm optimization (PSO). The system loss of electrical network is used as an indicator to evaluate the impact of DC location on system reliability and voltage profile. To demonstrate the global optimization power of the presented techniques, the IEEE 30-bus test system has been used in this study to evaluate the proper location of the DC in the electrical network. The results illustrate a high reduction of system losses when DC is located at the proper location with suitable size compared with the system loss at the base case.

genetic programming. The interpretation of a stochastic model results in a set of time series behaviors. Each time series denotes changing quantities of components within the modeled system. The time series are described by their statistical features. This paper uses genetic programming to reverse engineer stochastic pi-calculus models. Given the statistical characteristics of the intended model behavior, genetic programming attempts to construct a model whose statistical features closely match those of the target process. The feature objectives comprising model behavior are evaluated using a multi-objective strategy. A contribution of this research is that, rather than use conventional Pareto ranking, a summed rank scoring strategy is used instead. Summed rank scoring was originally derived for high-dimensional search spaces. This paper shows that it is likewise effective for evaluating stochastic models with low- to moderate-sized search spaces. Two models with oscillating behaviors were successfully evolved, and these results are superior to those obtained from earlier research attempts. Experiments on a larger-sized model were not successful. Reasons for its poor performance likely include inappropriate choices in feature selection, and too many selected features and channels contributing to an overly difficult search space.

can be passed. This study uses a recentering-restarting evolutionary algorithm to locate likely epidemic networks for six different epidemic profiles containing early peaks, late peaks, and multiple peaks in the number of infected individuals. This study demonstrates that the algorithm can fit a broad variety of epidemic profiles. The difficulty of finding a network likely to produce a given epidemic profile varies between profiles, but all six profiles are fitted well in at least some of the evolutionary runs. A pseudometric on pairs of networks based on diffusion characters is used to assess the networks distribution in the space of networks. Both the scatter of networks evolved to match a single epidemic profile and the between-profile distances are evaluated. The diffusion character based pseudometric separates the networks for some pairs of profiles neatly while others apparently overlap to some degree.

Using Gene Expression, Evolved Neural Networks, and a Cell-based Platform humans. This process includes a series of genotoxic screens in the discovery phase, and in the event the drug is designed for chronic use, a 2-year non- genotoxicity rodent study. Such non-genotoxicity studies are very expensive

because of their duration, the amount of compound required, and the number of rodents required. Models capable of predicting genotoxicity during discovery would reduce these costs and increase favorable outcomes for drugs in a pipeline of development by reducing the rate of attrition. To that end, we have used gene expression data and evolved neural networks to classify compounds by their carcinogenicity or genotoxicity. 60 compounds were used for the training and testing of classifiers relative to gene expression from rat liver cells. Genes related to xenobiotic metabolism, proliferation, apoptosis, and DNA damage were identified. Our study demonstrates that evolved neural networks can be used to classify compounds as carcinogenic or genotoxic with reasonable accuracy.

optimization problem attractive for its complexity, rich library of test data and variety of real world applications. In this paper, we use differential evolution accelerated by the GPU using the nVidia CUDA platform to find good LOP solutions. The well known LOLIB library was used to evaluate the efficiency and precision of the approach in solving LOP instances.

the parallel computing area is witnessing a rapid change in dominant parallel systems. A major hurdle in this switch is the Single Instruction Multiple Thread (SIMT) architecture of GPUs which is usually not suitable for the design of legacy parallel algorithms. Genetic Algorithms (GAs) is no exception for that. GAs are commonly parallelized due to the high demanding computational needs. Given the performance of GPGPUs, the need to best exploit them to maximize computing efficiency for parallel GAs is demandingly growing. The goal of this paper is to shed light on the challenges parallel GAs designers/programmers will likely face while trying to achieve this, and to provide some practical advice on how to maximize GPGPU exploitation as a result. To that end, this paper provides a study on adapting legacy parallel GAs on GPGPU systems. The paper exposes the design challenges of nVidia's GPU architecture to the parallel GAs community by: discussing features of GPU, reviewing design issues in GPU relevant to parallel GAs, the design and introduction of new techniques to achieve an efficient implementation for parallel GAs and observing the effect of the pivotal points that both capitalize on the strengths of GPU and limit the deficiencies/overheads of GPUs. The paper demonstrates the performance of designed-for-GPGPU parallel GAs representing the entire spectrum of legacy parallel model of GAs over nVidia Tesla C1060 workstation showing a significant improvement in performance after optimizing and tuning the algorithms for GPU.

quadratic assignment problems (QAPs) on a graphics processing unit (GPU) by combining fast, 2-opt local search in compute unified device architecture (CUDA). In 2-opt for QAP, 2-opt moves can be divided into two groups based on computing cost. In one group, the computing cost is O(1) and in the other group, the computing cost is O(n). We compute these groups of 2- opt moves in parallel by assigning the computations to threads of CUDA. In this assignment, we propose an efficient method that can reduce disabling time in each thread of CUDA. The results show GPU computation with 2-opt produces a speedup of x24.6 on average, compared to computation with CPU.

Settings properly configuring control parameters such as mutation rate, crossover rate, and population size. We consider the problem of setting control parameter values in a standard, island-model distributed genetic algorithm. As an alternative to tuning parameters by hand or using a self-adaptive approach, we propose a very simple strategy which statically assigns random control parameter values to each processor. Experiments on benchmark problems show that this simple approach can yield results which are competitive with homogeneous distributed genetic algorithm using parameters tuned specifically for each of the benchmarks.

NPCs in a game. The agents move based on information about their local environment and have evolved weapons, armor, ability to take damage, and movement factors. The creation of the agent is divided into two phases. In the first a population of competent movement controllers are evolved. In the second, the agents start with a competent movement controller and evolve weapons, levels of armor, number of hit points, and numbers of movement factors. The movement controller continues to evolve in the second phase. The evolution of the agents equipment is constrained by a budget together with a price for each type of object the agent can have. The gene specifying the agents equipment is in the form of a "wish list" of equipment, traversed left-to-right, with the agent buying items from the list as long as its budget suffices. An agent that is a more dangerous opponent can be evolved by giving it a larger budget. A group of experiment were conducted and they demonstrate that the budget can be used to control an agent's toughness. Additional experiments show that changing the price list for different items can also be used to control the types of agents that evolve. Pitfalls in the selection of the fitness function for the agents are discussed.

iterated prisoner's dilemma. Laran is based on an evolutionary algorithm, but instead of using

evolution as a mean to define a suitable strategy, it uses evolution to model the behavior of its adversary. In some sense, it understands its opponent, and then exploits such knowledge to devise the best possible conduct. The internal model of the opponent is continuously adapted during the game to match the actual outcome of the game, taking into consideration all played actions. Whether the model is correct, Laran is likely to gain constant advantages and eventually win. A prototype of the proposed approach was matched against twenty players implementing state-of-the art strategies. Results clearly demonstrated the claims.

function of a chess program whose search engine is based on evolutionary programming. In our proposed approach, each individual in the population of the evolutionary algorithm represents a virtual player with specific weights of its evaluation function. This differs from most of the previous approaches reported in the literature, in which normally a tournament between virtual players is held, and the final result (win, loss or draw) is used to decide which players pass to the following generation. The selection mechanism of our proposed algorithm uses games from chess grandmasters to decide which virtual player will pass to the following generation. Our results indicate that the weight values obtained by our approach are similar to the values known from chess theory. Additionally, the standard deviation from the different runs performed, are lower than those reported by authors of previous related approaches.

high-quality content elements for use in games. This study specifies and tests an evolutionary-computation based system to generate tiles and plans that decompose the problem of assembling large levels. Evolutionary computation is used as an off-line tool to generate libraries of both tiles and assembly plans. Systems for rapidly assembling tile libraries can then be used to generate large levels on demand with combinatorially huge numbers of levels available. The study also introduces new fitness functions, generalizing early work on checkpoint based fitness for the evolution of mazes, that is especially well suited for tile creation. Tiles are generated using two different representations that yield tiles with very different appearances. The study demonstrates assemblies of large levels and outlines several directions for extending the work.

solving Constrained Optimization Problems (COPs). Due to the variability of the characteristics in different COPs, none of these algorithms performs consistently over a range of problems. In this paper, we introduce a Genetic Algorithm with a new multi-parent crossover for solving a variety of COPs. The proposed algorithm also uses a randomized operator instead of mutation and maintains an archive of good solutions. The algorithm has been tested by solving the 36 test instances, introduced in the CEC2010 constrained optimization competition session. The results show that the proposed algorithm performs better than the state-of-the-art algorithms

Optimization than its unconstrained counterpart. In solving COPs, the feasibility of a solution is a prime condition that requires the conversion of one or more infeasible individuals to feasible individuals. In this paper, to encourage the effective movement of infeasible individuals towards a feasible region, we introduce a Constraint Consensus (CC) method within the Differential Evolution (DE) algorithm for solving COPs. The algorithm has been tested by solving 13 well-known benchmark problems. The experimental results show that the solutions are competitive, if not better, as compared to the state of the art algorithms

Immune Algorithm artificial immune algorithm. We have tested the algorithm in the recently proposed instances of the problem, the results obtained are very encouraging.

Radiosurgical Treatment Planning radiosurgical treatments delivered via the CyberKnife (Accuray, Inc., Sunnyvale, CA) system. The fitness function includes terms representing the tumor as well as terms representing organs-at-risk, and is of a quadratic form. Optimization involves inverse treatment planning, during which a set of beam weights is sought such that the user-specified radiation dose distribution is produced by the optimized ensemble of beam weights; the dose to the tumor is maximized, while the doses to the critical structures are minimized. In the present study, four distinct CT data sets for patients with carcinoma of the prostate were used to generate eight treatment plans, so that for each data set, a hypofractionated treatment plan (5 fractions) was created, as well as a treatment plan for a standard protracted dose fractionation schedule (38 fractions). In all cases, the memetic algorithm produced a treatment plan satisfying all clinical criteria in optimization times of 22-46 minutes.

system is deemed to be correct only if all jobs complete execution at or before their deadlines. Such strict timing requirements add to the complexity of the scheduling problem. This complexity is exacerbated when the system is executed on a multiprocessor platform. Even so, scheduling overheads must be kept to a minimum in order for the runtime behavior to be predictable. Thus, real-time scheduling algorithms have the dual requirement of satisfying complex requirements while using fairly

simple and straightforward logic. One way an algorithm may achieve this goal is to reduce the overhead due to preemption and migration by rearranging the schedule so as to increase the duration between preemptions. Unfortunately, determining how best to rearrange the jobs is an NP- Complete problem. Hence, we need to use heuristics when scheduling such systems. This leads us to ask a couple of questions. First, what is the best heuristic? Second, is the same heuristic best for all real-time systems? This paper uses a Genetic Algorithm to help us answer these questions. Our genetic algorithm based real-time system scheduler (GART) is based on the DP-Wrap scheduling algorithm. The genetic algorithm searches through a variety of candidate heuristics to determine the best heuristic for a given task set. Experimental results demonstrate that this approach is able to efficiently identify the best heuristic for all the systems we consider. Moreover, we find that the "best"heuristic does, in fact, depend of various system parameters.

swarm optimization reservoirs, it is necessary to create and update reservoir models using observations collected over time in a process known as history matching. This is an inverse problem: it requires the optimization of reservoir model parameters so that reservoir simulation produces response data similar to that observed. Since reservoir simulations are computationally expensive, it makes sense to use relatively sophisticated algorithms. This led to the use of the Bayesian Optimization Algorithm (BOA). However, the high performance of a much simpler algorithm - Particle Swarm Optimization (PSO) - led to the development of a BOA-PSO hybrid that outperformed both BOA and PSO on their own.

Engineering applications synthesis of MEMS components. A case study of layout synthesis of a comb-driven micro-resonator shows that the approach proposed in this paper can lead to design results accommodating two design objectives, i.e. simultaneous minimization of size and power input of a MEMS device, while investigating optimum geometrical configuration as the main concern. The major contribution of this paper is the application of memetic computing in MEMS design. An evolutionary multi-objective optimization (EMO) technique, in particular non- dominated sorting genetic algorithm (NSGA-II), has been applied to find multiple trade-off solutions followed by a gradient-based local search, i.e. sequential quadratic programming (SQP), to improve the convergence of the obtained Pareto-optimal front. In order to reduce the number of function evaluations in the local search procedure, the obtained non-dominated solutions are clustered in the objective space and consequently, a post-optimality study is manually performed to find out some common design principles among those solutions. Finally, two reasonable design choices have been offered based on manufacturability issues.

programming, Coevolution and collective behavior complex networks is to create multi-agent simulations that output networks with similar characteristics to the ones derived from real data. For example, a well know explanation for the power law degree distributions found in blog (and other) networks is the agent-level endogenous mechanism of preferential attachment. However, once simplifying assumptions are dropped, finding lower level behaviors that explain global network features can become difficult. One case, explored in this paper, is that of modeling a blog network generated by human agents with heterogeneous behaviors and a priori diversity. We propose an approach based on an hybrid strategy, combining a generic behavioral template created by a human designer with a set of programs evolved using genetic programming. We present experimental results that illustrate how this approach can be successfully used to discover a set of non-trivial agent-level behaviors that generate a network that fits observed data. We then use the model to make successful testable predictions about the real data. We analyze the diversity of behaviors found in the evolved model by clustering the agents according to the execution paths their programs take during the simulation. We show that these clusters map to different behaviors, giving credence to the need for exogenous, in addition to the more conventional endogenous explanations, for the dynamics of blog networks.

Classification Problems mining, Data mining search strategies, named Memetic Genetic Programming(MGP), for classification problems. MGP aims to acquire a classifier with large Area Under the ROC Curve (AUC), which has been proved to be a better performance metric for traditionally used metrics (e.g., classification accuracy). Three new ideas are presented in our new algorithm. First, a new representation called statistical genetic decision tree (SGDT) for GP is proposed on the basis of Genetic Decision Tree (GDT). Second, a new fitness function is designed by using statistic information from SGDT. Third, the concept of memetic computing is introduced into SGDT. As a result, the MGP is equipped with a local search method based on the training algorithms for decision trees. The efficacy of the MGP is empirically justified against a number of relevant approaches.

analysis and data mining providing different representations of a problem from which classifiers

can learn from. Examples of these representations are, for instance, sound and image for the case of the video classification problem. The main idea behind multi-view learning is that learning from these representations separately can lead to better gains than merging them into a single dataset. In the same way as ensembles combine results from different classifiers, the outputs given by classifiers in different views have to be combined in order to provide a final class for an example. This paper proposes a PSO algorithm to combine the outputs coming from different views. It also considers that some views may be better at classifying specific classes, and provides weighting schemes for both views and classes. Experiments were performed in two datasets with three views each, and compared with all views in a single dataset, a majority voting scheme and a scheme based on the Dempster-Shafer theory. Experimental results show that the PSO obtains statistically better results than the other approaches evaluated.

classification task. The main difference among them is that in HC examples have to be assigned to classes organized in a previously defined class hierarchy, while in traditional flat classification no class order is imposed. There are two main approaches commonly used to tackle HC: the top-down or local approach, which is classifier independent, and the big-bang or global approach, which usually is the product of a modification of a well-known flat classifier. Although evolutionary algorithms have been successfully applied to flat classification, they are underexplored in HC. In this direction, this paper proposes HCGA (Hierarchical Classification Genetic Algorithm), a method that takes both local and global information into account. HCGA uses a top-down approach for building a classification model and also for classifying new examples. This is in contrast with current top-down methods, which make use of this strategy only for test, using flat classifiers for training models. The method was applied to four GPCR (G protein-coupled receptor) activity datasets, obtaining results statistically equal or better than five baseline classifiers run using a top-down approach.

Classification: Variable Terminal Weighting mining programming (GP). GP's implicit feature selection was used to construct a feature weighting vector, based on the fitness of solutions in which the features were found and the frequency at which they were found. The vector was used to perform feature ranking and to perform meta-learning by biasing terminal selection in mutation. The proposed meta-learning mechanism significantly improved the quality of solutions in terms of classification accuracy on an unseen test set. The probability of success—the probability of finding the desired solution within a given number of generations (fitness evaluations)—was also higher than canonical GP. The ranking obtained by using the GP-provided feature weighting was very highly correlated with the ranking obtained by commonly-used feature ranking algorithms. Population information during evolution can help shape search behaviour (meta-learning) and obtain useful information about the problem domain such as the importance of input features with respect to each other.

optimization., Estimation of distribution algorithms identifying a proper sequence of distributions, in a given model, that minimize the expected value of the fitness function. Different algorithms fit this framework, and they differ according to the policy they implement to identify the next distribution in the model. In this paper we present two algorithms, in the stochastic relaxation framework, for the optimization of real-valued functions defined over binary variables: Stochastic Gradient Descent (SGD) and Stochastic Natural Gradient Descent (SNDG). These algorithms use a stochastic model to sample from as it happens for Estimation of Distribution Algorithms (EDAs), but the estimation of the model from the population is substituted by the direct update of model parameter through stochastic gradient descent. The two algorithms, SGD and SNDG, both use statistical models in the exponential family, but they differ in the use of the natural gradient, first proposed in the literature by Amari, in the context of Information Geometry. Due to the properties of the exponential family, both gradient and natural gradient can be evaluated in terms of covariances between the fitness function and the sufficient statistics of the exponential family. As the computation of the exact gradient is unfeasible, we approximate the gradient by evaluating empirical covariances. We test the performance of our algorithm over different standard benchmarks, and we compare the results with other well-known meta-heuristics in the framework of EDAs.

Decision Space Dimensions Estimation of distribution algorithms overcoming some difficulties of cur- rent MOEDAs. MONEDA has been shown to yield relevant results when confronted with complex problems. Furthermore, its performance has been shown to adequately adapt to problems with many objectives. Nevertheless, one key issue remains to be studied: MONEDA scalability with regard to the number of decision variables. In this paper has a two-fold purpose. On one hand we propose a modification of MONEDA that incorporates an indicator-based selection mechanism based

on the HypE algorithm, while, on the other, we assess the indicator-based MONEDA when solving some complex two-objective problems, in particular problems UF1 to UF7 of the CEC 2009 MOP competition, configured with a progressively-increasing number of decision variables.

Networks detect and transmit features from the physical environment. Generally, the sensor nodes transmit informations to a special node, called sink. The use of an unique sink represents a bottleneck in a network, especially for applications in real time. In this sense, some researches have directed studies to the use of multiple sinks. The approach proposed by this paper presents the application of Genetic Fuzzy System (GFS) for the selection of routes in WNSs, in order to make the communication between multiple sensor nodes and multiple sink nodes. Fuzzy Inference System of Mamdani are used to determine the most appropriate sink node through consideration of some characterstics of the sensors network, such as energy and number of hops. Genetic Algorithms are employed to obtain the optimal adjustment of Mandani's fuzzy inference system parameters. By applying GAs, we intend to achieve both a fuzzy database and a fuzzy rules base to maximize performance of the application of Mamdani's inference system in the selection of routes in Wireless Sensor Networks. The proposed route selection was applied by means of computer simulations todemonstrate the feasibility of the approach implemented. The results obtained through simulations demonstrated a sensor network with a longer lifetime, through the choice of the adequate sink used for sending packets through the network in order to find the best routes.

Variable Size Genetic Network Programming (GNPvs) with Binomial Distribution. In contrast to the individuals with fixed size in Standard GNP, GNPvs will change the size of the individuals and obtain the optimal size of them during evolution. The proposed method defines a new type of crossover to implement the new feature of GNP. The new crossover will select the number of nodes to move from each parent GNP to another parent GNP. The probability of selecting the number of nodes to move satisfies the binomial probability distribution. The proposed method can keep the effectiveness of crossover and improve the performance of GNP. In order to verify the performance of the proposed method, a well-known benchmark problem - - Tile-world is used in the simulations. The simulation results show the effectiveness of the proposed method.

are the focus of intense research interest. Search and score algorithms using nature-inspired metaheuristics are an important strand of this research, however performance is variable and strongly problem-dependent. In this paper we use fitness landscape analysis to explain empirically-observed performance differences between particular search and score algorithms on two well-studied benchmark problems. We investigate the average landscape discovered by random walks around optimal points in the space of BN node orderings. Differences in algorithm performance are explained in terms of these landscapes, which in turn are related to properties of the BN structures. These initial findings suggest that fitness landscape analysis is a promising approach for explaining existing empirical performance comparisons with further potential for understanding the relative difficulty of benchmark problems and the robustness of particular algorithms.

uncertain environments. are used to make these operations more efficient. Distributed storage systems provide means to distribute the burden of storing and retrieving data onto multiple different computers. Routing indices can answer the central question in these systems: Where should one look for a specified data item? To be able to query for different columns in a relation or different entries in tuples, indexing for multiple dimensions is necessary. Our group applies a swarm-based approach to distributed storage leading to a new class of distributed systems, which are fully self-organized in their behavior and lack any shared global data structures. In this paper, we research whether multiple levels of routing indices can be maintained and used in such a distributed and self-organized storage service. To achieve this, we look into different types of indices and evaluate them in an experiment.

learning combinatorial optimization problems. However, like many stochastic algorithms, the quality of solutions worsen as problem sizes grow. In an effort to increase performance, we added the variable step size off-policy hill-climbing algorithm called PDWoLF (Policy Dynamics Win or Learn Fast) to several ant colony algorithms: Ant System, Ant Colony System, Elitist-Ant System, Rank-based Ant System, and Max-Min Ant System. Easily integrated into each ACO algorithm, the PDWoLF component maintains a set of policies separate from the ant colony's pheromone. Similar to pheromone but with different update rules, the PDWoLF policies provide a second estimation of solution quality and guide the construction of solutions. Experiments on large traveling salesman problems (TSPs) show that incorporating PDWoLF with the aforementioned ACO algorithms that do not make use of local optimizations produces shorter tours than the ACO algorithms alone.

Protein Structure Prediction genetic drift. As the protein structure prediction problem is multimodal having several global optima, EAs empowered with combined application of local and global search e.g., memetic algorithms, can be more effective. This paper introduces two novel local improvement techniques for the clustered memetic algorithm to incorporate both problem specific and search-space specific knowledge to find one of the optimum structures of a hydrophobic-polar protein sequence on lattice models. Experimental results show the superiority of the proposed techniques against existing EAs on benchmark sequences.

of complex biological systems. In most cases, high throughput microarray gene expression data is used for finding these regulatory relationships among genes. In this paper, we present a novel approach, based on decoupled S-System model, for reverse engineering GRNs. In the proposed method, the genetic algorithm used for scoring the networks contains several useful features for accurate network inference, namely a Prediction Initialization (PI) algorithm to initialize the individuals, a Flip Operation (FO) for better mating of values and a restricted execution of Hill Climbing Local Search over few individuals. It also includes a novel refinement technique which utilizes the fit solutions of the genetic algorithm for optimizing sensitivity and specificity of the inferred network. Comparative studies and robustness analysis using standard benchmark data set show the superiority of the proposed method.

State Classifiers classification of polymerase chain reaction primers in mice using graph based evolutionary algorithms. Using these machine learning tools we can compensate for many lab, organism, and chemical specific factors that can cause these primers to fail. Using Finite State Classifiers can help to decrease the number of primers that fail to amplify correctly. For training these classifiers, fifteen different graph based evolutionary algorithms were used in two different experiments to explore the effects of diversity preservation on the development of these classifiers. By controlling the rate at which information is shared in the evolving population, classifiers with a high likelihood of not accepting bad primers were found. This proposed tool can act as a post-production add-on to the standard primer picking algorithm for gene expression detection in mice to compensate for local factors that may induce errors.

Problems evolutionary and metaheuristic algorithms. Since CEC 2005 and CEC 2008 competitions, many different algorithms have been proposed to solve continuous problems. The advances on this type of problems are of capital importance as many real- world problems from very different domains (biology, engineering, data mining, etc.) can be formulated as the optimization of a continuous function. For this reason, we have proposed a hybrid DE-RHC algorithm that combines the search strength of Differential Evolution with the explorative ability of a Random Hill Climber, which can help the Differential Evolution algorithm to reach new promising areas in difficult fitness landscapes, such as those than can be found on real-world problems. To evaluate this approach, the benchmark problems proposed in the "Testing Evolutionary Algorithms on Real-world Numerical Optimization Problems"CEC 2011 special session have been considered.

Problems Problems solving optimization problems. Due to the variability of the characteristics in different optimization problems, none of these algorithms performs consistently over a range of problems. In this paper, we introduce a GA with a new multi-parent crossover for solving a variety of optimization problems. The proposed algorithm also uses both a randomized operator as mutation and maintains an archive of good solutions. The algorithm has been applied to solve the set of real world problems proposed for the IEEE-CEC2011 evolutionary algorithm competition.

Real-world Numerical Optimization Problems Problems been introduced for solving Optimization Problems. Due to the variability of the characteristics in optimization problems, no single DE algorithm performs consistently over a range of problems. In this paper, for a better coverage of problem characteristics, we introduce a DE algorithm framework that uses multiple search operators in each generation. The appropriate mix of the search operators, for any given problem, is determined adaptively. The proposed algorithm has been applied to solve the set of real world numerical optimization problems introduced for a special session of CEC2011

Problems Their application in optimization problems is well understood and significant amount of research has gone into the development of efficient GA operators. Besides GAs, a number of other Evolutionary Algorithms (EAs) and their performance-enhancing variations have been proposed. However, this upgraded performance is often achieved at the undesirable cost of introducing additional user-defined parameters. In an attempt to put forward a case for GA even when a plethora of other EAs are available, we present the results obtained by using a Real-Coded, Elite preserving GA on the Real World optimization problems of IEEE CEC-2011. Based on our preliminary investigations, we

would like to stress that the current work shall help bring forth the need to take a step back to re-assess the applicability of basic GAs to practical optimization before yet another Bio- inspired algorithm is introduced.

World Optimization Problems Problems large number of variables and highly nonlinear constraints and objective functions. While a number of efficient optimization algorithms and numerous mathematical benchmark test functions have been introduced in recent years, the performance of such algorithms have rarely been studied across a range of real world optimization problems. In this paper, we introduce an improved adaptive differential evolution (DE) algorithm and report its performance on the newly proposed real world optimization problems. The proposed differential evolution algorithm incorporates adaptive parameter control strategies; a center based differential exponential crossover and hybridization with local search to improve its efficiency. While comprehensive results of other algorithms on the test problems are unavailable at this stage, our preliminary comparison with published results indicates promising performance of the proposed DE across the range of problems.

prisoner's dilemma. This study models a different situation, called the Shopkeeper model of interaction, in which a state conditioned agent interacts with a series of other agents without resetting its internal state. This is intended to simulate the situation in which a shopkeeper interacts with a series of customers. In a majority of other studies agents either reset their internal state information before each new encounter or have relatively little internal state information. This means they cannot model situations such as being the customer after the customer from hell. We train shopkeeper prisoner's dilemma agents against a variety of distributions of possible customers. The shopkeepers specialize their behavior to their customers but sometimes fail to discover maximally exploitative behaviors. The evolved shopkeeper agents are subject to fingerprint analysis and are shown to differ substantially from agents evolved with a round-robin fitness functions. Evaluation of the behavior of the shopkeeper agents with customers they did not encounter during evolution provides additional evidence that shopkeepers specialized to the customers, but did so incompletely for the more complex sets of customers.

Punctuated Anytime Learning, for learning autonomous agents in the space combat game Xpilot. Fitness Biasing was originally developed as a means of linking the model to the actual robot in evolutionary robotics. We use fitness biasing with a standard genetic algorithm to learn control programs for a video game agent in real-time. Xpilot-AI, an Xpilot add-on designed for testing learning systems, is used to evolve the controller in the background while periodic checks in normal game play are used to compensate for errors produced by running the system at a high frame rate. The resultant learned controllers are comparable to our best hand-coded Xpilot-AI bots, display complex behavior that resemble human strategies, and are capable of adapting to a changing enemy in real-time.

and virtual environments is a difficult task. One solution, shaping, has worked well in evolution of neural networks for agent control in relatively straightforward environments such as the NERO video game, but is very labor-intensive. Another solution, coevolution, promises to establish shaping automatically, but it is difficult to control. Although these two approaches have been used separately in the past, they are compatible in principle. This paper shows how shaping can be applied to coevolution to guide it towards more effective behaviors, thus enhancing the power of coevolution in competitive environments. Several automated shaping methods, based on manipulating the fitness function and the game rules, are introduced and tested in a "capture-the-flaglike environment, where the controller networks for two populations of agents are evolved using the rtNEAT neuroevolution method. Each of these shaping methods as well as their combinations are superior to a control, i.e. direct evolution without shaping. They are effective in different and sometimes incompatible ways, suggesting that different methods may work best in different environments. Using shaping, it should thus be possible to employ coevolution to create intelligent agents for a variety of games.

Computational Intelligence (CI) research. We show how TD games can provide an important test-bed for the often under-represented casual games research area. Additionally, the use of CI in the TD games has the potential to create a more interesting, interactive and ongoing game experience for casual gamers. We present a definition of the current state and development of TD games, and include a classification of TD game components. We then describe some potential ways CI can be used to augment the TD experience. Finally, a prototype TD game based on experience-driven procedural content generation is presented.

games and multi-agent systems recent decades. Beyond the formalism of simple hybrids, adaptive hybrids and memetic algorithms, the notion of memetic automaton as an adaptive entity that is self-contained and uses memes as building blocks of information is recently conceptualized in the context of

computational intelligence as potential tools for effective problem-solving. Taking this cue, this paper embarks a study on Memetic Multiagent system (MeM) towards human-like social agents with memetic automaton. Particularly, we introduce a potentially rich meme-inspired design and operational model, with Darwin's theory of natural selections and Dawkins' notion of a meme as the principal driving forces behind interactions among agents, whereby memes formed the fundamental building blocks of the agents' mind universe. Experimental studies on a Mine Navigation Task indicates the modeling of memetic agents that resemble the natural way of human interaction can lead to greater level of adaptivity and effective problem-solving.

that investigate the evolution of a sensible fictional dialogue. A user-supervised EA was used given the difficulty of defining a fitness function for evolving art tasks. Two EAs were tested for the task of evolving dialogue given an English word population. The EAs required user-assigned fitness values to be given as input with varying degrees of frequency during the evolutionary process. The success of the EAs were comparatively evaluated with respect to two-point recombination and a novel complement gene scan operator. Task performance was evaluated according to average fitness, word and genotype diversity, and the number of words used in the fittest evolved dialogue. Results indicated that for both EAs, complement gene scan was more effective for evolving complex, sensible and grammatically correct dialogue, comparative to sentences evolved by the EAs using two-point recombination.

number of complex mathematical images. Evolutionary computation can be used to search the Mandelbrot set for interesting views. This study compares the results of using several different fitness functions for this search. Some of the fitness functions give substantial control over the appearance of the resulting views while others simply locate parts of the Mandelbrot set in which there are complicated structures. All of the fitness functions are based on finding desirable patterns in the number of iterations of the basic Mandelbrot formula to diverge on a set of points arranged in a regular grid near the boundary of the set. It is shown that using different fitness functions causes an evolutionary algorithm to locate difference types of views into the Mandelbrot set.

using fractals generated via evolutionary techniques. A photomosaic is a rendering of an image performed by placing a grid of smaller images that permit the original image to be visible when viewed from a distance. The problem of selecting the smaller images is a computationally intensive one. In this study we use an evolutionary algorithm to create fractal images on demand to generate tiles of the photomosaic. A number of images and tile resolutions are tested yielding acceptable results.

Ants may be reduced to finding paths through a graph. However, this class of bio-inspired heuristics have raised the interest of the artistic community as well, namely of the artists that work on the blurred border between art and science. This paper describes an extension of an ant algorithm that, although has been designed as an edge detection tool and a model for collective perception, has also been used for creating artworks that were exhibited to a heterogeneous audience. The algorithm is a self-organized and stigmergic social insects' model that is able to evolve lines along the contours of an image, in a decentralized and local manner. The result is the emergence of global patterns called pheromone maps. These maps - which were later named with the term pherographia - are grayscale sketches of the original black-and-white image on top of which the model evolves. This work goes beyond grayscale images and addresses colored pherographia, by proposing several image transformation and border selection methods based on behavioral variations of the basic algorithm.

creation process. We propose a generative drama approach that integrates human creativity by using an agent-based system where the characters are developed using interactive evolution. The author can then create a scenario from the agents' interaction which provides a foundation for the desired story, which is given its final artistic form through a mapping to a visual representation.

Multiobjective optimization Assignment Problem (FAP), which is one of the key issues in the design of Global System for Mobile Communications (GSM) networks. The used formulation of the FAP is focused on aspects which are relevant for real-world GSM networks. The best up to date frequency plans for the considered version of the FAP had been obtained by using parallel memetic algorithms. However, such approaches suffer from premature convergence with some real world instances. Multiobjectivisation is a technique which transforms a mono-objective optimisation problem into a multi-objective one with the aim of avoiding stagnation. A Multiobjectivised Memetic Algorithm, based on the well-known Non-Dominated Sorting Genetic Algorithm II (NSGA-II) together with its required operators, is presented in this paper. Several multiobjectivised schemes, based on the addition of an artificial objective, are analysed. They have been combined with a novel crossover operator. Computational results obtained for two different real-world instances of the FAP demonstrate the validity of the proposed model. The

new model provides benefits in terms of solution quality, and in terms of time saving. The previously known best frequency plans for both tested real-world networks have been improved.

topologies is presented. Genetic programming is used to evolve shape grammars. When interpreted, the shape grammars generate 3D models of buildings. Fitness evaluation considers user-specified criteria that evaluate different aspects of the model geometry. Such criteria might include maximizing the number of unique normals, satisfying target height requirements, and conforming to supplied shape contours. Multi-objective evaluation is used to analyze and rank model fitness, based on the varied user-supplied criteria. A number of interesting models complying to given geometric specifications have been successfully evolved with the approach. A motivation for this research application is that it can be used as a generator of conceptual designs, to be used as inspirations for refinement or further exploration.

Environment Computational Intelligence: production and distribution, and offer higher quality, secure, and more reliable electricity at low prices. In a deregulated environment, utilities are not required to meet the total load demand. Generation companies (GENCOs) schedule the generators that produce less than the predicted load demand and reserve, but aim to deliver maximum profits. The scheduling of generators depends on the market price. More number of generating units are committed when the market price is higher. When more number of generating units are brought in the deregulated market, more profit can be achieved by producing higher amount of power. This paper present an algorithm to solve a profit based unit commitment problem in a deregulated environment. The proposed algorithm has been developed from generation company's point of view. It maximizes the profit of the generation company in the deregulated power and reserve markets. A hybrid methodology between Lagrangian Relaxation and Generic Algorithm (LRGA) is used to solve generation scheduling in a day-ahead competitive electricity market. The results obtained are quite encouraging and useful in deregulated market optimization.

Real-world applications computational tool to assist in red teaming studies. In these applications, analysts seek to understand the strategic and tactical options available to each side in a conflict situation. Combining scenario simulations with a coevolutionary search of parameter space is an approach that has many attractions. We argue that red teaming applications are sufficiently different from many others where coevolution is used so that specially designed algorithms can bring advantages. We illustrate by presenting a new algorithm that simultaneously evolves strong strategies along with dangerous counter-strategies. We test the new algorithm on two example problems: an abstract problem with some difficult characteristics; and a practical red teaming scenario. Experiments show that the new algorithm is able to solve the abstract problem well, and that it is able to provide useful insights on the red teaming scenario.

Programming defined by John Koza in his first book. These measures, mainly computational effort and number of individuals to be processed, estimate the performance of the algorithm as well as the difficulty of a problem. Although Koza's performance measures have been widely used in the literature, their behaviour is not well known. In this paper we try to study the accuracy of these measures and advance in the understanding of the factors that influence them. In order to achieve this goal, we report an empirical study that attempts to systematically measure the effects of two variability sources in the estimation of the number of individuals to be processed and the computational effort. The results obtained in those experiments suggests that these measures, in common experimental setups, and under certain circumstances, might have a high relative error.

Programming search space non-uniformly, giving preferences to certain subspaces according to some heuristics. Adaptable CGP (ACGP) is a method for discovery of the heuristics. CGP and ACGP have previously demonstrated their capabilities using first-order heuristics: parent-child probabilities. Recently, the same advantage has been shown for second-order heuristics: parent- children probabilities. A natural question to ask is whether we can benefit from extending ACGP with deeper-order heuristics. This paper attempts to answer this question by performing cost-benefit analysis while simulating the higher- order heuristics environment. We show that this method cannot be extended beyond the current second or possibly third-order heuristics without a new method to deal with the sheer number of such deeper-order heuristics.

Sampling incremental sampling on Genetic Programming (GP). The new system, called GPLL, is tested and compared with standard GP on twelve symbolic regression problems. While GPLL does not differ from standard GP on univariate target functions, it has better training efficiency on problems with bivariate targets. This indicates the potential usefulness of layered learning with incremental

sampling in improving the efficiency of GP evolutionary learning.

inter-generation program relationships. For each program we cache a partial summary of program execution, and use this summary to expedite the execution of all progeny. We study the theory behind our new caching algorithm and derive equations for optimizing algorithm performance. Through both theoretical and empirical results we demonstrate that our caching algorithm can decrease LGP execution time by up to 50%

Problem to solve the Multi-Level Capacitated Lot Sizing Problem (MLCLSP). The proposed method combines a multi-population genetic algorithm and fix-and-optimize heuristic. These methods are also integrated to a mathematical programming approach. For this, a mathematical reformulation of MLCLDP model is proposed to embed the exact solution of the model in the heuristic approaches. The hybrid heuristic is evaluated in two sets of benchmark instances. The solutions found are compared with those reached by other methods from literature. The preliminary results obtained indicate that the hybrid heuristic outperforms other approaches in the majority of problems solved.

Multi-objective evolutionary algorithms function evaluations which can be costly in practice. These evaluations can be replaced by evaluations of a cheaper meta-model (surrogate model) of the objective functions. In this paper we present a novel distance based aggregate surrogate model for multiobjective optimization and describe a memetic multiobjective algorithm based on this model. Various variants of the models are tested and discussed and the algorithm is compared to standard multiobjective evolutionary algorithms. We show that our algorithm greatly reduces the number of required objective function evaluations.

with Restricted Equality Constraint Function Mapping Meta-modeling and surrogate models more focused on the efficiency aspect of the algorithms such that it would be possible to effectively employ MAs to solve computationally expensive optimization problems where single evaluation of the objective and constraint functions may require minutes to hours of CPU time. One of the important design issues in MAs is the choice of the individuals upon which local search procedure should be applied. Selecting only some potential individuals lessens the demand for functional evaluations hence accelerates convergence to the global optimum. In recent years, advances have been made targeting optimization problems with single equality constraint $h(x) = 0$. The presence of previously evaluated candidate solutions with different signs of constraint values within some localities thus allows the estimation of the constraint boundary. An individual will undergo local search only if it is sufficiently close to the approximated boundary. Elegant as it may seem, the approach had unfortunately assumed that every constraint function maps the design variables to optimize into unbounded real values. This, however, may not always be the case in practice. In this paper, we present a strategy to efficiently solve constrained problems with a single equality constraint; the function of which maps the design variables into restricted (either strictly non-negative or strictly non-positive) real values only.

Evolutionary Multiobjective Algorithms algorithms, Genetic algorithms functions are studied here, in order to speed up the convergence and the quality of solutions in evolutionary multiobjective algorithms. The hybrid methods studied here pick up points from the nondominated population and determine a CQA for each objective function. Since the CQA of the functions and the respective weighted sums are convex, fast deterministic methods can be used in order to generate approximated Pareto-optimal solutions from the approximated functions. A new scheme is proposed in this paper, using a CQA model that represents a lower bound for the function points, which can be solved via linear programming. This scheme and also another one using the methodology of linear matrix inequality (LMI) for CQA are coupled with a canonical implementation of the NSGA-II. Comparison tests are performed, using Monte Carlo simulations, considering the S-metric with an equivalent final number of evaluated objective functions and the algorithm execution time. The results indicate that the proposed scheme is promising.

Influence Function optimization. system based upon principles of cultural evolution. Cultural Algorithms employ a basic set of knowledge sources, each related to knowledge observed in various social species. Here we extend the influence and integration function in Cultural Algorithms by adding a mechanism by which knowledge sources can spread their influence throughout a population in the presence of heterogeneous layered social network. The interaction (overlapping) of the knowledge sources, represented as bounding boxes on the landscape, at the right level projects how efficient the cooperation is between the agents in the resultant "Social Network". The inter-related structures that emerge with this approach are critical to the effective functioning of the approach. We view these structures as constituting a "normal form"for Cultures within these real-valued optimization

landscapes. Our goal will be to identify the minimum social structure needed to solve problems of certain complexities. If this can be accomplished, it means that there will be a correspondence between the social structure and the problem environment in which it emerged. An escalating sequence of complex benchmark problems to our system will be presented. We conclude by suggesting the emergent features are what give cultural systems their power to learn and adapt.

optimization objectives. A computational version of cultural systems, Cultural Algorithms, has been extended to deal with multi-objective optimization problems. These approaches while employing the basic framework have used only a subset of the available knowledge sources. In this paper we present an extension of Cultural Algorithms for Multi-Objective optimization, MOCAT, the fully utilizes all of the available categories of knowledge sources. The synergy of this ensemble is demonstrated through the application to an example problem and the results compared with that of other approaches in metric terms.

Optimization metaheuristics for optimization, as it tends to allow a better exploration of the search space, thus reducing the susceptibility to local optima in multimodal optimization problems. In this context, metaheuristics based on the Artificial Immune System (AIS) framework, especially those inspired by the Immune Network theory, are known to be capable of stimulating the generation of diverse sets of solutions for a given problem, even though generally implementing very simple mechanisms to control the dynamics of the network. To increase such diversity maintenance capability even further, a new immune-inspired algorithm was recently proposed, which adopted a novel concentration-based model of immune network. This new algorithm, named cob-aiNet (Concentration-based Artificial Immune Network), was originally developed to solve real-parameter single-objective optimization problems, and it was later extended (with cob-aiNet[MO]) to deal with real- parameter multi-objective optimization. Given that both cob-aiNet and cob- aiNet[MO] obtained competitive results when compared to state-of-the-art algorithms for continuous optimization and also presented significantly improved diversity maintenance mechanisms, in this work the same concentration-based paradigm was further explored, in an extension of such algorithms to deal with single-objective combinatorial optimization problems. This new algorithm, named cob-aiNet[C], was evaluated here in a series of experiments based on four Traveling Salesman Problems (TSPs), in which it was verified not only the diversity maintenance capabilities of the algorithm, but also its overall optimization performance.

distribution algorithms Perceptrons (MLPs) for classification problems. Our proposal, called Gaussian Artificial Immune System (GAIS), is an estimation of distribution algorithm that replaces the traditional mutation and cloning operators with a probabilistic model, more specifically a Gaussian network, representing the joint distribution of promising solutions. Subsequently, GAIS utilizes this probabilistic model for sampling new solutions. Thus, the algorithm takes into account the relationships among the variables of the problem, avoiding the disruption of already obtained high-quality partial solutions (building blocks). Besides the capability to identify and manipulate building blocks, the algorithm maintains diversity in the population, performs multimodal optimization and adjusts the size of the population automatically according to the problem. These attributes are generally absent from alternative algorithms, and all were shown to be useful attributes when optimizing the weights of MLPs, thus guiding to high-performance classifiers. GAIS was evaluated in six well-known classification problems and its performance compares favorably with that produced by contenders, such as opt-aiNet, IDEA and PSO.

architectures design of a method for building complex systems with specific structural and/or functional properties. Most developmental models target specific computational architectures or structures of strictly defined building blocks, in both cases developmental models have strong connection to the target computational architecture/phenotype structure. In this work we seek a common developmental model that can target different architectures but also to find a common genetic representation that can include information that enables such a developmental model. The computational architectures with sparsely connected computational elements considered herein are cellular automata and boolean networks. The experiments study the evolvability of the genetic representation and prove that it is able to build stable structures for distinct computational architectures.

computation that have been described in the literature are graph-based mimicking the interactions observed in biological gene regulatory networks. Alternative methods that directly manipulate the dynamical control system for developmental processes have been termed Vector Field Embryogeny (VFE) and have been applied successfully to cell differentiation. In this paper, we compare the evolvability of graph-based and vector field representations for controlling developmental processes.

Inspired by the notion of strong causality in evolutionary strategies, we measure the covariance between genotype and phenotype changes for both representations. Furthermore, we propose a measure to characterize the representational power of both methods. If we compare VFE and graph-based representations with similar representational power, we notice that the covariance measure and therefore, the expected evolvability of VFE is higher. We also observe that the representational power of both methods decreases with increasing degree of freedom. We speculate that the reason for this could be the increased probability of the occurrence of strong point attractors.

on the generalized performance of the evolved solutions. Historically, if the training set was not representative of the problem's overall state space, the evolved solutions could not practically be applied to the problem in general. However, generative systems and indirect encodings are able to identify and leverage regularities in and the geometry of the state space to produce effective solutions to complex problems. This ability presents the possibility of using the regularity of a problem to effectively extrapolate evolved solutions to areas of the state space for which the training set was not representative. In this work, two different experiments are performed involving pattern reproduction and robot control to explicitly evaluate this extrapolation ability. Results show that an indirect encoding is able to extrapolate performance in one area of a problem's state space to a new area in which it has no experience with little to no loss of performance, depending on the regularities of the problem's state space. If the regularities were consistent through the entire state space and across the boundary between areas in which there was experience and no experience, extrapolation performance was high, but if the regularities were not consistent, there was a loss of performance.

Image Processing Techniques Acid (RNA) structure comparison is a fundamental problem. It is because structural comparison can facilitate RNA structure prediction and studies in RNA energy landscapes and conformational switches as well. There are many different tools have been proposed for RNA secondary structure comparison. This paper describes and presents a novel algorithm, RNADPCompare, for computing similarity measure of RNA secondary structures. The main idea for this algorithm is to represent the RNA secondary structure as a dot plot, and then process the dot plot as an image. The algorithm will utilize image processing techniques and heuristic understanding of the image properties to compute similarity measure of RNA secondary structures. Since many evolutionary and machine learning algorithms for RNA secondary structure design and prediction rely on good metric for examining structural similarities, therefore this novel metric will make significant contribution to the advances to these algorithms. An evaluation of the algorithm in terms of correlation to the native structure is made. The results from the six sequences of RNA from a variety of sequence lengths and organisms were tested. When comparing with Sfold, the prediction accuracy of RNADPCompare seems to be very promising. These results demonstrated that RNADPCompare is highly competitive in terms of the processing speed and accuracy when compare to other methods. This supports the use of this algorithm on other research in RNA secondary structure design and prediction.

complementary strengths for developing models of complex systems. Evolutionary algorithms are powerful meth- ods for finding solutions to optimisation problems with large search spaces but require an accurately defined fitness function to provide valid results. Process algebras are an effective method for defining models of complex interacting processes, but tuning parameters to allow model outputs to match experimental data can be difficult. Defining models in the first place can also be problematic. Our long term goal is to build a framework to synthesise process algebra models. Here we present a first step in that development: combining process algebra with an evolutionary approach to fine tune the numeric parameters of predefined models. The Evolving Process Algebra (EPA) framework is demonstrated through examples from epidemiology and computer science.

and Decision-Tree studied in many DNA related studies in Genetics. Recently some attempts in computer science have been made to use computational power to distinguish the different splice junction and non-junction regions in genes. Ambiguity in identifying nucleotides is an important issue when dealing with splice junction regions, which has been ignored in many approached toward this problem up to this date. In this paper a novel method is proposed along with an encoding schema which take ambiguities into account using intuitions from probability. The method is based on Decision Trees, using K-Nearest Negihbours classifier, and Support Vector Machines. The results have shown the significance of using the proposed encoding schema and classification method in improving splice junction classification.

evolutionary systems with the idea that evolution could be used as an optimization tool for engineering problems. For these evolutionary-computation researchers, the mechanisms of evolution

seem well suited for some of the most pressing computational problems in many fields. Ideas from Genetics are usually incorporated into evolutionary algorithms, such as: haploid crossover, mutation, diploid, inversion, gene doubling, deletion, and others. In the present study, we proposed an operator, named transgenic, for evolutionary algorithms, especially designed for Genetic Algorithms (GA). This operator is inspired in genetically modified organisms (GMOs), where important features are introduced into their genome artificially. The transgenic operator uses historical information to choose the best attributes, converging to the better results faster than traditional GAs. The GA, used in this study, allow the discovery of concise, yet accurate, high-level rules (from a biological and synthetic database) which can be used as a classification system. The obtained results show that transgenic operator is promising, obtaining better or the same results with a low number of generations and smaller populations.

Real-world Numerical Optimization Problems Problems have been proposed for diverse optimization tasks, most of which are practical engineering applications. In the previous research, one variant is always designed for one specific engineering application. In IEEE Congress on Evolutionary Competition, the numerical optimization competition is held to benchmark different optimization algorithms for more general applications. In this paper, we conduct the optimization method estimation of distribution and differential evolution (ED-DE) by implementing a two-stage ensemble idea, whose effectiveness and efficiency has been experimentally verified.

Optimization Problems Problems as in Memetic Algorithms (MAs), have been quite successful in solving a variety of optimization problems in the past. More recently, several excellent Differential Evolution (DE) based algorithms have been proposed which have had outstanding success in IEEE Congress on Evolutionary Computation (CEC) competition problems. Inspired by previous studies, we propose an algorithm combining the strengths of EA, DE and MA in this paper. The algorithm utilizes a population of random solutions to start with and generates a child population either through EA or DE based evolution with equal probability. Local search is then performed from one of the solutions in the population for further improvement objective value. To avoid stagnation, re-initialization of the population is performed whenever the local search is unable to improve the values consecutively for a prescribed number of generations. The performance of the proposed algorithm is presented in this paper for the newly introduced real world optimization problems for CEC 2011 competition.

Optimization Problems Problems assessment for bound and equality/inequality constrained numerical optimization is presented. The proposed algorithm is called Continuous Differential Ant-Stigmergy Algorithm and is derived from the Differential Ant-Stigmergy Algorithm, which transforms a real-parameter optimization problem into a graph-search problem. The original algorithm is extended to use arbitrary real offsets to navigate through the search space. Experimental results are given for the Real World Optimization Problems proposed for the Special Session on Testing Evolutionary Algorithms on Real-world Numerical Optimization Problems at 2011 IEEE Congress on Evolutionary Computation.

Optimization Problems and constraints. From an application point of view, it is usually desirable that the global optimum be achieved in such cases. Among selection, crossover and mutation operators of a genetic algorithm, the last two are responsible for search and diversity maintenance. By improving these operators, the efficiency of GAs can be improved. In this paper, we solve the problems specified in "CEC 2011 Competition on Testing Evolution Algorithms on Real World Optimization Problems"using a variation of the Simulated Binary Crossover (SBX) which adaptively shifts between parent-centric and mean-centric recombinations. The shift occurs automatically during program execution through the use of current population statistics and is expected to improve the performance of GA. Further, we also employ a self- adaptive mutation strategy developed earlier.

most informative or most interesting data. We show its usefulness for global black box optimization when data point evaluations are expensive. Gaussian process regression is used to model the fitness function based on all available observations so far. For each candidate point this model estimates expected fitness reduction, and yields a novel closed-form expression of expected information gain. A new type of Pareto-front algorithm continually pushes the boundary of candidates not dominated by any other known data according to both criteria, using multi-objective evolutionary search. This makes the exploration-exploitation trade-off explicit, and permits maximally informed data selection. We illustrate the robustness of our approach in a number of experimental scenarios.

Document Clustering data analysis and data mining clustering called HHWDC. The HHWDC algorithm has been designed from a hyper- heuristic approach and allows defining the best algorithm

for web document clustering. HHWDC uses as heuristic selection methodology two options, namely: random selection and roulette wheel selection based on performance of low-level heuristics (harmony search, an improved harmony search, a novel global harmony search, global-best harmony search, restrictive mating, roulette wheel selection, and particle swarm optimization). HHWDC uses the k-means algorithm for local solution improvement strategy, and based on the Bayesian Information Criteria is able to automatically define the number of clusters. HHWDC uses two acceptance/replace strategies, namely: Replace the worst and Restricted Competition Replacement. HHWDC was tested with data sets based on Reuters-21578 and DMOZ, obtaining promising results (better precision results than a Singular Value Decomposition algorithm)

Distributed Systems Discrete and combinatorial optimization. distributed systems still remains a serious challenge in today's most prolific decentralized environments. System-level fault diagnosis is concerned with the detection of all faulty nodes in a set of interconnected units. This is accomplished by thoroughly examining the collection of outcomes of all tests carried out by the nodes under a particular test model. Such task has non-polynomial complexity and can be posed as a combinatorial optimization problem, whose optimal solution has been sought through bio-inspired methods like genetic algorithms, ant colonies and artificial immune systems. In this paper, we employ a swarm of artificial fireflies to quickly and reliably navigate across the search space of all feasible sets of faulty units under the invalidation and comparison test models. Our approach uses a binary encoding of the potential solutions (fireflies), an adaptive light absorption coefficient to accelerate the search and problem-specific knowledge to handle infeasible solutions. The empirical analysis confirms that the proposed algorithm outperforms existing techniques in terms of convergence speed and memory requirements, thus becoming a viable approach for real-time fault diagnosis in large-size systems.

Problem by Means of a Multiobjective Genetic Algorithm realistic multiobjective versions of the classical assembly line balancing involving the joint optimization of conflicting criteria such as the cycle time, the number of stations, and/or the area of these stations. This industrial problem is very difficult to solve and of crucial importance in the manufacturing context. As TSALBP-1/3 contains a set of hard constraints like precedences or cycle time limits for each station it has been mainly tackled using multiobjective constructive metaheuristics (e.g. ant colony optimization). Global search algorithms in general –and multiobjective genetic algorithms in particular– have shown to be ineffective to solve this family of problems up to now. The goal of this contribution is to present a new multiobjective genetic algorithm design, taking the well known NSGA-II algorithm as a base and new coding scheme and specific operators, to properly tackle with the TSALBP. An experimental study on six different problem instances is used to compare the proposal with the state-of-the-art methods.

applications and weighting (GEFeW) using a number of biometric datasets. GEFeS and GEFeW have been implemented as instances of Steady-State Genetic and Estimation of Distribution Algorithms. Our results show that GEFeS and GEFeW dramatically improve recognition accuracy as well as reduce the number of features needed for facial recognition. Our results also show that the Estimation of Distribution Algorithm implementation of GEFeW has the best overall performance.

Optimization evolutionary algorithms difficulties for traffic control. Nowadays application of computational techniques helps traffic engineers, giving more efficiency, security and agility to decision making tasks. In this context, a good traffic lights management improves vehicles flow, decreasing traffic jams and delays. This paper applies a multiobjective technique to traffic lights timing using Non Dominated Sorting Genetic Algorithm (NSGA-II) and aggregates the proposed algorithm to a microregion traffic simulator coupled into Geographic Information System (GIS). Experiments performed in Porto Alegre area (Brazil) validate the applied technique, comparing obtained results with similar ones from earlier reports.

Optimization objects, like e.g. car shapes in the context of aerodynamic efficiency, usually depends on a well-balanced combination of representation, optimizer and design evaluation method. Shape representation requires a fair trade-off between minimum number of design parameters and design flexibility which likewise guarantees a good optimization convergence while allowing manifold design variations. Recently, shape morphing methods have gained increased attention because of their capability to represent complex shapes with a reasonable number of parameters, especially powerful if coupled with numerical simulations for measuring design performance. Free-form deformation, as prominent shape morphing representative, relies on an initial grid of control points, the control volume, which allows the modification of the embedded shape. The set-up of the control volume is a crucial process which in practice is done manually based on the experience of the human user. Here, a method for the

automated construction of control volumes is suggested based on a proposed measure ECV which relies on the concept of evolvability as a potential capacity of representations to produce successful designs in a reasonable time. It is shown for target shape matching experiments that optimizations based on ECV-tuned control volumes provide a significantly better performance in design optimization.

a good mutation operator should look like. In order to be able to anticipate which operators may perform well and which may perform poorly, knowledge about the behavior of the mutation operator is necessary. This paper therefore presents measures to characterize mutation operators. To this end, we formally define three operator properties: Exhaustiveness, locality and unbiasedness. Furthermore, we provide statistical measures with which operators that work on the same optimization problem can be compared according to each property. The novelty of our approach is that the properties are formally defined in a unified manner, and that the measures can be calculated on arbitrary decision spaces, only assuming that a distance measure between solutions in decision space is given. Tests on a binary decision space using several mutation operators with known properties show that the statistical measures presented in this paper are able to reflect the properties well. Also, the measures are calculated for mutation operators of a more complex problem, namely the cluster partitioning problem. To test the validity of our measures, we introduce an exploration benchmark that measures how well the solutions can move across the decision space when applying a mutation operator to them. Tests on both the binary and the partitioning problem show that our measures reflect the operator behavior well.

Genetic Algorithms to Induce Phenotypic Variability over Deceptive Uncertain Landscapes genotype-phenotype mapping (GP-map). This paper presents a GP-map loosely based on the biological phenomena of transcription and translation, to create a multi-layered GP-map which increases the level of phenotypic variability. The aim of the paper is to examine through the use of a fixed non-trivial GP-map, the impact of increased phenotypic variability, on search over a set of deceptive landscapes. The GP-map allows for a non-injective genotype-phenotype relationship, and the phenotypic variability of a number of phenotypes, introduced by the GP-map, are advanced from the genotypes used to encode them through a basic interpretation of transcription and translation. We attempt to analyse the level of variability by measuring diversity, both at a genotypic and phenotypic level. The multi-layered GP-map is incorporated into a Genetic Algorithm, the multi-layered mapping GA (MMGA), and runs over a number of GA-Hard landscapes. Initial empirical results appear to indicate that over deceptive landscapes, as the level of problem difficulty increases, so too does the benefit of using the proposed GP-map to probe the search space.

values under different computational constraints accurate solution, but may be computationally constrained in terms of the number of objective function evaluations (OFEs) that can be afforded. The OFE budget is application specific, varying depending on the time, computing resources, and the nature of the optimization problem. Control parameter value sensitivity to this OFE budget constraint is investigated for the particle swarm- and differential evolution optimization algorithms. The algorithms are tuned to selected testing problems under different OFE budget constraints, and then their performance is assessed at different OFE budgets from what they were tuned for. The results give evidence that combinations of optimization algorithm control parameter values which perform well for high OFE budgets do not perform well for low OFE budgets and vice versa. This indicates that when selecting control parameter values for these two algorithms, not only should the optimization problem characteristics be taken into account, but also the computational constraints.

the optimal classifiers of the functions they deal with overlap. As this overlap is the property of Boolean functions and the generalization capabilities of the ternary alphabet {0,1,X}, it is necessary to improve XCSs to better deal with those functions that make up most of the possible Boolean functions. This paper proposes two techniques that improve XCS performance, both in terms of system and population state metrics. The first technique, termed Essentiality Assessment, alters the current fitness update mechanism by disallowing competition between potentially essential classifiers. The second technique, named Individualized Learning Rate, proposes an individually computed learning rate for each classifier based on the level of generality of each classifier. The results obtained show improvement and significance both in absolute and statistical terms, for the vast majority of system and population state metrics. This paper is a contribution toward improving XCS performance when dealing with single-step problems that necessarily require overlapping classifiers for their optimal solution.

System continuous-valued dynamical system representation within the XCSF Learning Classifier System. In particular, dynamical arithmetic genetic networks are used to represent the traditional

condition-action production system rules. It is shown possible to use self-adaptive, open-ended evolution to design an ensemble of such dynamical systems within XCSF. The results presented herein show that the collective emergent behaviour of the evolved systems exhibits competitive performance with those previously reported on a non-linear continuous-valued reinforcement learning problem. In addition, the introduced system is shown to provide superior approximations to a number of composite polynomial regression tasks when compared with conventional tree-based genetic programming.

classifier systems, Genetic programming called decision lists) for a number of benchmark classification problems, with evaluation of both predictive performance and comprehensibility. The main purpose is to compare this approach to the standard decision list algorithm JRip and also to evaluate the use of different length penalties and fitness functions for evolving this type of model. The results, using 25 data sets from the UCI repository, show that genetic decision lists with accuracy-based fitness functions outperform JRip regarding accuracy. Indeed, the best setup was significantly better than JRip. JRip, however, held a slight advantage over these models when evaluating AUC. Furthermore, all genetic decision list setups produced models that were more compact than JRip models, and thus more readily comprehensible. The effect of using different fitness functions was very clear; in essence, models performed best on the evaluation criterion that was used in the fitness function, with a worsening of the performance for other criteria. Brier score fitness provided a middle ground, with acceptable performance on both accuracy and AUC. The main conclusion is that genetic programming solves the task of evolving decision lists very well, but that different length penalties and fitness functions have immediate effects on the results. Thus, these parameters can be used to control the trade-off between different aspects of predictive performance and comprehensibility.

classifier systems, Genetic programming predictive performance. Random forests models are, however, due to their sheer complexity inherently opaque, making human interpretation and analysis impossible. This paper presents a method of approximating the random forest with just one decision tree. The approach uses oracle coaching, a recently suggested technique where a weaker but transparent model is generated using combinations of regular training data and test data initially labeled by a strong classifier, called the oracle. In this study, the random forest plays the part of the oracle, while the transparent models are decision trees generated by either the standard tree inducer J48, or by evolving genetic programs. Evaluation on 30 data sets from the UCI repository shows that oracle coaching significantly improves both accuracy and area under ROC curve, compared to using training data only. As a matter of fact, resulting single tree models are as accurate as the random forest, on the specific test instances. Most importantly, this is not achieved by inducing or evolving huge trees having perfect fidelity; a large majority of all trees are instead rather compact and clearly comprehensible. The experiments also show that the evolution outperformed J48, with regard to accuracy, but that this came at the expense of slightly larger trees.

Salesman Problem traveling salesman problem (TSP). When applying GA to the TSP, it is necessary to use a large number of individuals in order to increase the chance of finding optimal solutions. However, this incurs high evaluation costs which make it difficult to obtain fitness values of all the individuals. To overcome this limitation we propose an efficient genetic algorithm based on fuzzy clustering which reduces evaluation costs with minimizing loss of performance. It works by evaluating only one representative individual for each cluster of a given population, and estimating the fitness values of the others from the representatives indirectly. A fuzzy c-means algorithm is used for grouping the individuals and the fitness of each individual is estimated according to membership values. The experiments were conducted with randomly generated cities, and the performance of the method was evaluated by comparing to other GAs. The results showed the usefulness of the proposed method on the TSP.

Routing Problem Discrete and combinatorial optimization. including automotive industry and cash management for ATM networks. In the specific case of vendor-managed IRPs, in which the supplier is responsible for managing the product inventory in each client and for properly providing replenishments, the challenge is to determine which retailers should be served, the amount of product that should be delivered to each of these retailers, and which routes the distribution vehicles should follow, so that the associated costs are minimized. Although this is clearly a multi-objective optimization problem, in the literature it has been generally modeled as a single-objective problem, which limits the scope of the obtained results. Therefore, this work presents a multi-objective approach to solve one version of the IRP usually found in the scientific literature, by simultaneously minimizing both the inventory and transportation costs. The method proposed in this work is based on the well-known

SPEA2 (Strength Pareto Evolutionary Algorithm) and includes innovative aspects mainly associated with the representation of candidate solutions, genetic operators and local search. The experiments were performed on a set of known benchmark IRPs from the literature, so that the obtained results could be properly compared to the best solution found for the single-objective version of each problem.

Correlated Objectives objective optimization (EMO) algorithms with Pareto dominance-based fitness evaluation do not work well on many-objective problems with four or more objectives. In this paper, we examine the behavior of well-known and frequently- used EMO algorithms such as NSGA-II, SPEA2 and MOEA/D on many-objective problems with correlated or dependent objectives. First we show that good results on many-objective 0/1 knapsack problems with randomly generated objectives are not obtained by Pareto dominance-based EMO algorithms (i.e., NSGA-II and SPEA2). Next we show that the search ability of NSGA-II and SPEA2 is not degraded by the increase in the number of objectives when they are highly correlated or dependent. In this case, the performance of MOEA/D is deteriorated. As a result, NSGA-II and SPEA2 outperform MOEA/D with respect to the convergence of solutions toward the Pareto front for some many-objective problems. Finally we show that the addition of highly correlated or dependent objectives can improve the performance of EMO algorithms on two-objective problems in some cases.

Numerical optimization. MOEA/D for solving multiobjective optimization problems. MOEA/D decomposes a multiobjective optimization problem into many single-objective subproblems. The objective of each subproblem is a weighted aggregation of the original objectives. Using evenly distributed weight vectors on subproblems, solutions to subproblems form a set of well-spread approximated Pareto optimal solutions to the original problem. In MOEA/D, each individual in the population represents the current best solution to one subproblem. Mating selection is carried out in a uniform and static manner. Each individual/subproblem is selected/solved once at each generation, and the mating pool of each individual is determined and fixed based on the distance between weight vectors on the objective space. We propose an adaptive mating selection mechanism for MOEA/D. It classifies subproblems into solved ones and unsolved ones and selects only individuals of unsolved subproblems. Besides, it dynamically adjusts the mating pools of individuals according to their distance on the decision space. The proposed algorithm, MOEA/D-AMS, is compared with two versions of MOEA/D using nine continuous functions. The experimental results confirm the benefits of the adaptive mating selection mechanism.

and Interpretable Fuzzy Knowledge Bases for Classification Classification, clustering, data analysis and data mining as fuzzy rules, neural networks, and others, has led to novel and powerful approaches in many problem areas. This study tests an implementation of cellular evolution for fuzzy rule learning problems and compares the results with other related approaches. The paper also examines characteristics of the cellular evolutionary approach in generating more diverse solutions in a multiobjective specification of the learning task, and finds that solutions seem to have useful properties that could enable anticipating out of sample performance. We consider a bi-objective problem of learning fuzzy classifiers that balance accuracy and interpretability requirements.

Structures Classification, clustering, data analysis and data mining recent years. Compared to the traditional single-objective optimization for community detection, the multi-objective optimization for community detection with evolutionary computation is a promising solution. It is an important and unsolved issue to make use of the optimal solution set returned by evolutionary multiobjective algorithm for community detection. This paper adapts a multi-objective community detection algorithm and further proposes four model selection methods to aid the decision makers to select the preferable community structures. The experiments with four synthetic and real social networks illustrate that the proposed method can discover more authentic and comprehensive community structures than traditional single-objective approaches.

metaheuristics and hyper-heuristics learning to assist evolutionary algorithms in solving discrete and combinatorial optimization problems. To our knowledge, this is the first attempt to apply opposition to combinatorics. We introduce two different methods of opposition to solve two different type of combinatorial optimization problems. The first technique, open-path opposition, is suited for combinatorial problems where the final node in the graph does not have be connected to the first node, such as the graph-coloring problem. The latter technique, circular opposition, can be employed for problems where the endpoints of a graph are linked, such as the well-known traveling salesman problem (TSP). Both discrete opposition methods have been hybridized with biogeography-based optimization (BBO). Simulations on TSP benchmarks illustrate that incorporating opposition into BBO improves its performance.

Climber high selection pressure, dubbed the "Jugate Adaptive Method"is examined. Its performance and behavior are compared to those of a canonical genetic algorithm with tournament selection, and a random-restarting next-ascent stochastic hill- climber. All three algorithms are tuned using parameter sweeps to optimize their success rates on five combinatorial optimization problems, tuning each algorithm for each problem independently. Results were negative in that the new method was outperformed in nearly all experiments. Experimental data show the hill climber to be the clear winner in four of five test problems.

This paper investigates the effects of adding greediness to the standard roulette-wheel selection. The results of this study are tested on a Cyclic Genetic Algorithm (CGA) used for learning gaits for a hexapod servo-robot. The effectiveness of CGA in learning optimal gaits with selection based on roulette-wheel selection with and without greediness is compared. The results were analyzed based on fitness of the individual gaits, convergence time of the evolution process, and the fitness of the entire population evolved. Results demonstrate that selection with too much greediness tends to prematurely converge with a sub-optimal solution, which results in poorer performance compared to the standard roulette-wheel selection. On the other hand, roulette-wheel selection with very low greediness evolves more diverse and fitter populations with individuals that result in the desired optimal gaits.

of video games, agents have to cope with a large number of input information in order to decide their actions at every time step. We have proposed the use of Isomap, a famous Manifold Learning, to reduce the dimensionality of inputs. Especially, we have applied it into scene information. In this paper, we newly extend to enemy information, where the number of enemies is not fixed. Hence, we introduce the proximity metrics in terms of enemies. The generated low-dimensional data is used for input values of Neural Networks. That is, at every time step, transferred data by using a map from raw inputs into the low-dimensional data are presented to Neural Networks. Experimental results on Mario AI environment show the effectiveness of the proposed approach.

intelligent and autonomous control agents. At the same time, the Xpilot environment is highly complex, with very many state variables and action choices. Basic reinforcement learning (RL) techniques are somewhat limited in their application when dealing with such large state- and action- spaces, since the repetition of exposure that is key to their value updates can proceed very slowly. To solve this problem, state-abstractions are often generated, allowing learning to move more quickly, but often requiring the programmer to hand-craft state representations, reward functions, and action choices in an ad hoc manner. We apply an automated technique for generating useful abstractions for learning, adaptive Kanerva coding. This method employs a small sub-set of the original states as a proxy for the full environment, updating values over the abstract representative prototype states in a manner analogous to Q-learning. Over time, the set of prototypes is adjusted to provide more effective coverage and abstraction, again automatically. Our results show that this technique allows a simple learning agent to double its survival time when navigating the Xpilot environment, using only a small fraction of the full state-space as a stand-in and greatly increasing the potential for more rapid learning.

generation with proper leg coordination involves a series of actions that are continually repeated to create sustained movement. In this paper we present the use of a Cyclic Genetic Algorithm (CGA) to learn gaits for a quadruped servo-robot with three degrees of movement per leg. An actual robot was used to generate a simulation model of the movement and states of the robot. The CGA used the robot's unique features and capabilities to develop gaits specific for that particular robot. Tests done in simulation show the success of the CGA in evolving a reasonable control program and preliminary tests on the robot show that the resultant control program produces a suitable gait.

Intrusion Detection networks from a range of threats. Modern ID techniques must cope with increasingly sophisticated attacks as well as rapidly rising network line speeds. Signature-based ID is forced to sample sparsely, increasing the likelihood of malicious traffic entering the network without scrutiny. Consequently, flow-based ID is gaining attention as an effective complement. ID systems are furthermore often characterized as either network-based or host- based. The autonomous multi agent design paradigm is a scalable, attractive alternative for its potential to leverage the strengths of both architectures: the broad perspective and visibility into distributed malicious activity provided by network-based ID, and the comprehensive view of the local node provided by host-based ID. This paper therefore develops an architecture for a new multi agent, flow-based intrusion detection sysem. The architecture is designed in two iterations of increasing complexity. These innovative ID designs use a "repuation" system to permit agents to dynamically find nodes that are most effective for classifying malicious network activity. Furthermore, each system design includes the development of an innovative

classifier that uses multi objective evolutionary algorithms to aid in the search for effective operational parameter values. Evaluation using an extensive agent simulation framework highlights the conditions under which the reputation system provides a significant classification benefit.

against VoIP traffic? Numerical Optimization Problems techniques such as port numbers or deep packet inspection are ineffective against voice over IP (VoIP) applications, which uses non-standard ports and encryption. Statistical information based on network layer with the use of machine learning (ML) can achieve high classification accuracy and produce transportable signatures. However, the ability of ML to find transportable signatures depends mainly on the training data sets. In this paper, we explore the importance of sampling training data sets for the ML algorithms, specifically Genetic Programming, C5.0, Naive Bayesian and AdaBoost, to find transportable signatures. To this end, we employed two techniques for sampling network training data sets, namely random sampling and consecutive sampling. Results show that random sampling and 90-minute consecutive sampling have the best performance in terms of accuracy using C5.0 and SBB, respectively. In terms of complexity, the size of C5.0 solutions increases as the training size increases, whereas SBB finds simpler solutions.

Numerical Optimization Problems Problems evolutionary algorithms on real world optimization problems using a hybrid differential evolution algorithm are presented. The proposal uses a local search routine to improve convergence and an adaptive crossover operator. According to the obtained results, this algorithm shows to be able to find competitive solutions with reported results.

Numerical Optimization Problems (Chair: P. Suganthan) for solving real world problems. To achieve optimal performance with DE, time consuming parameter tuning is essential as its performance is sensitive to the choice of the mutation and crossover strategies and their associated control parameters. During different stages of DE's evolution, different combinations of mutation and crossover strategies with different parameter settings can be appropriate. Based on this observation different adaptive and self-adaptive techniques have been proposed. In this paper, we employ a DE with an ensemble of mutation and crossover strategies and their associated control parameters known as EPSDE. In EPSDE, a pool of distinct mutation and crossover strategies along with a pool of values for each control parameter coexists throughout the evolution process and competes to produce offspring. The performance of EPSDE is evaluated on a set of real world problems taken from different fields of engineering and presented in the technical report of Conference on Evolutionary Computation (CEC) 2011.

Optimization Numerical Optimization Problems Evolutionary Algorithm (EA) over real world applications. This is why the performance of any EA over the real world optimization problems is very important for judging its efficiency. In this work, we represent a multi-population based memetic algorithm CDELS. It is hybridization of a competitive variant of Differential Evolution (DE) and a Local Search method. As the number of optima is large in this case, we have also incorporated a distant search method to hop from one optima to other optima. However, it is well known that DE has fast but less reliable convergence property. To overcome this limitation, a hybrid mutation strategy is developed to balance between exploration and thorough search. In addition, a proximity checking method is applied to distribute the subpopulations over a larger portion of the search space as this further enhances the searching ability of the algorithm. The performance of CDELS algorithm is evaluated on the test suite provided for the Competition on Testing Evolutionary Algorithms on Real-world Numerical Optimization Problems in the 2011 IEEE Congress on Evolutionary Computation and the simulation results are shown in this paper.

issue that plays a key role in understanding and developing algorithms. In order to study the ability limit of estimation of distribution algorithms (EDAs), this paper experimentally tests three different EDA implementations on a sequence of additively decomposable functions (ADFs) with an increasing number of interactions among binary variables. The results show that the ability of EDAs to solve problems could be lost immediately when the degree of variable interaction is larger than a threshold. We argue that this phase-transition phenomenon is closely related with the computational restrictions imposed in the learning step of this type of algorithms. Moreover, we demonstrate how the use of unrestricted Bayesian networks rapidly becomes inefficient as the number of sub-functions in an ADF increases. The study conducted in this paper is useful in order to identify patterns of behavior in EDAs and, thus, improve their performances.

optimization. solutions to an optimization problem by introducing a statistical model, and by replacing classical variation operators of Genetic Algorithms with statistical operators, such as estimation and sampling. The choice of the model plays a key role in the evolutionary process, indeed it strongly

affects the convergence to the global optimum. From this point of view, in a black-box context, especially when the interactions among variables in the objective function are sparse, it becomes fundamental for an EDA to choose the right model, able to encode such correlations. In this paper we focus on EDAs based on undirected graphical models, such as Markov Networks. To learn the topology of the graph we apply a sparse method based on \l1-regularized logistic regression, which has been demonstrated to be efficient in the high-dimensional case, i.e., when the number of observations is much smaller than the sample space. We propose a new algorithm within the DEUM framework, called \deuml1, able to learn the interactions structure of the problem without the need of prior knowledge, and we compare its performance with other popular EDAs, over a set of well known benchmarks.

goal for life cycle management and life extension efforts. This paper explores the use of evolutionary computational methods to help estimate some of these helicopter dynamic loads. Thirty standard time-dependent flight state and control system parameters were used to construct a set of 180 input variables to estimate the main rotor blade normal bending during forward level flight at full speed. Evolutionary computation methods (single and multi-objective genetic algorithms) optimizing residual variance, gradient, and number of predictor variables were employed to find subsets of the input variables with modeling potential. Clustering was used for composing a statistically representative training set. Machine learning techniques were applied for prediction of the main rotor blade normal bending involving neural networks, model trees (black and white box techniques) and their ensemble models. The results from this work demonstrate that reasonably accurate models for predicting component loads can be obtained using smaller subsets of predictor variables found by evolutionary computation based approaches.

Estimation algorithm(EDA). Generally, the form of a probabilistic model has to be chosen before executing an EDA. In each generation, the probabilistic model parameters will be estimated by training the model on a set of selected individuals and new individuals are then sampled from the probabilistic model. In this paper, we propose to use probabilistic models in a different way: firstly generate a set of candidate points, then find some as offspring solutions by a filter which is based on a nonparametric density estimation method. Based on this idea, we propose a nonparametric estimation of distribution algorithm (nEDA) for global optimization. The major differences between nEDA and traditional EDAs are (1) nEDA uses a generating-filtering strategy to create new solutions while traditional EDAs use a model building-sampling strategy to generate solutions, and (2) nEDA utilizes a nonparametric density model with traditional EDAs usually utilize parametric density models. nEDA is compared with a traditional EDA which is based on Gaussian model on a set of benchmark problems. The preliminary experimental results show that nEDA is promising for dealing with global optimization problems.

interactive method to solve three aerodynamic airfoil shape optimization problems with 2, 3, and 6 objectives, respectively. The expensive simulations required to evaluate the objective functions makes these problems an excellent example in which the use interactive methods is very advantageous. First, the search can be focused on the decision maker's region of interest, saving this way, valuable function evaluations. Second, the preference relation used in the interactive method helps to deal with a large number of objectives since it is able to rank incomparable nondominated solutions. The experimental evaluation reveals that in the three problems studied, the interactive method achieved a better final solution than a traditional a posteriori method with no preferences. Nevertheless, in the problem with 6 objectives, only 3 of them were improved. A possible explanation for this is that local optima become harder to overcome when the size of the region of interest is very small. Additional experiments confirmed that the convergence is deteriorated if very small regions of interest are used.

fractal landscapes. Virtual landscapes are important for applications ranging from games to simulation. This paper extends work done on the auto generation of virtual landscapes for climate change visualisation, by adding an aesthetic measure based fitness function to the evolutionary algorithm, thus reducing the reliance of the method on user based evaluation. A genetic algorithm that uses an aesthetic measure of fitness based on information theory is defined. This GA is used to explore a multi-dimensional parameter space that defines how 3D virtual landscapes are created. The utility of this fitness measure is assessed by evaluating the solutions generated by the system with real users. Results indicate that genetic algorithms that use information theory based fitness measures do indeed generate virtual artefacts that match user preferences. Moreover the images generated are visually appealing enough to be curated for public exhibition along side human artists in art galleries by professional art critics.

Algorithms data mining, Real-world applications object detection and recognition in image processing.

Segmentation is the process of dividing the image into disjoint homogeneous regions. There are many segmentation methods and approaches, the most popular are clustering methods and approaches such as Fuzzy C-Means (FCM) and K-means. The success of clustering methods depends strongly on the selection of the initial spectral signatures. Normally, this is done either manually or randomly, in either case the outcome is unpredictable. In this paper an unsupervised method based on Multi-Objective Genetic Algorithm (MOGA) for the selection of spectral signature from satellite images is described. The new method works by maximizing the number of the selected pixels (minimize over-segmentation) and by minimizing the difference between these pixels and their spectral signature (maximize homogeneity). Experimental results are conducted using a high resolution SPOT V satellite image, the collected spectral signatures, and the K-means clustering algorithm. The verification of the segmentation results is based on a very high resolution satellite image of type QuickBird. The spectral signatures provided to K-means by MOGA increased the speed of clustering to approximately 4 times the speed of the random based selection of signatures. At the same time MOGA improved the accuracy of the results of clustering using K-means to more than 10 %.

simulation-based optimization attention in the last decade. Typically, vast situation and configuration spaces do not allow for using a predefined set of adaptation policies. Based on the principles of Organic Computing, a 3-layered learning architecture has been developed which is capable of coping with the problem by enabling selfadaptation and self-improvement. A major focus has been set on developing safety-based and efficient machine learning concepts founding on evolutionary search heuristics and rule-based learning. The general design has been successfully applied to safety-critical real-world applications like urban traffic control and data communication protocols. This paper investigates the question for which class of technical systems the design is applicable. Thus, a generalised model based on mathematical functions is introduced and evaluated. The evaluation demonstrates that the approach works well for systems where the configuration spaces are steadily representable by functions of the situation space. This statement holds even in the presence of noise.

Optimization Problems optimization problems is proposed, which combines the global search ability of particle swarm optimization with an attraction based local search operator for directed local fine-tuning. Firstly, a new particle updating strategy is proposed based on the concept of uncertain personal-best to deal with the problem of premature convergence. Secondly, an attraction based local search operator is proposed to find good local search direction for the particles. Finally, the convergence of the algorithm is proved. The proposed algorithm is examined and compared with two well known existing algorithms on five benchmark test functions. The results suggest that the new algorithm can evolve more good solutions, and the solutions are more widely spread and uniformly distributed along the Pareto front than the two existing methods. The proposed two developments are effective individually, but the combined effect is much better for these constrained multi-objective optimization problems.

example in improving bound-handling for optimizing high-dimensional and complex problems uncertainty handling when it is applied to high-dimensional and complex problems. In this study, we introduce principal components analysis (PCA) into PSO in order to remedy the problem caused by the absorbing bound-handling approach. The experiments on 100- D composition functions demonstrate the effectiveness of PCA. Furthermore, the strong influence of bound-handling on PSO is also evidently revealed by the results. The fact that none of the studied bound-handling methods excels on all of the benchmark functions highlights the necessity of developing more sophisticated and robust bound-handling approaches that can facilitate the application of PSO on high-dimensional problems.

Unconstrained Discrete Problems Large-scale problems. high dimensional optimization problems with discrete variables. The proposed method combines an innovative jumping particle swarm optimization technique which is well adapted to discrete variables with a variable neighborhood local search heuristic and an efficient stretching technique. A dedicated mathematical formalism used to handle real-coded discrete variables is defined previously to the theoretical background section which ends with a full description of the developed hybrid local/global optimization algorithm. This section presents among others developed principles an adaptive boundary vector notion which ensures an efficient convergence for jumping particle swarm optimization. Proposed hJPSO-VNS algorithm performances are then evaluated for solving both low and high combinatorial unconstrained optimization problems. For low dimensions, our hJPSO-VNS method is compared with standard and variable particle swarm optimization techniques developped by Clerc. For high dimensional optimization problems, a dedicated benchmark composed of numerous reference multimodal functions whose search domains have been disadvantageously discretized is considered. Results are discussed by focusing on four selected but

representative objective functions. Our hJPSO-VNS optimization technique shows excellent overall performances. Some comments and perspectives dealing with the future works conclude this paper.

Numerical optimization. presented for improving PSO performance by automatically adapting acceleration coefficients. While this approach can be shown to be effective on its own as a source of swarm diversity on difficult functions, it is also capable of enhancing other adaptive strategies commonly employed with PSO. Significantly, and unlike many other PSO enhancements designed to improve swarm diversity, this approach does not typically harm the performance of the underlying method, allowing it to work well on easy and difficult functions alike.

Detection of real world in the field of artificial intelligence. Dynamic Bayesian network, a kind of Bayesian network, can solve problems in dynamic environments. However, as node and state values of node in Bayesian network grow, it is very difficult to define structure and parameter of Bayesian network. This paper proposes a method which generates and evolves structure of dynamic Bayesian network to deal with uncertainty and dynamic properties in real world using genetic algorithm. Effectiveness of the generated structure of dynamic Bayesian network is evaluated in terms of evolution process and the accuracy in a domain of the traffic accident detection.

Intelligence:, Particle swarm optimization allocation given different target configurations requires the tuning of parameters affecting the robustness and run time of the algorithm. In this context, parameter settings in evolutionary algorithms are usually set through empirical testing or rules of thumb that do not always provide optimal results within time constraints. Design of experiments (DOE) is a methodology that provides some principled guidance on parameter settings in a constrained experiment environment but relies itself on a final inductive step for optimization. This paper describes a sensor allocation tool developed for intelligence, surveillance and reconnaissance (ISR) in the maritime domain and introduces a hybrid methodology based on DOE and machine learning techniques that enables the tuning of an embedded particle swarm optimization (PSO) algorithm for different scenarios.

with Size Constraints traditional Quadratic Assignment Problems (QAP). While the objective is still to minimize the summed cost of the (flow * distance), the facilities in the FLP have different given sizes and their locations must be determined on a continual planar site. Based on the visual facility layout design system proposed by Chiang [13], this paper presents a study on using Tabu Search (TS), Particle Swarm Optimization (PSO) and their combinations (TS+PSO and PSO+TS) to tackle the FLP. The computation results show that the two-stage algorithms are able to achieve better results in most cases than TS and PSO individually on the FLP. The proposed two- stage algorithms and visual layout design system provide an effective tool to solve the practical FLP.

that accumulate in axon terminals. The number and position of these vesicles have been related to some important functional properties of the synapse. For this reason, an accurate mechanism for semi-automatically counting this small cellular structures will be of great help for neuroscientists. In this paper, we present a Differential Evolution algorithm that quantifies the number of synaptic vesicles in electron micrographs. The algorithm has been tested on several images that have been obtained from the somatosensory cortex of the rat and compared with some traditional approaches for detecting circular structures. Finally, the results have been validated by two independent expert anatomists.

Continuous Optimization called CMADO, to evaluate the amplitudes of the deformations of the walls of the third cerebral ventricle on a brain cine-MR imaging. CMADO based segmentation technique is applied on a 2D+t dataset to detect the contours of the region of interest (i.e. lamina terminalis). Then, the successive segmented contours are matched using a procedure of global alignment. Finally, local measurements of deformations are derived from the previously determined matched contours. The validation step is realized by comparing our results to the measurements achieved on the same patients through a manual segmentation provided by an expert using Ethovision (c) software.

of Tasks - Part I problems. To be adaptive to these changes, new solutions to the problems are to be found every time change occur. Our previous publication showed that centroid of non-dominated solutions found through Multi-Objective Optimization with Evolutionary Algorithm (MOEA) from previous changes enhances MOEA's search quality of solutions for the current change. However, the number of tasks in the test environment employed was fixed. In this two-part paper, we address the dynamic adaptation with time- varying task number. To cope with this variability, new components of the solution, corresponding to the new tasks, are inserted appropriately to all solutions of the previous changes. Then centroid of these modified solutions is recomputed. Further, to avoid confusion in solution presentation, the insertion of new components obliged the use of task ID number greater than the largest of the previous IDs. The first part of this paper will show that the resulting task

numbering system will alter the centroid significantly which will degrade MOEA's search quality. To circumvent, task IDs are mapped to new values in order to minimize difference in IDs between adjacent solution components; an approach which significantly upgraded MOEA's search performance despite changes in task number as supported by the obtained results.

Set-based Multiobjective Evolutionary Algorithms complexity analysis approximated neatly by some versions of evolutionary algorithms. The quality of the approximation can be measured by the hypervolume that is dominated by the approximation. Open questions concern the existence of population-based evolutionary algorithms whose population converge to an approximation of the Pareto front with maximal dominated hypervolume for a given reference point and, if applicable, the convergence velocity. Here, the existence of such an algorithm is proven by providing a concrete example that converges to the maximal dominated hypervolume geometrically fast.

Algorithms multiobjective optimization problems. In literature, a heuristic approach is often taken. For a chosen benchmark problem, the performance of multiobjective evolutionary algorithms (MOEAs) is evaluated via some heuristic chosen performance metrics. The conclusion is then drawn based on statistical findings given the preferable choices of performance metrics. The conclusion, if any, is often indecisive and reveals no insight pertaining to specific problem characteristics that the underlying MOEA could perform the best. In this paper, we introduce an ensemble method to compare MOEAs by combining a number of performance metrics using double elimination tournament selection. Double elimination design allows characteristically poor performance of a quality algorithm under the special environment to still be able to win it all. Experimental results show that the proposed metrics ensemble can provide a more comprehensive comparison among various MOEAs than what could be obtained from single performance metric alone.

Programming programming multiobjective evolutionary programming (MOEP). A mined subgraph is defined by two objectives, support and size. These objectives are conflicting as a subgraph with high support value is usually of small size and \emph{vice-versa}. MOEP applies NSGA-II's nondominated sorting procedure to evolve the population during the subgraph generation process. An experimental study on five synthetic and real-life graph-based datasets shows that MOEP outperforms Subdue-based methods, a well-known heuristic search approach for subgraph discovery in data mining community. The comparison is done using hypervolume, C and I_ϵ multiobjective performance metrics.

optimization based on a modified hybrid particle swarm optimization (MHPSO). Hybrid real and binary PSO is coupled with the proposed heuristic based constraint satisfaction strategy that makes the solutions/particles feasible for PSO. The velocity equation of particle is also modified to prevent particle stagnation. Unit commitment priority is used to enhance the performance of binary PSO. The proposed algorithm is tested for 10, 20, 40 and 60 unit systems and the results are reported for 10 different runs. Statistical results and their comparison show a good performance of MHPSO over other existing optimization methods.

Genetic algorithms inertia weight (EPSOIW) for obtaining the PSOIW with high performance. Due to the use of meta-optimization, it can systematically estimate appropriate values of parameters in the PSOIW corresponding to a given optimization problem without prior knowledge. Accordingly, the EPSOIW could be expected to not only obtain an optimal PSOIW for efficiently solving a given optimization problem, but also to quantitatively analyze the know-how on designing it. To demonstrate the effectiveness of the proposed method, computer experiments on a suite of multidimensional benchmark problems are carried out. We investigate the intrinsic characteristics of the proposal, and compare the search ability and efficiency with the other methods. The obtained experimental results indicate that the search performance of the PSOIW optimized by the EPSOIW is superior to those of the original PSOIW, OPSO and RGA/E. The EPSOIW is verified to be relatively high in the processing capacity for solving multimodal problems in comparison with the EPSO and ECPSO.

Diversive Curiosity computation theory inertia weight with diversive curiosity (MPSOIWα/DC) for improving the search performance and intelligent processing of a plain MPSOIW. It has the following outstanding features: (1) Decentralization in multi-swarm exploration with hybrid search, (2) Concentration in evaluation and behavior control with diversive curiosity, (3) Practical use of the results of evolutionary PSOIW, and (4) Their effective combination. This achievement expands the applied object of cooperative PSO, and develops the approach of the curiosity-driven multi-swarm. To demonstrate the effectiveness of the proposal, computer experiments on a suite of multidimensional benchmark problems are carried out to analytical judgment. We examine its intrinsic characteristics, and compare the search performance with other methods. The obtained experimental results indicate

that the search performance of the MPSOIWα/DC is superior to that by the PSOIW/DC, EPSOIW, PSOIW, OPSO, RGA/E, and MPSOα/DC for the given benchmark problems.

Classification applications chemical composition of materials remotely. Factors limiting the use of hyperspectral sensors in practical land-based applications, such as robotics and mining, are the complexity and cost of data acquisition, and the processing time required for the subsequent analysis. This is mainly due to the high dimensional and high volume nature of hyperspectral image data. In this paper, we propose to combine a feature selection method, based on particle swarm optimization (PSO), with a kernel method, support vector machines (SVM), to reduce the dimensionality of hyperspectral data for classification. We evaluate several different kernels, including some optimized for hyperspectral analysis. In particular, a recent kernel called observation angle dependent (OAD) kernel, originally designed for Gaussian Process regression, was extended for SVM classification. The SVM with the optimized kernel was then applied to induce the feature selection of a binary version of PSO. We validate the method using hyperspectral data sets acquired of rock samples from Western Australia. The empirical results demonstrate that our method is able to efficiently reduce the number of features while keeping, or even improving, the performance of the SVM classifier.

Applied to UAV Path Planning Problem particle swarm optimization, MSSPSO, to deal with uncertain-dimension factor space optimization problems. The proposed MSSPSO can provide more wide capability for unknown solution space exploration. In this paper, the MSSPSO is applied to UAV path planning problem. Based on characteristic number of different paths, it has to use different number of control point to produce varied flight paths. In order to explore suitable solution within suitable characteristic number interval, MSSPSO is employed to explore better solution and the variable-length crossover concept is used to share information among different dimension swarms. The simulation is show that MSSPSO has the ability to explore suitable solution and determine suitable characteristic for flight path. On the other hand, swarm crossover helps swarm to avoid falling local optimal position; swarm manager is applied to enhance computing efficiency and prune the helpless swarms.

is studied with the proposal of a hypervolume contribution based multiobjective evolutionary approach. The main feature of the presented method is that all individuals in the population are periodically replaced by the selected non-dominated candidates in the archive based on hypervolume contribution, besides the well designed evolutionary operators and some popular techniques such as dominated relation and archive. Our algorithm may obtain well distributed Pareto set approximation efficiently, which is superior to the implementations based on the framework of NSGA-II and SMSEMOA with respect to the hypervolume.

Constrained Multiobjective Optimization evolutionary algorithms conflicting objectives and subject to many constraints. Much research has been done in the fields of multiobjective optimization and constrained optimization, but little focused on both topics simultaneously. In this study we present a hybrid constraint handling mechanism, which combines the epsilon-comparison method and penalty method. Unlike original epsilon-comparison method, we set an individual epsilon-value to each constraint and control it by the amount of violation. The penalty method deals with the region where constraint violation exceeds the epsilon-value and guides the search toward the epsilon-feasible region. The proposed algorithm is based on a well-known multiobjective evolutionary algorithm, NSGA-II, and introduces the operators in differential evolution (DE). A modified DE strategy, DE/better-to-best_feasible/1, is applied. The better individual is selected by tournament selection, and the best individual is selected from an archive. Performance of the proposed algorithm is compared with NSGA-II and an improved version with a self-adaptive fitness function. The proposed algorithm shows competitive results on sixteen public constrained multiobjective optimization problem instances.

particular intelligent behavior of honeybee swarms. In this study, we propose a new HCO containing a characteristic of guidepost pheromone that has the effect to attract other bees. Namely, many bees can move to the optimal place. We investigate the performance of the proposed HCO by using four bench mark problems. It discovered that the effect of guidepost pheromone works well for the high dimension problems. We consider that the proposed HCO with pheromone can leave from local minima more easily than the standard HCO.

Detection and Adaptive Contour Tracking evolutionary computation and image processing. Edges often act as primary artifacts of visual data. Edge detection is to mark sharp changes of the intensity or brightness of digital images. Canny edge detection and ant colony optimization detection are two essential edge detection approaches. The former is susceptible to noises presented on source images. The information loss occurs when Gaussian smoothing is used to improve connectivity of Canny edge

detection. Edges can be also detected via other approaches. To avoid edge suppression and feature deformity, ACO has been proposed for edge and contour detection against false detection, by which more intrinsic information will be extracted. The evolutionary computation oriented ACO scheme is a promising approach for feature capturing without the necessity of smoothing filters. It is among the most effective approaches for edge detection. However, it may give rise to broken pieces of numerous true edges occasionally. To further improve accuracy, contour tracking schemes are needed to achieve stable feature recognition. Some intelligent schemes are too complex to handle in real time, so a simple adaptive contour tracking scheme has been proposed which is combined with enhanced ACO schemes. This technology integration will result in the sufficient true edge representation together with well connected linkage, which can be easily extended to contour detection of binary, grayscale and true color images. Using quantitative metrics, an objective study is made to evaluate performance outcomes based on integration of the ACO schemes and adaptive contour tracking.

Multiobjective optimization preliminary study on MOPSO. The proposed scenario includes tournament selection for global best solutions, jump-improved operation to expand the searching space, cluster operation to improve the diversity, and Taguchi-based disturbance can enhance the searching ability and reduce the possibility of falling into local optima of particles. Experiments are conducted on seven two- objective benchmarks. The results show that the proposed method operates better than other algorithms in three performance metrics.

optimization algorithms. The PSO contains many control parameters. These causes, the performance of the searching ability of the PSO is significantly alternated. In order to analyze the dynamics of such PSO system rigorously, we proposed a canonical deterministic PSO (abbr. CD-PSO) systems which does not contain any stochastic factors, and its coordinate of the phase space is normalized. %The trajectory of the CD-PSO must converge to a fixed point. The funded global best information influences the dynamics. This situation can be regarded as the full-connection state. On the other hand, there is the case where the best information in a limited population. Such information is called as lbest. How to get the lbest information from any population is equivalent to a network structure. Such network structure influences the performance of searching ability. In order to clarify a relationship between network structures of CD-PSO and its performance, we pay attention to the degree and the average distance used in graph theory. First, we consider the case where the CD-PSO has an extended cycle structure. Our numerical simulation results indicates the searching performance is depended on the average distance of the node, and the optimal average distance is existed. Next, we consider the case where the CD-PSO has a Small World network structure. The extended cycle structure has uniform symmetric property. On the contrary, a small world network has nonuniform property. Even in the case where the CD-PSO has the small world network structure, the searching performance is depended on the average distance

and Delivery Problem optimization., Real-world applications of vehicle routing problem. The MVSPDP aims to minimize the total distance traveled by a fleet of vehicles to collect and supply commodities, subject to vehicle capacity and travel distance. This problem relaxes the constraint that the vehicles have to visit all customers. In the MVSPDP, vehicles only need to collect sufficient commodities from some selected pickup nodes for all delivery nodes. To resolve the problem, this study develops a genetic algorithm with path relinking (GAPR). A repair operator is presented for the GAPR to handle the constraints. Experimental results on fourteen benchmarks validate the effectiveness of the proposed GAPR for the MVSPDP.

with a local search method. Following the same track we present PSO2. In PSO2 the local search is performed by smaller independent swarms of PSO located around particles of the main PSO2. Different modifications are made to help basic PSO2 escape from local optima.PSO2-RS and PSO2-SA are 2 modified versions of PSO2 that target to increase the swarm diversity. The third and best enhanced version, PSO2-SA-DYSS, is achieved by increasing the local search swarms sizes as the search progresses. This last enhancement to PSO2 algorithm proved to make PSO2 behavior more exploitive. PSO2 versions have been tested against the benchmark test functions using different velocity update methods and topologies. Results have suggested the third and final version PSO2-SA-DYSS. This version is examined against 4 functions of the CEC-2005 benchmark suite and results are reported.

Problems theory last two decade. In multi-objective genetic algorithm (MOGA), quality of new generated offspring of population will affect the performance of finding Pareto optimum directly. In this paper, an improved MOGA is proposed named SMGA to solving multi-objective optimization problem. For improving solution searching efficiency, an effective mutation named sharing mutation is adopted

for generating potential offspring. Experiments were conducted on CEC-09 MOP test problems. The results showed that the proposed method exhibits better performance when solving these benchmark problems compared to related multi- objective evolutionary algorithm (MOEA).

Instantaneous and Time-Delayed Interactions Artificial ecology and artificial life instantaneously while others with time-delay, current modeling techniques for genetic network reconstruction make simplifications and assume that the interactions can be either of these but not both. In this paper, we propose a gene regulatory network reconstruction algorithm that can model concurrent occurrence of both, instantaneous as well as time-delayed interactions, thus providing a better representation of the original biological processes. First we introduce a novel framework using the Bayesian network (BN) formalism that can model both types of interactions. A gene regulatory network reconstruction algorithm using this proposed framework is then developed that employs an evolutionary search strategy and a decomposable scoring metric based on information theoretic quantities. Investigations of our approach are performed using both, the synthetic data as well as Saccharomyces cerevisiae gene expression data. Comparisons with recent reconstruction methods show the superiority of the proposed method.

Electric Vehicle with a Genetic Algorithm a Lithium-Ion (Li-Ion) Battery, used in Electric Vehicles (EVs). A battery pack containing 150 cylindrical type Li-Ion battery cells in a PVC casing is investigated. An equal number of tubes has been used in the pack as a medium to cool the battery by using a fan when the vehicle is stationary or with ambient air when in motion. The parameters affecting the air cooling of battery have been studied and optimized by considering their practical constraints. The objective function and Net Transfer Unit (NTU) have been developed. Finally, a Genetic Algorithm has been employed to optimize the decision variables. Analyzing the results shows that NTU can be maximized by increasing the diameter of tubes on the battery and keeping the air velocity in a certain range.

The Case of a Piezoelectric simulation-based optimization Micro-Electromechanical- Systems (MEMS) is of particular interest in this research. The application of such devices is becoming an attractive alternative to the traditional use of batteries in wireless and body sensor networks. An evolutionary Multi-Objective Design Optimisation (DO) Framework is developed to experiment with one class of EH-MEMS, namely, Piezoelectric, using a reconstructed analytical model of the system. The application of such a Framework in this application domain is unprecedented and has already shown very promising results and in some cases it outperformed the human engineer. A thorough analysis of the results has been undertaken, which reveals interesting conclusions about the behaviour and physics of such devices. Besides, the main features of the Framework are explored enabling the enhancement of the MEMS-DO.

Topology Multiobjective optimization widely used for a verity of optimization problem in both research and industrial domains. Due to the potential of PSO, several variants of the original PSO algorithms have been developed to improve PSO's efficiency and robustness. This paper proposes another variant of particle swarm optimization algorithm, called N-PidSO. This N-PidSO algorithm is based on classical feedback control theory and topological neighborhood, which offers better search efficiency and convergence stability. As a result, our N-PidSO method features faster searching from the proportional term without steady-state error. And empirical results show that our N-PidSO algorithm is able to achieve high performance for both unimodal and multimodal optimization problems.

for a fixed-frequency synchronous step-down DC-DC converter is investigated. A new weighted control technique that uses the replicator dynamics concepts to weight the operation of different controllers tuned to operate in different modes, and with different control objectives is presented. Simulations for four critical process conditions are shown to illustrate the performance of this novel technique.

active research. It has been successfully applied to many real world problems. In this paper, an improved DE with a novel mutation scheme is proposed. The improved DE assigns a distinct scale factor for each individual mutation based on the fitness associated with each base vector involved in the mutation. With the adoption of different scale factors for mutation, DE is capable of searching more locally around superior points and explore more broadly around inferior points. Consequently, a good balance between exploration and exploitation can be achieved. Also, an adaptive base vector selection scheme is introduced to DE. This scheme is capable of estimating the complexity of objective functions based on the population variance. When the problem is simple, it will tend to select good vectors as base vector which will lead to quick convergence. When the objective function is complex, it will select base vector randomly so that the population maintains a high exploration capability and

will not be trapped into local minima so easily. A suite of 12 benchmark functions are used to evaluate the performance of the proposed method. The simulation result shows that the proposed method is promising in terms of convergence speed, solution quality and stability.

Disturbance applications tuning Proportional Integral Derivative (PID) controller. There is a great deal of general literature on PID controller with ignoring the disturbance interference. However, in practical applications, the ability of interference avoidance of PID controller should be considered in evaluating the performance of system response. In this study, using PSO online tuning mechanism, PID controller can track the input signal effectively even though the setpoint changes and load disturbance influences. The simulation results describe that the proposed method is able to obtain the good performance and stability.

Kernel combines pattern recognition techniques with an evolutionary computation kernel applied to financial markets time series in order to optimize trading strategies. Moreover, for pattern matching a template-based approach is used in order to describe the desired trading patterns. The parameters for the pattern templates, as well as, for the decision making rules are optimized using a genetic algorithm kernel. The approach was tested considering actual data series and presents a robust profitable trading strategy which clearly beats the market, SP 500 index, reducing the investment risk significantly.

maximum output in all scenarios of a given problem. The minimax problem can be transformed in a two players zero-sum game considering the fact that the Nash equilibria of this game would represent the solution of the original problem. Using the Nash ascendancy relation the equilibria of the game can be directly computed using a differential evolution algorithm. Results obtained by using this approach are compared with best known results from literature on six minimax benchmark problems.

Evolutionary computation theory proposes an improved NSGA-II algorithm, which updates the population in each sub-region by using non-dominated sorting and crowded distance selection operator (NSGA-II). Since performing the evolutionary operator is independent in each sub-region and the number of the individuals in a sub-region is far less than the size of the population, the computational complexity at each generation is lower than NSGA-II. The computational complexity of each generation in the proposed algorithm is O(mN3/2), where m is the number of the objective and N is its population size. For enhancing the capability of proposed algorithm, The algorithm exchanges the information between sub-regions through re-dividing their offsprings and the evolutionary operators between individuals are operated in the same sub-region. Such evolutionary operators can largely play a role of exploring the good individuals in this area and improve the local search capabilities of the algorithm. A specific selection in this paper surmounts the intrinsic shortcoming of the subregion decomposition technique, which there may be no Pareto optimal solutions in some sub-region. Numerical results show that the proposed algorithm has a good performance.

Ensemble Systems data mining recognition tasks, its elaboration and design is not an easy task. Some aspects such as the choice of its individual classifiers and the use of feature selection methods are very difficult to define. In addition, these aspects can have a strong effect in the accuracy of these systems, leading, for instance, to cases where the produced ensembles have no performance improvement. In order to avoid this situation, there is a great deal of research to select individual classifiers or distribute attributes to the individual classifiers of ensemble systems. In most of these works, however, only one aspect is tackled (either member selection or feature selection). In this paper, we present an analysis of two well-known optimization techniques to choose the ensemble members and to select attributes for these individual classifiers. In order to do this analysis, we use accuracy as well as two recently proposed diversity measures as parameters, in a multi-objective optimization problem.

Density Classifier Cellular Automata rule space, relies on representing the candidate rule numbers by their corresponding binary sequence. Recently the use of ternary representation has been tried, which is based upon the traditional notion of schemata in genetic algorithms, though not with a focus on their effectiveness for the search. Here, we specifically go about such an evaluation, in the context of the classical benchmark task of density classification, in which the objective is to find a binary, one-dimensional rule that indicates the prevailing bit in a binary sequence, given to the rule as an initial configuration. The role of ternary representation is probed by comparing their introduction into two simple and traditional genetic algorithms of the literature, developed for the task. The experiments show that the ternary representation can lead to an increase in the number of high performance rules found for the task.

Although the remaining potential is still large, most of it is located far from the industrialized south-

eastern states. In addition to that, the increasing opposition to the construction of new large reservoirs, for ecological and social reasons, highlights the need for the efficient operation of the existing system. In this work, a formulation recently developed by the authors, which has been shown to efficiently deal with the operational constraints of a single plant, is expanded to the multi-reservoir case. A multi-objective optimization of a system of five Brazilian hydropower plants is performed, with the objectives of increasing the mean power generation along a year and reducing the peak of demand of non-renewable energy sources.

Problems as an extension of a classical version of differential evolution (DE) (i.e., as an extension of DE/rand-to-best/1/exp). MRDE is designed to simultaneously search on different and evenly distributed sub-regions on the whole search space. The number and extent of the search regions change during the execution of the algorithm, in such a way that, at the final stage of the evolutionary process, only one region remains (i.e., the whole search space). Our proposed MRDE is compared with respect to the classical DE algorithm on a set of well-known benchmark problems. The results achieved show enough evidence of the benefits of distributing the population of vectors when dealing with large-scale optimization problems.

Differential Evolution Algorithm optimization popular wireless transmission technique in which digital data bits are transmitted at a high speed in a radio environment. But the high peak-to-average power ratio (PAPR) is the major setback for OFDM systems demanding expensive linear amplifiers with wide dynamic range. In this article we introduce a low-complexity partial transmit sequence (PTS) technique for diminishing the PAPR of OFDM systems. But the computational complexity of the exhaustive search technique for PTS increases exponentially with the number of sub- blocks present in an OFDM system. So we propose a modified differential evolution algorithm with novel mutation, crossover as well as parameter adaptation strategies (MDE_pBX) as a sub-optimum PTS for PAPR reduction of OFDM systems. MDE_pBX is utilized to search for the optimum phase weighting factors and extensive simulation studies have been conducted to show that MDE_pBX can achieve lower PAPR as compared to other DE and PSO variants like JADE, SaDE and CLPSO.

Many to One Communications in Wireless Sensor Networks optimization wireless sensor networks providing real-time guarantees and potentially reducing the delay and also it saves power by eliminating collisions. In TDMA based MAC, the sensor are not allowed tom radiate signals when they are not engaged. On the other hand, if there are too many switching between active and sleep modes it will also unnecessary waste energy. In this paper, we have presented a multi-objective TDMA scheduling problem has been demonstrated to prevent the wasting of energy discussed above and also further improve time performance. A modified discrete Differential Evolution algorithm (MDDE) has been proposed to enhance converging process in an proposed effective optimization framework. Simulation results are given with different network sizes. The results are compared with the Particle Swarm Optimization (PSO) and genetic Algorithm (GA) and the original discrete DE (DDE). The proposed MDDE algorithm has outperformed these two algorithms on the objective specified, which is the total time or energy for data collection.

clustering, data analysis and data mining and this paper aims to improve the evolutionary neural network algorithm EPNet to take advantage of those benefits. Neural networks exist with varying degrees of modularity ranging from pure modular networks characterized by disjoint partitions of hidden nodes with no communication between modules, to pure homogeneous networks with significant connections throughout. In between are apparently homogeneous networks that can be seen to have some degree of modularity if the hidden nodes are reorganized appropriately. In this paper, a modularity measure is presented and extended that can be applied to any neuron at any level in the network to provide a fine analysis of node partitioning. It also allows the rearrangement of nodes to create modules in homogeneous networks, and that is used to improve the EPNet algorithm to evolve modular neural networks. Experimental results on a simple classification task confirm that the new modular EPNet algorithm does indeed lead to more modular networks than the classical EPNet algorithm, without compromising the performance on the given task.

programming science nowadays. It is well-known that the genomes of complex organisms are highly organized. Many studies show that DNA sequence can be divided into a few segments, which have various properties of interest. Detection of this segments is extremely significant from the point of view of practical applications, as well as for understanding evolutional processes. We model genome sequences as a multiple change-point process, that is, a process in which sequential data are divided into segments by an unknown number of change-points, with each segment supposed to have been

generated by a process with different parameters. Multiple change-point models are important in many biological applications and, specifically, in analysis of biomolecular sequences. In this paper, we propose to use genetic algorithm to identify change-points. Numerical experiments illustrate the effectiveness of our approach to the problem. We obtain estimates for the positions of change-points in artificially generated sequences and compare the accuracy of these estimates to those obtained via Markov chain Monte Carlo and the Cross-Entropy method. We also provide examples with real data sets to illustrate the usefulness of our method.

number of parameters to tune. However, the performance of DE is sensitive to the mutation and crossover strategies and their associated parameters. To obtain optimal performance, DE requires time consuming trial and error parameter tuning. To overcome the computationally expensive parameter tuning different adaptive/self-adaptive techniques have been proposed. Recently the idea of ensemble strategies in DE has been proposed and favorably compared with some of the state-of-the-art self-adaptive techniques. Compact Differential Evolution (cDE) is modified version of DE algorithm which can be effectively used to solve real world problems where sufficient computational resources are not available. cDE can be implemented on devices such as micro controllers or Graphics Processing Units (GPUs) which have limited memory. In this paper we introduced the idea of ensemble into cDE to improve its performance. The proposed algorithm is tested on the 30D version of 14 benchmark problems of Conference on Evolutionary Computation (CEC) 2005. The employment of ensemble strategies for the cDE algorithms appears to be beneficial and leads, for some problems, to competitive results with respect to the-state-of-the-art DE based algorithms

Evolution on Multi-Objective Optimization swarm optimization meta-heuristics which have been found to be successful in a wide variety of optimization tasks. The high speed of convergence and the relative simplicity of PSO make it a highly viable candidate to be used in multi-objective optimization problems (MOPs). Therefore, several PSO approaches capable to handle MOPs (MOPSOs) have appeared in the past. There are some problems, however, where PSO-based algorithms have shown a premature convergence. On the other hand, multi-objective DEs (MODE) have shown lower speed of convergence than MOPSOs but they have been successfully used in problems where MOPSO have mistakenly converged. In this work, we have developed experiments to observe the convergence behavior, the online convergence, and the diversity of solutions of both meta-heuristics in order to have a better understanding about how particles and solutions move in the search space. To this end, MOPSO and MODE algorithms under (to our best effort) similar conditions were used. Moreover, the ZDT test suite was used on all experiments since it allows to observe Pareto fronts in two-dimensional scatter plots (more details on this are presented on the experiments section). Based on the observations found, modifications to two PSO-based algorithms from the state of the art were proposed resulting in a rise on their performance. It is concluded that MOPSO presents a poor distributed scheme that leads to a more aggressive search. This aggressiveness showed to be detrimental for the selected problems. On the other hand, MODE seemed to generate better distributed points on both decision and objective space allowing it to produce better results.

Problems optimization. requires a large number of fitness evaluations to obtain a sufficiently good solution. This is an obstacle for applying DE to computationally expensive problems. Many previous studies have been carried out to develop surrogate- assisted approaches for EAs to reduce the number of real fitness evaluations. Existing methods typically build surrogates with either regression or ranking methods. However, due to the pairwise selection scheme of DE, it is more appropriate to formulate the construction of surrogate as a classification problem rather than a regression or ranking problem. Hence, we propose a classification-assisted DE in this paper. Experimental studies showed that the classification-assisted DE has great potential when compared to the DE that uses regression or ranking techniques to build surrogates.

Differential evolution phenomenon dipole repulsion by a magnetic field. In this paper, a new version of this algorithm, which employs an estimation of distribution step as an additional search heuristic, is proposed and applied to seven well-known test functions for 30-dimensional, 120-dimensional and 1000-dimensional search spaces. The performance of the new approach is compared to that of benchmark differential evolution and estimation of distribution methods, and the results reveal its potential in terms of multimodal search in the context of complex optimization tasks.

Interactions games and multi-agent systems complex systems in various knowledge intensive domains. The communication between different agents interacting in an integrated multi-agents system can be managed through a set of steering rules, which together form interaction protocols. To support the

negotiation, communication and interaction between different intelligent agents, using an appropriate knowledge representation formalism is crucial. This paper introduces the potential of category theory as a formal representation vehicle to facilitate evolutionary analysis of agent interaction and negotiation for managing evolving ontologies in the domain of biomedicine. Utilizing categories supports agents' communication, negotiation, state transitions, compositions and transformations in different levels of abstractions.

to help researchers gain a better understanding of how cooperation develops in populations. One criticism of IPD is it underestimates the level of cooperation particularly in human populations. The iterated snowdrift (ISD) game has emerged as a viable alternative model, in part because it predicts higher cooperation levels. To date no numerical analysis of ISD has been done. In this paper we report the results from a numerical analysis conducted on an ISD with an N -player, well-mixed population. Our results show, with certain cost-to-benefit ratios, evolved ISD strategies can maintain surprisingly high quasi-stable levels of cooperation in the population.

Algorithms engine of a bot designed to play the Planet Wars game. This game, which has been chosen for the Google Artificial Intelligence Challenge in 2010, requires that the artificial player is able to deal with multiple objectives, while achieving a certain degree of adaptability in order to defeat different opponents in different scenarios. The decision engine of the bot is based on a set of rules that have been defined after an empirical study. Then, an Evolutionary Algorithm is used for tuning the set of constants, weights and probabilities that define the rules, and, therefore, the global behavior of the bot. The paper describes the Evolutionary Algorithm and the results attained by the decision engine when competing with other bots. The proposed bot defeated a baseline bot in most of the playing environments and obtained a ranking position in top-20% of the Google Artificial Intelligence competition.

plans in a robotic competition. The algorithm was used both as a static planner, making plans before matches, and as a dynamic replanner during matches, a task with much stricter demands of efficiency. The genetic algorithm was hybridized with a local search technique, which experiments proved essential to finding good solutions in this complex task. To enable rapid response under environmental changes, a heuristic for immediate response and a contingency planning module were also implemented. Experiments proved that the algorithm was able to generate good plans, and continuously modify them in light of a rapidly changing environment.

Optimization populations is a well studied and successful strategy to cope with the difficulties of tracking optima in dynamic environments in single-objective optimization. This paper studies a probabilistic model, suggesting that centroid-based diversity measures can mislead the search towards optima, and presents an extended taxonomy of immigration schemes, from which three immigrants strategies are generalized and integrated into NSGA2 for Dynamic Multiobjective Optimization (DMO). The correlation between two diversity indicators and hypervolume is analyzed in order to assess the influence of the diversity generated by the immigration schemes in the evolution of non-dominated solutions sets on distinct continuous DMO problems under different levels of severity and periodicity of change. Furthermore, the proposed immigration schemes are ranked in terms of the observed offline hypervolume indicator.

Vector Evaluated Particle Swarm Optimisation with one another and that change over time, called dynamic multi-objective problems. To solve these problems an algorithm must be able to track the changing Pareto Optimal Front (POF) over time and find a diverse set of solutions. This requires detecting that a change has occurred in the environment and then responding to the change. Responding to the change also requires to update the archive of non-dominated solutions that represents the found POF. This paper discusses various ways to manage the archive solutions when a change occurs in the environment. Furthermore, two new benchmark functions are presented where the POF is discontinuous. The dynamic Vector Evaluation Particle Swarm Optimisation (DVEPSO) algorithm is tested against a variety of benchmark function types and its performance is compared against three state-of-the-art DMOO algorithms.

Real-world applications of computational hardware throughout a given environment. In order to capitalize on the increased abundance of the underlying infrastructure multi-agent systems will be required to reflect the characteristics of the ubiquitous networks upon which they operate. Due to the potential for limited communication capacity experienced by agents in the wild it will become increasingly important for mobile agents to migrate to devices in greater proximity to the problem upon which they are working or the resources they require. A result of highly mobile agents operating in

potentially constrained computational and communication environments is that widely used command and coordination structures are no longer able to scale efficiently. Engineers are currently struggling with aspects of managing the physical devices which comprise such networks, particularly the obsolescence management of their constituent, highly dispersed, hardware. Analogously the obsolescence management of deployed agents is of increasing concern. The paper examines and synthesizes several biological metaphors which may be employed in order to mitigate the inherent complexity of managing deployed mobile agent systems and presents this functionality in a service oriented manner.

Real-world applications the weights assigned to the biometric modalities of a multi-biometric system for score-level fusion. Our results show that GEC-based multi-biometric fusion provides a significant improvement in the recognition accuracy over evenly fused biometric modalities, increasing the accuracy from 90.77% to 95.24%.

Genetic Programming programming (QILGP) to the growth of self-assembled quantum dots. Quantum inspired linear genetic programming is a novel model to evolve machine code programs exploiting quantum mechanics principles. Quantum dots are nanostructures that have been widely applied to optoelectronics devices. The method proposed here relies on an existing database of growth parameters with a resulting quantum dot characteristic to be able to later obtain the growth parameters needed to reach a specific value for such a quantum dot characteristic. The computational techniques were used to associate the growth input parameters with the mean height of the deposited quantum dots. Trends of the quantum dot mean height behavior as a function of growth parameters were correctly predicted, improving on the results obtained by artificial neural network and classical genetic programming.

mining, Real-world applications unseen glyph. The complexity of the problem necessitates a large network, which hampers the training of the weights. Three hybrid algorithms — combining evolution and back-propagation learning — are compared to the standard back-propagation algorithm. The results indicated that pure back-propagation is preferable to any of the hybrid algorithms. Back-propagation had both the best classification results and the fastest runtime, in addition to the least complex implementation.

Optimization and hyper-heuristics artificial neural networks (ANNs), especially to train them. These methods have advantages over the conventional backpropagation (BP) method because of their low computational requirement when searching in a large solution space. In this paper, we employ Chemical Reaction Optimization (CRO), a newly developed global optimization method, to replace BP in training neural networks. CRO is a population-based metaheuristics mimicking the transition of molecules and their interactions in a chemical reaction. Simulation results show that CRO outperforms many EA strategies commonly used to train neural networks.

Genetic Algorithms functions for Real-coded Genetic Algorithms (RCGAs). In the continuous function optimization, Evolutionary Algorithms (EAs) are one of the most effective optimization methods. However, most conventional EAs, such as RCGAs and CMA-ES, work efficiently on functions with big-valley landscape and they deteriorate on multi- funnel functions. Innately Split Model (ISM) has been proposed as a framework of GAs for multi-funnel functions and outperforms conventional GAs on this kind of functions. However, ISM is considered to have two problems in terms of efficiency of the search and difficulty of parameter settings. Our framework repeats a search by RCGAs as ISM does and has two effective mechanisms to remedy the two problems of ISM. We conducted experiments on benchmark functions with multi-funnel and big- valley landscapes and our framework outperformed conventional EAs, Multi-start RCGA (MS-RCGA), Multi-start CMA-ES (MS-CMA-ES) and ISM, on the multi-funnel functions. Our framework achieved as good performance as MS-RCGA and MS-CMA-ES on the big-valley function where ISM significantly deteriorates.

Multiobjective Route Planning in Dynamic Multi-hop Ridesharing consumption of fuel and reducing the congestion in urban cities, hence reducing the environmental pollution. Route planning is a key component for the success of ridesharing systems in which multiple objectives can be optimized. The multiobjective route planning problem in multi-hop ridesharing is categorized as NP–complete. Multiobjective evolutionary algorithms have received a growing interest in solving the multiobjective optimization problems. In this work, we compare the behaviour of different multiobjective evolutionary algorithms for solving the multiobjective route planning in dynamic multi-hop ridesharing. Comparison results indicate that there is no single algorithm, as in literature, that wins all the tournaments regarding all the quality indicators. However, a subset of the algorithms is recommended with better quality and runtime.

Multiobjective optimization wide variety of applications. However, in spite of their advantages, their

computational cost is still a prohibitive factor in certain real-world applications involving expensive (computationally speaking) fitness function evaluations. In this paper, we depart from the observation that nature's survival of the fittest is not about exact measures of fitness; rather it is about rankings among competing peers. Thus, by exploiting this natural tolerance for imprecision, we propose here a new, fuzzy granules-based approach for reducing the number of necessary function calls involving time consuming real-world problems. Our proposed approach is compared with respect to the standard NSGA-II, using the Set Coverage, Hypervolume and Generational Distance performance measures. Our results indicate that our proposed approach is a very promising alternative for dealing with multi-objective optimization problems involving expensive fitness function evaluations.

evolutionary computation techniques. However, when dealing with more than three conflicting objectives (the so-called many-objective problems), the performance of such approaches deteriorates. The problem lies in the inability of Pareto dominance to provide an effective discrimination. Alternative ranking methods have been successfully used to cope with this issue. Nevertheless, the high selection pressure associated with these approaches usually leads to diversity loss. In this study, we focus on parallel genetic algorithms, where multiple partially isolated subpopulations are evolved concurrently. As in nature, isolation leads to speciation, the process by which new species arise. Thus, evolving multiple subpopulations can be seen as a potential source of diversity and it is known to improve the search performance of genetic algorithms. Our experimental results suggest that such a behavior, integrated with an effective ranking, constitutes a suitable approach for many-objective optimization.

Multi-objective evolutionary algorithms high-performing Pareto-optimal solutions,without considering their sensitivity to minor deviations from their original values. It is a fair assumption that practical realization of optimal solutions is often accompanied by minor differences from the exact numerical results produced by an optimizer. Taking this factor into account, Robust Optimization methods seek to find high-performing solutions which are also less sensitive to such deviations. In this work, we have proposed strategies to minimize the number of function evaluations (which can be an expensive enterprise) to enhance one of the earliest proposed methods for robust Multi-objective Optimization. Our focus is on constrained Multi-objective optimization problems and hence we make use of the Infeasibility Driven Evolutionary Algorithm (IDEA), as the Evolutionary Multi-objective Optimizer. We take up three constrained Multi-objective engineering design optimization problems from the literature as the test-bed for our experiments and present results on the same.

combinatorial optimization. both experienced a significant and rapid growth in publications and research since the turn of the century. Despite this it is more often than not that methods in both fields are applied only to problems of one type of encoding. However, many real-world problems require parameters vectors that use multiple encodings. This paper presents a suite of novel multi-objective optimisation test problems (Exeter1 to 6) with mixed encodings (real and binary) and offer variable correlation between the objectives at different stages of the search. The problems are demonstrated using NSGA-II, SPEA2 and a (mu + lambda) Evolution Strategy which were modified to operate on both encodings simultaneously.

scalability and complexity analysis algorithms with proportional selection. Evolutionary annealing is a novel evolutionary algorithm that makes this connection explicit, resulting in an evolutionary optimization method that can be viewed either as simulated annealing with improved sampling or as a non-Markovian selection mechanism for genetic algorithms with selection over all prior populations. A martingale-based analysis shows that evolutionary annealing is asymptotically convergent and this analysis leads to heuristics for setting learning parameters to optimize the convergence rate. In this work and in parallel work evolutionary annealing is shown to converge faster than other evolutionary algorithms on several benchmark problems, establishing a promising foundation for future theoretical and experimental research into algorithms based on evolutionary annealing.

Computation Multi-objective evolutionary algorithms global optimization (BGO) and metamodel-assisted evolutionary computation, both applied in optimization with costly function evaluations. Recently, it has been adopted in different ways to multiobjective optimization. A promising approach to formulate the expected improvement in this context, is to base it on the hypervolume indicator. Given the Bayesian model of the optimization landscape, the EI in hypervolume computes the expected gain in attained hypervolume for a given input point. Although a formulation of this expected improvement is relatively straightforward, its computation and mathematical properties are still to be investigated. This paper will outline and derive an algorithm for the exact computation of the proposed hypervolume-based EI. Moreover, this paper establishes monotonicity properties of the expected improvement.

In particular the effect of the predictive distribution's variance on the hypervolume-based EI and elementary properties of the EI landscape are studied. The monotonicity properties will reveal regions where Pareto front approximations can be improved as well as underexplored regions that are favored by the hypervolume-based expected improvement. A first numerical example is included that illustrates the behavior of the hypervolume-based EI in the multiobjective BGO framework.

one goal, several optimization techniques have been proposed in the past. However, traditional optimization techniques are computationally expensive and are normally highly susceptible to some characteristics such as high dimensionality, non-differentiability, non-linearity, highly expensive function calculation, among others. Evolutionary algorithms are bio-inspired meta-heuristics that have shown flexibility, adaptability and good performance when solving these sort of problems. In order to achieve acceptable results, some problems usually require several evaluations of the optimization function. However, when each of these evaluations represents a high computational cost, these problems remain intractable even by these meta-heuristics. To reduce the computational cost in expensive optimization problems, some researchers have replaced the real optimization function with a computationally inexpensive surrogate model. Despite there are comparison studies among these techniques, these studies focused on revised the accuracy of the meta-model for the problem at hand, but neither its suitability to be used with evolutionary algorithms, nor its scalability in the variable design space. In this work, we compare four meta-modeling techniques, polynomial approximation, kriging, radial basis functions and support vector regression, in different aspects such as accuracy, robustness, efficiency, and scalability with the aim to identify advantages and disadvantages of each meta-modeling technique in order to select the most suitable one to be combined with evolutionary optimization algorithms.

Distribution in Self-Compacting Concrete: A Feasibility Study Real-world applications been getting more attention from the industry. Its application area varies from standard structural elements in bridges and skyscrapers to modern architecture having geometrical challenges. However, heterogeneities induced during the casting process may lead to variations of local mechanical properties and hence to a potential decrease in load carrying capacity of the structure. This paper presents a methodology for optimization of SCC casting aiming at having a homogeneous aggregate distribution; a beam has been used as geometric example. The aggregate distribution is predicted by a numerical flow model coupled with a user defined volume fraction subroutine. The process parameters in casting with SCC in general are horizontal and vertical positions, movement, as well as the size of the inlet, and the duration of the filling etc., however since this work is the initial feasibility study in this field, only three process parameters are considered. Despite the reduction in the number of process parameters, the complexity involved in the considered casting process results in a non trivial optimal design set.

Generation Scheduling day-ahead thermal generation scheduling problem. The objective functions considered to model the scheduling problem are: 1) minimizing the system operation cost and 2) minimizing the emission cost. In the proposed algorithm, the chromosome is formulated as a binary unit commitment matrix (UCM) which stores the generator on/off states and a real power matrix (RPM) which stores the corresponding power dispatch. Problem specific binary genetic operators act on the binary UCM and real genetic operators act on the RPM to effectively explore the large binary and real search spaces separately. Heuristics are used in the initial population by seeding the random population with two Priority list (PL) based solutions for faster convergence. Intelligent repair operator based on PL is designed to repair the solutions for load demand equality constraint violation. The ranking, selection and elitism methods are borrowed from NSGA-II. The proposed algorithm is applied to a large scale 60 generating unit power system and the simulation results are presented and compared with our earlier algorithm [26]. The presented algorithm is found to outperform our earlier algorithm in terms of both convergence and spread in the final Pareto-optimal front.

Distribution Networks by a Hybrid Genetic Algorithm power distribution networks: (a) the installation of capacitor banks to compensate the losses produced by reactive currents; and (b) the redefinition of the topology of electric distribution networks by changing the state of some sectionalizing switches to balance the load. Both strategies can be formulated as combinatorial optimization problems. The optimization problems for the first and the second strategies are usually known as Capacitor Placement Problem (CPP) and Network Reconfiguration Problem (NRP), respectively. In this paper, we propose a new approach based on Genetic Algorithm (GA) to solve both CPP and NRP simultaneously. The new approach makes use of two previously proposed and independent techniques for the CPP and the NRP. The performance of the new approach is compared with the performance of the two previously proposed techniques applied in a separate manner. The experiments show that the new method is more

efficient regarding the metrics of power loss reduction and voltage profile enhancement.

algorithms paper and is converted to a multi-objective optimization problem with constraints, of which the positions of secondary speakers and error sensors are the decision variables, the summation of the squared pressure at all points within the noise quiet zone and the total source strength for the secondary speakers are the multi-objective functions. The multi-objective genetic algorithms and simple genetic algorithm are implemented to solve the optimization problem so as to determine the appropriate positions of the secondary speakers and error sensors. The large sound pressure reduction within the noise quiet zone to control the single tone primary noise and motor operating noise shows that the optimal schemes obtained by the genetic algorithms are efficient.

in Social Networks different ways recently. To identify communities in social networks we can formulate it with two different objectives, maximization of internal links and minimization of external links. Because these two objects are correlated, the relationship between these two objectives is a trade-off. This study employed harmony search algorithm, which was conceptualized using the musical process of finding a perfect state of harmony to perform this bi- objective trade-off. In the proposed algorithm an external repository considered to save non-dominated solutions found during the search process and a fuzzy clustering technique is used to control the size of repository. The harmony search algorithm was applied on well-known real life networks, and good Pareto solutions were obtained when compared with other algorithms, such as the MOGA-Net and Newman algorithms.

problem intensively studied in recent years. This paper investigates the performance of evolutionary algorithms for the task of detecting overlapping communities. This task is of great importance as the membership of a node to more than one group is naturally occuring in many real-world networks from fields such as sociology, biology and computer science. One of the major challenges in designing evolutionary algorithms for overlapping community detection is the efficient assessment of the quality of any particular division of nodes into groups. We test four different fitness functions in an evolutionary approach to the problem using the same chromosome representation and search scheme. The performance of the resulting algorithms is tested in a set of computational experiments for some real-world networks. We show that none of the fitness functions used are able to guide the search process towards good partitions based on a measure of the normalized mutual information.

Network Topology providing better user experiences. The complexity in developing recommendation systems is largely due to the heterogeneous nature of social networks. This paper presents an approach to friend recommendation systems by using complex network theory, cognitive theory and a Pareto-optimal genetic algorithm in a two-step approach to provide quality, friend recommendations while simultaneously determining an individual's perception of friendship. Our research emphasizes that by combining network topology and genetic algorithms, better recommendations can be achieved compared to each individual counterpart. We test our approach on 1,200 Facebook users in which we observe the combined method to outperform purely social or purely network-based approaches. Our preliminary results represent strong potential for developing link recommendation systems using this combined approach of personal interests and the underlying network.

Rotation-Invariant Local Sampling Operation has been successfully applied to optimization problems including non-linear, non-differentiable, non-convex and multimodal functions. However, the performance of DE degrades in problems having strong dependence among variables, where variables are strongly related to each other. One of the desirable properties of optimization algorithms for solving the problems with the strong dependence is rotation-invariant property. In DE, the mutation operation is rotation-invariant, but the crossover operation is not rotation-invariant usually. In this study, we propose a new operation, called local sampling operation that is rotation-invariant. In the operation, independent points are selected from the population, difference vectors from a parent to the points span a local area centered at the parent, and a new point is generated around the area. Also, the operation is used for judging whether intensive search or extensive search is desirable in each generation. The effect of the proposed method is shown by solving some benchmark problems.

the problem of optimal selection of cluster-heads and cluster-members in mobile ad hoc networks. A novel encoding scheme is used to represent nodes in the network graph, and randomly-generated networks of different sizes are solved. The present method handles problems of much larger sizes than do the best-known methods in the literature. Empirical results show the superiority of this method over state-of-the-art approaches on two counts: quality of the solution and time to find the solution.

affected by its parameter setting. But the choice of parameters is heavily dependent on the problem characteristics. Therefore, recently a couple of adaptation schemes that automatically adjust DE

parameters have been proposed. The current work presents another adaptation scheme for DE parameters namely amplification factor and crossover rate. We systematically analyze the effectiveness of the proposed adaptation scheme for DE parameters using a standard benchmark suite consisting of ten functions. The undertaken empirical study shows that the proposed adaptive DE (aDE) algorithm exhibits an overall better performance compared to other prominent adaptive DE algorithms as well as canonical DE.

Refinement Of Agent-Based Model Specifications Evolutionary simulation-based optimization and so far no established testing technique has been devised for this kind of software applications. Reverse engineering an agent-based model specification from model simulations can help establish a confidence level about the implemented model and in some cases reveal discrepancies between observed and normal or expected behaviour. In this study, a multiobjective optimisation technique based on a simple random search algorithm is deployed to dynamically infer and refine the specification of three agent-based models from their simulations. The multiobjective optimisation technique also incorporates a dynamic invariant detection technique which serves to guide the search towards uncovering new model behaviour that better captures the model specification. The Non-Dominated Sorting Genetic Algorithm (NSGA-II) [1] was also deployed to replace the random search algorithm, and the results from both approaches were compared. While both algorithms revealed good potential in capturing the model specifications, the pure exploratory nature of random search was found more suitable for the application at hand, compared to the balanced exploitation/exploration nature of genetic algorithms in general.

Signaling Pathway identify and create hierarchies of cooperative agents. Once a group of cooperative agents is found, a higher-order agent is created which in turn learns the group behaviour. This way, the number of agents and thus the complexity of the multiagent system will be reduced, as one agent emulates the behaviour of several agents. Our proposed method of creating hierarchies captures the dynamics of a multiagent system by adaptively creating and breaking down hierarchies of agents as the simulation proceeds. Experimental results on two MAPK signaling pathways suggest that the proposed approach is suitable in stable systems while periodic systems still need further investigations.

perform better if it was allowed to search deeper in the game tree. However, there has been some discussion as to whether the evaluation function or the depth of the search is the main contributory factor in the performance of the player. There has been some evidence suggesting that look-ahead (i.e. depth of search) is particularly important. In this work we provide a rigorous set of experiments, which support this view. We believe this is the first time such an intensive study has been carried out for evolutionary checkers. Our experiments show that increasing the depth of a look-ahead has significant improvements to the performance of the checkers program and has a significant effect on its learning abilities.

Evolutionary games and multi-agent systems as the optimal solutions. The rule accumulation method tries to find good experiences from individuals throughout the generations and store them as decision rules, which is regarded as solutions. Genetic Network Programming (GNP) is competent for dynamic environments because of its directed graph structure, reusability of nodes and partially observable processes. A GNP based rule accumulation method has been studied and applied to the stock trading problem. However, with the changing of dynamic environments, the old rules in the rule pool are incompetent for guiding new agent's actions, thus updating these rules becomes necessary. This paper proposes a new method to update the accumulated rules in accordance with the environment changes. Sarsa- learning which is a good on-line learning policy is combined with off-line evolution to generate better individuals and update the rules in the rule pool. Tileworld problem which is an excellent benchmark for multi-agent systems is used as the simulation environment. Simulation results demonstrate the efficiency and effectiveness of the proposed method in dealing with the changing environments.

Network Optimization in routing a set of lightpaths (all-optical connections), such that the cost of the optical components necessary to operate the network is minimized. We propose a genetic algorithm with random keys that extends the best heuristic in the literature by embedding it into an evolutionary framework. Computational results showed that the new heuristic improves the best heuristic in the literature.

Engineering (TE) over IP-based networks in the last few years, being used to reach the best set of link weights in the configuration of intra-domain routing protocols, such as OSPF. In this work, the multiobjective nature of a class of optimization problems provided by TE with Quality of Service constraints is identified. Multiobjective EAs (MOEAs) are developed to tackle these tasks and their

results are compared to previous approaches using single objective EAs. The effect of distinct genetic representations within the MOEAs is also explored. The results show that the MOEAs provide more flexible solutions for network management, but are in some cases unable to reach the level of quality obtained by single objective EAs. Furthermore, a freely available software application is described that allows the use of the mentioned optimization algorithms by network administrators, in an user-friendly way by providing adequate user interfaces for the main TE tasks.

wireless sensor networks (WSNs). In this paper, we explore the problem of wake- up scheduling in WSNs where sensors have different lifetime. A novel local wake- up scheduling (LWS) strategy is proposed to prolong the network lifetime with full coverage constraint. In the LWS strategy, sensors are divided into a first layer set and a successor set. The first layer set which satisfies the coverage constraint is activated at the beginning. Once an active sensor runs out of energy, some sensors in the successor set will be activated to satisfy the coverage constraint. Based on the LWS strategy, this paper presents an ant colony optimization based method, namely mc-ACO, to maximize the network lifetime. The mc-ACO is validated by performing simulations on WSNs with different characteristics. A recently published genetic algorithm based wake-up scheduling method and a greedy based method are used for comparison. Simulation results reveal that mc-ACO yields better performance than the two algorithms.

Multi-objective Evolutionary Optimization conditions by transducing cellular signals into specific regulatory programs, which control gene expression states of thousands of different genes. One of the central problems in understanding gene regulation is to decipher how combinations of transcription factors control sets of co-expressed genes under specific experimental conditions. Existing methods in this field mainly focus on sequence aspects and pattern recognition, e.g., by detecting cis-regulatory modules (CRMs) based on gene expression profiling data. We propose a novel approach by combining experimental data with a priori knowledge of respective experimental conditions. These various sources of evidence are likewise considered using multi-objective evolutionary optimization. In this work, we present three objective functions that are especially designed for stimulus-response experiments and can be used to integrate a priori knowledge into the detection of gene regulatory modules. This method was tested and evaluated on whole-genome microarray measurements of drug-response in human hepatocytes.

biomedical applications difficult technical challenges. Compression and reconstruction techniques must guarantee no significant loss of clinical information. This paper presents a convenient technique for improving the quality of reconstructed computed tomography (CT) images previously subjected to specified levels of lossy compression. Our genetic algorithm (GA) evolves novel transforms that consistently outperform state-of-the-art wavelet-based schemes supported by the Digital Imaging and Communication in Medicine (DICOM) standard.

Models of amino acids is a computationally challenging problem even in simplified lattice protein models. A hybrid evolutionary model is designed and tested in the current paper to address this well-known NP-hard problem. Hill-climbing strategies are integrated in the search operators and a meaningful diversification of genetic material occurs during the population evolution. The main features of the proposed algorithm refer to a weak hill-climbing application of uniform crossover and pullmove transformations and the randomization of genetic material based on the fingerprint of the protein conformations. Numerical experiments are performed for several difficult bidimensional instances from lattice models (the hydrophobic-polar model and functional model proteins). The results are competitive with those obtained by related population-based optimization algorithms.

Prediction combinatorial optimization. conformation of a protein given only its amino acid sequence. The HP lattice model is an abstract formulation of this problem, which captures the fact that hydrophobicity is one of the major driving forces in the protein folding process. This model represents a hard combinatorial optimization problem and has been widely addressed through metaheuristics such as evolutionary algorithms. However, the conventional energy (evaluation) function of the HP model does not provide an adequate discrimination among potential solutions, which is an essential requirement for metaheuristics in order to perform an effective search. Therefore, alternative energy functions have been proposed in the literature to cope with this issue. In this study, we inquire into the effectiveness of several of such alternative approaches. We analyzed the degree of discrimination provided by each of the studied functions as well as their impact on the behavior of a basic memetic algorithm. The obtained results support the relevance of following this research direction. To our knowledge, this is the first work reported in this regard.

biomedical applications optimization, Evolutionary programming Optimization (PSO), which are based on competitiveness and collaborative algorithms respectively, are investigated for plasmonic design. Actually, plasmonics represents a rapidly expanding interdisciplinary field with numerous devices for physical, biological and medicine applications. In this study, four EM and PSO algorithms are tested in two different plasmonic applications: design of surface plasmon resonance (SPR) based biosensors and optimization of hollow nanospheres used in curative purposes (cancer photothermal therapy). Specific problems–in addition of being multimodal and having different topologies– are related to plasmonic design; therefore the most efficient optimization method should be determined through a comparative study. Results of simulations enable also to characterize the optimization methods and depict in which case they are more efficient.

Continuous Optimization evolutionary computation diversity seem to be crucial to deal with multimodal continuous optimization. However, usually this crucial aspect is not an inherent feature of generally adopted meta-heuristics. In this paper, we propose to associate diversity maintenance with the detection and elimination of redundant candidate solutions in the search space, more specifically candidate solutions located at the same attraction basin of a local optimum. Two low computational cost heuristics are proposed to detect redundancy, in a pairwise comparison of candidate solutions and by extracting local features of the fitness landscape at runtime. Those heuristics are not tied to a specific class of algorithms, and are thus able to be incorporated into a broad range of population-based meta-heuristics, and even into multiple executions of non-population-based algorithms. In a set of experimental results, the two heuristics were implemented as an attached module of an already existing multipopulation meta-heuristics, and the results indicate that they operate properly, no matter the number and conformation of the attraction basins in multimodal optimization problems.

new spatial method based on the discretization of the container into a grid of cells with predefined resolution. Before an item is added, grid cells are checked whether they can accommodate the item. If an appropriate empty cell cluster is found, the item is added and moved towards the bottom-left corner of the container. This placement and sliding method is supplemented by a heuristic that orders the items according to descending size. Order and rotation of items can be improved by hybridizing the heuristic with a genetic algorithm (GA) in which a population of order-rotation chromosomes is evolved. The method is tested on 47 benchmark problems and compared to other methods in the literature. This shows that it is fast and performs very well in finding close to optimal problem solutions. Particularly for large problem sizes, it outperforms some of the currently leading methods, such as heuristic recursive (HR). The hybridization with the GA metaheuristic results in further performance improvements.

Multi-method Global Optimization optimization. This paper investigates the use of various algorithm selection strategies derived from well known evolutionary selection mechanisms. Selection strategy performance is evaluated on a diverse set of floating point benchmark problems and meaningful conclusions are drawn with regard to the impact of selective pressure on algorithm selection in a multi-method environment.

Human Immunodeficiency Virus (HIV), which causes the Acquired Immunodeficiency Syndrom (AIDS). This has been a long lasting problem in high-risk populations such as sex workers: individuals in this population may face drug addiction and share infected needles, or have unprotected sex, and both issues can result in an HIV infection that may then be transmitted to other parts of the population. To study the dynamics of the HIV epidemic in such a highrisk community, we propose a model in which the population is represented as a cellular automaton. At the macro-level, our model accounts for the fact that the sexual behaviour of an individual is influenced by the social norms of his acquaintances(social network) as well as by his awareness of HIV status. At the micro-level, randomized neighborhoods provide an explicit representation of personal interactions standing for the large number of non-repeated encounters in populations at risk. Our simulations study the dynamics of the disease for different social norms as well as the probability that a seropositive individual get tested.

Weighted Sums multicriteria optimization problems. The algorithm alternates between different single-criterium optimization problems characterized by weight vectors. The policy for switching between different weights is an adaptation of the universal restart strategy defined by [LSZ93] in the context of Las Vegas algorithms. We demonstrate the effectiveness of our algorithm on multicriteria quadratic assignment problem benchmarks and prove some of its theoretical properties.

to adequately order sets of points in multi- and many-objective optimization problems. The use of relaxed and alternative dominance relationships has been an important tool for improving the performance of multiobjective evolutionary optimization algorithms, and their ordering ability is among

the most important characteristics responsible for such improvement. Three relaxed formulations of dominance are investigated, along with the traditional Pareto ordering, in order to provide a comparison baseline. The results obtained show that all three relaxed dominance approaches presented greater robustness to the increase in the number of objectives, and are therefore more appropriate for use in many-objective optimization algorithms.

unconstrained multi-objective optimization problems (MOPs). The proposed algorithm adopts a nonlinear simplex search scheme in order to obtain multiple approximations of the Pareto optimal set. The search is directed by a well-distributed set of weighted vectors. Each weighted vector defines a scalarization problem which is solved by deforming a simplex according to the movements described by Nelder and Mead's method. The simplex is constructed with a set of solutions which minimize different scalarization problems defined by a set of neighbor weighted vectors. The solutions found in the search are used to update a set of solutions considered to be the minima for each separate problem. In this way, the proposed algorithm collectively obtains multiple trade-offs among the different conflicting objectives, while maintaining a well distributed set of solutions along the Pareto front. The main aim of this work is to show that a well-designed strategy using just mathematical programming techniques can be competitive with respect to a state-of-the-art multi-objective evolutionary algorithm.

Function Optimization analysis optimization methods based on scalarization for solving multiobjective function optimization problems. It progressively generates new solutions to refine the approximation of the Pareto set or the Pareto front by the subdivision, and iteratively estimates the appropriate weight vector for scalarization in each search by the weight adaptation. Our recent study shows that AWA's solution set combinatorially increases for the number of objectives. In this paper, we propose a new subdivision and weight adaptation scheme of AWA to improve its scalability. Numerical experiments show that the effectiveness of the proposed method.

algorithms. To date, most of the competitive coevolution research has been done in the domain of single-objective optimization. We propose a novel competitive coevolutionary framework to explore Pareto-based multi-objective competitive coevolution. This framework utilizes the hypervolume indicator and fitness sharing mechanism to address disengagement and over-specification issues. A diversity-driven evolutionary selection scheme is utilized to deal with the loss of fitness gradient problem. Several series of experiments are conducted using multi- objective two-sided competitive games. The results suggest that Pareto-optimal solution sets can effectively be found using our proposed coevolutionary framework.

Distribution Algorithms (Univariate EDAs) are closely related algorithms in that both update marginal distributions/populations, and test samples of those distributions/populations by grouping them with collaborators drawn from elsewhere to form a complete solution. Thus the quality of these samples is context-sensitive and the algorithms assume low linkage among their variables. This results in well-known difficulties with these methods. While EDAs have commonly overcome these difficulties by examining multivariate linkage, CCEAs have instead examined basing the fitness of each marginal sample on the maximum of several trials. In this study we examine whether multiple-trial CCEA approach is really effective for difficult problems and large numbers of subpopulations; and whether this approach can be used to improve Univariate EDAs as well.

behavior expensive fitness computations often form a critical performance bottleneck. A preferred method of reducing the computational overhead is to coevolve rank predictors, providing a coarse and lightweight fitness approximation that has proven to drastically increase performance. However, the majority of previous work on rank predictor coevolution focused solely on improving the predictor heuristics while strategies to select the equally important trainer population is often an afterthought. Four different strategies are presented and benchmarked on a symbolic regression problem using hundreds of test problems with varying complexities. Of the four strategies, updating the trainer population with the solution of the highest rank variance is found to be significantly superior, resulting in a four to ten fold reduction in computational effort for similar convergence rates over the remaining strategies.

Optimisation and Parameter Analysis hyper-heuristics context of the supply chain operations. A two-silo supply chain was built for experimentation and three approaches were used for global optimisation: a classical evolutionary approach, a cooperative coevolutionary approach and a coevolutionary approach with on the fly partner generation where the solution from the second component of the supply chain is generated deterministically based on the first one. The second approach produced higher quality solutions due to its use of communication between silos. Additional experiment was

conducted to choose optimal species sizes.

Embedded with Memetic Feature Selection hybrid algorithms features which degrade both prediction accuracy and computational efficiency, feature selection is an effective data reduction technique showing promising performance. This paper presents a cooperative coevolution framework to make the feature selection process embedded into the classification model construction within the genetic-based machine learning paradigm. The proposed approach utilizes the divide-and-conquer strategy to manage two populations in parallel, corresponding to the selected feature subsets and the rule sets of classifier respectively, in which a memetic feature selection algorithm is adopted to evolve the feature subset population while a Pittsburgh-style learning classifier system is used to carry out the classifier evolution. These two coevolving populations cooperate with each other regarding the fitness evaluation and the final solution is obtained via collaborations between the best individuals from each population. Empirical results on several benchmark data sets chosen from the UCI repository, together with a non-parametric statistical test, validate that the proposed approach is able to deliver classifiers of better prediction accuracy and higher stability with fewer selected features, compared with the original learning classifier system. In addition, the incorporated feature selection process is shown to help improve the computational efficiency as well.

Nonuniform Illumination deconvolution for barcode signals by using evolutionary algorithms. Indeed, such optimization problems are highly non convex and a robust method is needed in case of noisy and/or blurred signals and nonuniform illumination. Here, we present the construction of a genetic algorithm combining discrete and continuous optimization which is successfully applied to decode real images with very strong noise and blur.

Genetic Algorithm optimization successfully used for many real world optimization applications in scientific and engineering areas. One of these areas is computational nanoscience. Semi-empirical models with physics-based symmetries and properties can be developed by using EC to reproduce theoretically the experimental data. One of these semi-empirical models is the Valence Force Field (VFF) method for lattice properties. An accurate understanding of lattice properties provides a stepping stone for the investigation of thermal phenomena and has large impact in thermoelectricity and nano-scale electronic device design. The VFF method allows for the calculation of static properties like the elastic constants as well as dynamic properties like the sound velocity and the phonon dispersion. In this paper a parallel genetic algorithm (PGA) is employed to develop the optimal VFF model parameters for gallium arsenide (GaAs). This methodology can also be used for other semiconductors. The achieved results agree qualitatively and quantitatively with the experimental data.

Shop Scheduling Problems. The proposed MA is based on Machine Operation Lists (MOL), which is the exact sequence of operations for each machine. Machine Operation Lists representation is a modification of Preference List-Based representation. Linear Order Crossover (LOX) and Random operations are first considered as crossover and mutation operators for the proposed MA. Local Search heuristic (LS) of the proposed MA reconsiders all the operations of a job. It chooses a job and removes all of its operations and finally reassigns them again one by one in their sequencing order to improve the fitness value of the schedule. The proposed algorithm has been applied on the well-known benchmark of classical Job Shop Scheduling Problems (JSSP). Comparing it with the existing methods shows that the proposed MA and the proposed Genetic Algorithm (GA) without LS are effective in JSSP. Moreover, comparing the results of MA and GA shows that using LS not only improves the final results but also helps GA to converge to the final solution.

Evolution Strategy operators the engineering of technical solutions, for example control system design. This paper presents an multi-objective evolutionary approach for identification of dynamic systems of variable structure. The evolutionary algorithm employs domain specific operators in order to evolve the block oriented structure of the model and simultaneously optimize its parameters. Based on the observed inputs and outputs the multi-objective method identifies an entire set of optimal compromise models which contrast model accuracy against complexity. The models are constructed from a set of basic blocks that capture phenomenons such as linear transfer functions, nonlinear gains and hysteresis that typically occur in mechanical, hydraulic and electrical systems. This representation enables the incorporation of domain knowledge in terms of building blocks and the interpretation of the identified model for further analysis and design. The feasibility of the proposed method is validated in the identification of an artificial dynamic system as well as a hydraulic proportional valve.

Memetic Framework capability than their conventional counterparts. Due to its good robustness and universality, differential evolution (DE) has been frequently used as the global search method in

MAs. However, on account of the limited performance of the conventional local search operators, the performance of previous DE-related MAs still needs further improvement. In this paper, we implement more efficient evolutionary algorithms (EAs) as the local search techniques in an adaptive MA framework to form two MA(DE-LS) variants, and investigate their impacts. In order to comprehensively show the effectiveness and efficiency of MA(DE-LS), we experimentally compare it with state-of-the-art EAs, DE-based MAs and other MAs.

Regular Networks-on-Chip routing algorithm for Networks-on-Chip (NoCs). The proposed algorithm is based on the ball-and-string model and employs a distributed approach based on partitioning of the regular NoC architecture into regions controlled by local monitoring units. Each local monitoring unit runs a shortest path computation procedure to identify the best routing path so that highly congested routers and faulty links are avoided while latency is improved. To dynamically react to continuously changing traffic conditions, the shortest path computation procedure is invoked periodically. Because this procedure is based on the ball-and-string model, the hardware overhead and computational times are minimal. Experimental results based on an actual Verilog implementation demonstrate that the proposed adaptive routing algorithm improves significantly the network throughput compared to traditional XY routing and DyXY adaptive routing algorithms.

Programming with Rule Accumulation with Rule Accumulation (GNP-RA) has been proposed in this paper. The generalized rules extracted by training GNP are pruned by GA in the validation phase. Each rule has two variables: U and N. Variable U determines if the rule is used or not, while variable N shows that the information on N days is used. By mutating variables U and N of each rule, the portfolio of U and N is changed, as a result, the rules are pruned. The performance of the pruned rules is tested in the testing phase, meanwhile, the best mutation rates for variable U and variable N are also studied. The simulation results show that the pruned rules work better than the rules without pruning.

Ranking Selection, Direction-Based Crossover and Dynamic Mutation (RCGA) for process optimization. The proposed RCGA is equipped with Ranking Selection (RS), Direction-Based Crossover (DBX) and Dynamic Random Mutation (DRM) operators. The RS operator is used to eliminate the bad solutions and reproduce good solutions, making the whole population to achieve a better average fitness. The DBX operator uses relative fitness information to direct the crossover toward a direction that significantly improves the objective fitness. The DRM operator prevents the premature convergence of RCGA and at the same time increases the precision of the searched solution. The effectiveness and application of the proposed RCGA are demonstrated through a variety of single- objective optimization benchmark problems. For comparative study, other existing RCGAs with different evolution operators are also performed to the same problem set. Extensive experiment results reveal that the proposed RCGA provides a significantly faster convergence speed and much better search performance than comparative methods.

Programming with Nonconvex Objective Functions nonconvex objective functions, in which the follower objective is a function of linear expression of all variables and the follower constraints are linear. For the leader functions, there are no any restrictions on the convexity as well as the differentiability. The distinguished feature of the problem is the nonconvexity of the follower objective function, which breaks through the barrier that the follower must be convex or concave in literature. First, for any fixed leader variable x, two linear programming are got from the follower and used to obtain the follower optimal solution y. In addition, in order to avoid solving directly the follower problem for each x, a real-binary encoding scheme is given which consists of x and the bases of two linear programming. Finally, a new crossover operator is designed based on the characteristics of the mixed encoding, and a novel genetic algorithm is proposed. The numerical results on 15 examples illustrate that the proposed algorithm is effective and stable.

applications inverter is to produce a sinusoidal ac voltage with adjustable amplitude and frequency. Pulse-width modulation (abbr. PWM) is one of the most used techniques in static inverters. For the PWM, the switching angle is most important, and the switching angle controls the efficiency of DC-AC inversion. For this reason, the design of the optimal switching angle vector is very important. In this article. we obtain such switching angle vector by particle swarm optimization system (abbr. PSO). Our simulation results indicate that the proposed design procedure gives high efficiency inversion.

Multiobjective optimization nondominated solutions and the number of nondominated solutions increases exponentially when the number of objectives increases. To select a desired solution out of them, preference-based solution selection algorithm (PSSA) was proposed by incorporating user's

preference into multi-objective evolutionary algorithms. In this paper, multi-objective particle swarm optimization with preference-based sorting (MOPSO-PS) is proposed, where a global best position is randomly selected from the archive of nondominated solutions sorted by global evaluation considering user's preferences for multiple objectives. The user's preference is represented as a degree of consideration for the objectives by the fuzzy measures. The global evaluation of the solutions is carried out by the fuzzy integral of partial evaluation with respect to the fuzzy measures, where the partial evaluation of each solution is obtained as a normalized objective function value. To demonstrate the effectiveness of the proposed MOPSO-PS, empirical comparisons to NSGA-II, MQEA, and MOPSO are carried out for the DTLZ functions. Experimental results show that the user's preference is properly reflected in the selected solutions without any loss of overall quality and diversity.

Weak Selection: A Preliminary Study previous studies presumed that the interactions between individuals are discrete, namely, each individual offers either cooperation or defection. This discrete strategy seems unrealistic in real systems and cooperative behavior in nature should be viewed as a continuous trait. Existing research work on games with a continuous strategy mainly focuses on infinite well-mixed populations. Additionally, our previous work showed that there is a considerable difference in terms of equilibria between continuous and discrete strategy games on graphs under strong selection. This paper studies the game dynamics in finite structured populations under weak selection using the stochastic dynamics based on respectively the mutant fixation probability (ρ_{Y}) and the fixation probability ratio of mutant to resident (ρ_{Y}/ρ_{X}). For three update rules, called 'birth-death' (BD), 'death-birth' (DB) and 'imitation' (IM), we derive exact conditions for natural selection favoring one strategy over another. Comparing discrete strategy games, we find that for continuous ones (i) the rule, $b/c>k$, is also valid; (ii) the same selection conditions are also derived using ρ_{Y}/ρ_{X}; however, (iii) the selection conditions obtained using ρ_{Y} and ρ_{Y}/ρ_{X} are the same instead of different; and (iv) interestingly, the '1/3' rule is not observed for DB and IM updating.

opportunities to power buyers, once price takers of a monopolistic economy, to look forward to a free market economy with market forces determining the market clearing prices and quantities. However, the strong influence of technical and physical constraints of the network may result in economic decisions that adversely affect the interests of the consumers. Compared to the monopolistic economy of yesteryears, power buyers may actually be able to influence the market by cooperating with other power buyers in the network. This paper presents a co-evolutionary algorithm for evolving individual and cooperative strategies of electricity buyers in a power market. The algorithm focuses on how the buyers choose their bidding strategies through learning to maximize the profits in different scenarios of playing individually or cooperatively. The results show that it is of great benefit to cooperate but the free rider problem may arise when an individual buyer gains more profit due to the cooperative effort of the others.

applications, Engineering applications companies (GENCOs) to schedule their generators in order to maximize their profit without actually satisfying the load and the reserve requirements. Various techniques have been developed for solving the profit based unit commitment (PBUC) problem. Among them, the multi-agent approach is different where each generator unit is referred to as an intelligent agent. In this paper, we develop a new multi-agent approach for PBUC problem in which the rule based intelligence is provided to the independent system operator (ISO) agent. Intelligence of generator agents (GenAgents) is limited to maximize their profit for the given demand and reserve using real-parametric genetic algorithm (GA) and share the results with ISO agent. In this approach, ISO agent commits the maximum profit generating GenAgents for every hour while satisfying the up/down time constraints. ISO agent also asks other GenAgents to calculate their profit for the remaining demand and reserve. The simulation results of 10 units problem for two payment methods are shown and compared with other techniques.

algorithms hybrid method between the Kriging model and the radial basis function (RBF) networks is proposed in this paper. In the hybrid method, RBF approximates the macro trend of the function and the Kriging model estimates the micro trend. Then, hybrid methods using two types of model selection criteria (MSC): leave-one-out cross-validation and generalized cross-validation for RBF and the ordinary Kriging (OK) model for comparison are applied to three types of one-dimensional test problems, in which the accuracy of each response surface is compared by shapes and root mean square errors. As a result, the hybrid models are more accurate than the OK model for highly nonlinear functions because the hybrid models can capture the macro trend of the function properly by RBF,

but the OK model cannot. However, because the accuracy of the hybrid method turns down significantly when RBF causes overfitting, stable MSC is required. In addition, the hybrid models can find out the global optimum with a few sample points by using the Kriging model's approximation errors effectively.

evolutionary algorithms Constraint and uncertainty handling world applications. Previous theories and methods suitable for them, however, are few. We present a large population evolutionary algorithm with a user's interval preferences to effectively solve the problems above in this study. In this algorithm, a large population is adopted to improve the performance of the algorithm in exploration. A similarity-based strategy is employed to estimate the implicit indices of the individuals that the user has not evaluated to alleviate the user's fatigue. When Pareto domination is utilized to compare different individuals, the user's preferences to the individuals with the same rank are calculated to further distinguish their performance. In addition, the user's preferences to different indices, expressed with intervals, are quantified by solving another optimization problem. We apply the proposed algorithm to the interior layout problem, a typical optimization one with both interval parameters in the explicit index and interval value of the implicit index, and compare it with other three optimization algorithms. The experimental results validate its superiority.

Convergence, scalability and complexity analysis is recognized as one of the most promising methods for solving continuous global optimization problems. Although DE has been used by many researchers, the reasons how and why it can generally solve such problems so well are not fully explained. To find the reasons, we study the common behavior of individuals in DE through various numerical experiments. Regarding DE as a multi-point directional search model, we investigate convergence and practicality of the search directions used by its individuals. Specifically, we focus on the characteristics of two difference vectors for each individual: (a) a vector from the target vector, i.e., the individual itself, to the corresponding mutant vector, and (b) another vector from it to the corresponding trial vector. The experimental results, in which famous benchmark problems are solved by DE/rand/1/bin, exhibit the phenomenon that both of the vectors (a) and (b) automatically decrease their length exponentially, and show the possibility that the mutant vectors improve the corresponding individuals more frequently than the trial vectors.

Design Optimization Problem of Hybrid Rocket Engine application to optimization problems. Recently, Multi-objective Genetic Algorithm (MOGA) is focused on in the engineering design field. In this field, the analysis of design variables in the acquired Pareto solutions, which gives the designers useful knowledge in the applied problem, is important as well as the acquisition of advanced solutions. This paper proposes a new visualization method using Isomap which visualizes the geometric distances of solutions in the design variable space considering their distances in the objective space. The proposed method enables a user to analyze the design variables of the acquired solutions considering their relationship in the objective space. This paper applies the proposed method to the conceptual design optimization problem of hybrid rocket engine and studies the effectiveness of the proposed method. It shows that the visualized result gives some knowledges on the features between design variables and fitness values in the acquired Pareto solutions.

Optimization with Free Search Range such as resistors, capacitors, and inductors which have to be optimized in order to obtain good circuit performance. In current studies, the search ranges of these components are always pre-defined carefully by expert designers, making it difficult for practical applications. In this paper, the search space is freely set to the commonly used ranges and an efficient orthogonal learning particle swarm optimization (OLPSO) is applied to optimally design the PEC with such search space. OLPSO uses an orthogonal learning (OL) strategy for PSO to discover useful information that lies in the personal historical best experience and the neighborhood's best experience via orthogonal experimental design. Therefore, OLPSO can construct a more promising and efficient exemplar to guide particle to fly better towards the global optimal region. OLPSO is implemented to optimize the design of a buck regulator in PEC. The optimized results are compared with those obtained by using a genetic algorithm (GA) approach and those obtained by using PSO with traditional learning strategy. Results show that the OLPSO algorithm is more promising in the design and optimization of the PEC with large search space. Moreover, the simulations results demonstrate the advantages of OLPSO by showing that the circuit optimized by OLPSO exhibits better startup and large-signal disturbance performance when compared with the one optimized by GA.

preliminary approach musical audio, and fundamental for music information retrieval systems. The problem of automatic musical genre detection has attracted large attention in the last decade, due to the emergence of digital music databases and Internet. Although a number of techniques has been

applied to the problem, no general solution still exists, due to the imprecise features that properly define musical genre. This paper presents a preliminary attempt to apply Fuzzy Rules Based System (FRBS) in cooperation with Evolutionary Algorithms to musical genre classification. The novelty of the approach -which allows us to use fuzzy information extracted from audio files- is aligned with the fuzzy nature of the problem at hand, where no clear-cut rules are available for the classification. Preliminary results presented allows to foresee the potential of the technique.

(GAs) to create building blocks (BBs) and combine them appropriately in the evolutionary process. However, such BBs are often destroyed by unwanted crossovers, soon after they are created. Also, we may suffer from a "loose"encoding of chromosomes since BBs are in general unknown. In this paper, we propose a framework named GAP (GA with patterns), in which key patterns are extracted from significantly "good"chromosomes and protect such key patterns against unwanted crossover. GAP is applicable to optimization problems with fixed-point encoding and permutation encoding in a uniform fashion, and unlike perturbation-based linkage learning methods, GAP does not require extra fitness evaluations. Experimental results with the royal road problems and traveling salesman problems show the performance improvement of GAP over standard GAs.

by a social grouping in which members behave anarchically to improve their situations. The basis of ASO is a group of individuals who are fickle, adventurous, dislike stability, and frequently behave irrationally, moving toward inferior positions they have visited during the exploration phase. The level of anarchic behavior among members intensifies as the level of difference among members' situations increases. Using these anarchic members, ASO explores the solution space perfectly and avoids falling into local optimum traps. First we present a unified framework for ASO, which can easily be used for both continuous and discrete problems. Then, we show that Particle Swarm Optimization (PSO), for which a general introduction was initially implemented for continuous optimization problems, is a special case of this framework. To evaluate the performance of ASO for discrete optimization, we develop an ASO algorithm for a challenging scheduling problem. The numerical results show that the proposed ASO algorithm significantly outperforms other effective algorithms in the literature. Our study indicates that developing an ASO algorithm is basically straightforward for any problem to which a PSO or Genetic algorithm has been applied. Finally, it is shown that under mild conditions an ASO algorithm converges to a global optimum with probability one.

conditions. The obtained data need to be analyzed using data mining methods. Biclustering is a data mining method which consists in simultaneous clustering of rows and columns in a data matrix. Using biclustering, we can extract genes that have similar behavior (co-express) under specific conditions. These genes may share identical biological functions. The aim in analyzing gene expression data is the extraction of maximal number of genes and conditions that present similar behavior. The two objectives to be optimized (size and similarity) are conflicting. Therefore, multi objective optimization is suitable for biclustering. In our work, we combined a well-known multi objective genetic algorithm (NSGA-II) with a heuristic to solve the biclutering problem. We used a string of integers as a solution representation, the integers represent the indexes of the rows and the columns. Experimental results on real data set show that our approach can find significant biclusters of high quality.

Optimization Problems and hyper-heuristics Annealing) which embeds quantum computation into the Simulated Annealing (SA) process for optimization problems. Compared with previous SA studies, QISA adopts Quantum Bits (Qubits) rather than the conventional binary bits as the coding scheme, and update the entries in the Qubits sequence with different probabilities by the proposed methods of heat observation and quantum rotation gate. By flexibly controlling the heating function and rotation angle, QISA does not have to either accept or reject, but can partially accept a new solution. The careful experiments on a number of numerical optimization and combinatorial optimization problems validate its better convergent performance and lower sensitivity to parameters.

clustering, data analysis and data mining optimization algorithm (PSO), called Frankstein PSO or just FPSO, which is used to adjust the weights and architectures of a feed-forward neural network. To evaluate the algorithm we used benchmark classification problems in medical care area. The results were compared with other algorithms which use the same methodology to find out the weights and architectures.

players that are allowed to move between different gaming environments (i.e. habitats) is investigated. The stochastic mobile model under study is realized over connected habitats that are situated on two dimensional grid environment. The players appearing in the same habitat are allowed to interact with their immediate neighbors. Mobility of a player is defined as movement from its habitat to another

based on both obtained payoff and randomly assigned habitat diversity values. By the end extensive experimentation, it is concluded that player mobility is an effective factor that contributes to promotion of cooperation in spatial evolutionary games. Also, even for higher values of temptation of PD game, habitat diversity supports and triggers a collective resistance for the emergence and promotion of cooperative system behavior.

the evolution performance can be improved by varying the environment or evolution process under a more freeform artificial evolution. Previous studies have demonstrated that the modular structure naturally arisen as a response of the variations on environment and selection process, however, since the models they used were relatively simple and with some biasing constraints, the results may lack of generality. In contrast, we evolve more freeform neural networks to address this issue, and an artificial tracer method was employed to quantify the modularity. A series of varying scenarios have been experimented, the results show that the evolution performance have been improved in most cases, however, the modularity never appeared among those scenarios. A further experiment shows that our method has the potentials to produce modular networks but the more advanced methods are still needed to encourage the emergence of modularity on the complex questions.

clustering, data analysis and data mining, Real-world applications clinical diagnosis. This problem involves a combinatorial search to find the essential modules among a large number of brain regions. Despite statistical approaches, cortical analysis remains a formidable challenge due to high- dimensionality and data sparsity. Here we describe an evolutionary method for finding significant modules from cortical data. The method uses a hypernetwork which is encoded as a population of hyperedges, where hyperedges represent building blocks or potential modules. We develop an efficient method for evolving the hypernetwork using mutual information to generate essential hyperedges. We evaluate the method on predicting IQ levels and finding potential significant modules on IQ from brain MRI data consisting of 62 healthy adults with over 80,000 measured points. The experimental results shows that our information-theoretic evolutionary hypernetworks improve the classification accuracy by about 10 percents. Moreover, it extracts significant cortical modules that distinguish high IQ from low IQ groups.

for Constrained Optimization Optimization Problems, no single Differential Evolution strategy, with no single constraint handling technique, performs consistently over a range of problems. In this paper, for a better coverage of the problem characteristics, we introduce a DE algorithm that uses multiple search operators and constraint handling techniques. In the proposed algorithm, initially each individual is assigned a random combination of operators. After a certain number of generations, the improvement made by each combination is recorded, and the best combination is then assigned to more and more individuals, while each of the other individuals are assigned a random combination. To accelerate the convergence of the proposed algorithm, a local search procedure is also applied to selected individuals. The algorithm has been tested by solving 18 test problems, with 10D and 30D. The results showed that the proposed algorithm is superior to state of the art algorithms

High-Dimensional Problems solve high-dimensional global optimization problems effectively. The proposed approach, called DEVP, employs a variable population size mechanism, which adjusts population size adaptively. Experiments are conducted to verify the performance of DEVP on 19 high-dimensional global optimization problems with dimensions 50, 100, 200, 500 and 1000. The simulation results show that DEVP outperforms classical DE, CHC (Crossgenerational elitist selection, Heterogeneous recombination, and Cataclysmic mutation), G-CMA-ES (Restart Covariant Matrix Evolutionary Strategy) and GODE (Generalized Opposition-Based DE) on the majority of test problems.

Evolution solving dynamic economic dispatch (DED) problems with valve-point effects. DEDs are high dimensional optimization problems with many equality and inequality constraints. The problem of premature convergence in solving high dimensional optimization problems using evolutionary algorithms (EAs) could be fought using population structuring. This work investigates the suitability a structured DE algorithm, called cDE, in solving these large dimensional optimization tasks. The suitability and effectiveness of the proposed algorithm is validated using two test systems consisting of 10 and 13 thermal units respectively. Numerical results clearly show that the proposed method outperforms existing methods in terms of solution quality and robustness.

in solving both benchmark functions and real-world problems. However, DE, similar to other evolutionary algorithms deteriorate in performance during solving high-dimensional problems. Opposition-based Differential Evolution (ODE) was introduced and, in general, has shown better performance comparing to classical DE for solving largescale problems. In this paper, we propose an enhancement

to ODE in order to improve its ability to solve large-scale problems more effectively. The proposed modified version of ODE is called Center-Based Differential Evolution (CDE) which utilizes the exact algorithm of ODE except replacing of opposite points with center-based individuals. This paper compares DE and ODE with the proposed algorithm, CDE. Furthermore, CDE with dynamic range (CDE_d) will be compared to CDE with fixed range (CDE_f). Experimental verifications are conducted on seven well-known shifted large-scale benchmark functions for dimensions of 100 and 500, including detailed parameter analysis for CDE. The shifted version of the functions ensures there is no bias towards the center of search space, in favor of CDE algorithm. The results clearly show that the CDE outperforms DE and ODE during solving large-scale problems, and also clarifies the superiority of CDE_d to CDE_f .

and detecting game equilibria. Generative relations are particularly useful for defining new classes of equilibria, for example joint equilibria. In order to avoid difficulties for games involving many players (n>2) a new generative relation for fuzzy Nash-Pareto equilibrium is introduced. An evolutionary procedure relying on this generative relation is used for detecting several types of fuzzy equilibria. Experimental results indicate the effectiveness and robustness of the proposed approach.

games and multi-agent systems other fields, require a solution composed by a set of structurally homogeneous elements. Each element tackles a subset of the original task, and they cumulatively solve the whole problem. Sub-tasks, however, have exactly the same structure, and the splitting is completely arbitrary. Even the number of sub-tasks is not known and cannot be determined a-priori. Individual elements are structurally homogeneous, and their contribution to the main solution can be evaluated separately. We propose an evolutionary algorithm able to optimize groups of individuals for solving this class of problems. An individual of the best solution may be sub-optimal when considered alone, but the set of individuals cumulatively represent the optimal group able to completely solve the whole problem. Results of preliminary experiments show that our algorithm performs better than other techniques commonly applied in the CAD field.

puzzle evolutionary algorithms, since it is at the same time a constrained and a dynamic problem, and has eventually a single solution. In previous papers we have presented and evaluated different evolutionary algorithms to this game and shown how their behavior scales with size, looking mainly at the game-playing performance. In this paper we fine-tune the parameters of the evolutionary algorithms so that the worst-case number of evaluations, and thus the average and median, are improved, resulting in a better solution in a more reliably predictable time.

games and multi-agent systems discovery of intermediate terms for learning, is an area of increasing interest in artificial learning. Such a hierarchy is a recognised aspect of human visual processing and has an important role in recognition of objects. A hierarchy allows efficiency of representation, and a manner of preserving links between related concepts. The use of such an approach in an artificial system requires addressing processes for discovery of features, and for activation of features according to an observation. Learning Classifier Systems provide a means of developing a population of rules relevant to a task according to reinforcement, capturing features of the problem in a population of rules. Implementation of a hierarchical representation to define rules is examined using the Activation-Reinforcement Classifier System, acting in a game environment. Two methods of activation of fragments are examined, one using a parallel activation method allowing multiple interpretations to be active in tandem, the other based on attention to a single higher level concept at once, using a limited working memory. Attention to a high level rule provides a bias on the low level features to be activated. Trials show the system operates successfully on the game of Dots and Boxes with a large game size, and is able to extract relevant features of the game using a body of 4000 autonomously produced features. The attention-based activation method operates with a reduced memory requirement and faster processing time than the parallel method. The network of features produced shows a scale-free connectivity distribution, a common property of many human semantic networks.

Representation and operators part of the biochemistry of life. In this study we incorporate an analogous code, called a translation table, into the self-avoiding walk test problem. Use of a translation table permits evolution of both the distribution of commands and the behavior of the mutation operator. It thus can evolve to encode two types of domain knowledge about the test problem. The translation tables are shown to specialize to specific cases of the test problem but yield no significant improvement in performance. The emergence of encoded problem-specific knowledge in the translation tables is demonstrated. A translation table constructed from extrapolation of the evolutionary trend yields a performance improvement, suggesting that the current algorithm would require more time to

locate translation tables that would enhance performance. A tentative technique for overcoming this limitation is outlined.

representations like those in nature. Such evolvability in natural evolution is encouraged through selection: Lineages better at molding to new niches are less susceptible to extinction. Similar selection pressure is not generally present in evolutionary algorithms; however, the first hypothesis in this paper is that novelty search, a recent evolutionary technique, also selects for evolvability because it rewards lineages able to continually radiate new behaviors. Results in experiments in a maze-navigation domain in this paper support that novelty search finds more evolvable representations than regular fitness-based search. However, though novelty search outperforms fitness-based search in a second biped locomotion experiment, it proves no more evolvablethan fitness-based search because delicately balanced behaviors are more fragile in that domain. The second hypothesis is that such fragility can be mitigated through self- adaption, whereby genomes influence their own reproduction. Further experiments in fragile domains with novelty search and self-adaption indeed demonstrate increased evolvability,while, interestingly, adding self-adaptation to fitness- based search decreases evolvability. Thus, selecting for novelty may often facilitate evolvability when representations are not overly fragile; furthermore, achieving the potential of self-adaptation may often critically depend upon the reward scheme driving evolution.

Language Evolution algorithms artificial language simulation. The efficacy of a Particle Swarm Optimization (PSO) method versus an Artificial Evolution (AE) method was examined for the purpose of adapting communication between agents. The objective of the study was for agents to derive a common (shared) lexicon for talking about food resources in the simulation environment. In the simulation, communication was essential for agent survival and as such facilitated lexicon adaptation. Results indicated that PSO was effective at adapting agents to quickly converge to a common lexicon, where, on average, one word for each food type was derived. AE required more method iterations to converge to a common lexicon that contained, on average, multiple words for each food type. However, there was greater word diversity in the lexicon converged upon by AE evolved agents, compared to that converged upon by PSO adapted agents.

using a Path-Relinking Strategy Heuristics, metaheuristics and hyper-heuristics the prediction of three-dimensional structures (3-D) of polypeptides or proteins. The rate at which amino acid sequences are identified is increasing faster than the 3-D protein structure determination by experimental methods. Computational prediction methods have been developed during the last years, but the problem still remains challenging because of the complexity and high dimensionality of a protein conformational search space. In this article we present a hybrid genetic algorithm for the Protein Structure Prediction (PSP) Problem. A genetic algorithm is combined with a structured population, and it is hybridized with a path-relinking procedure that helps the algorithm to scape from local minima. We perform a set of experiments and show that the proposed hybrid genetic algorithm is effective in finding good quality solutions for the PSP Problem.

procedure implement evolutionary algorithms directly in vitro. They have a wide range of applications in detecting and targeting diseases and potential applications in other areas as well [1]. However it is relatively difficult and expensive to carry out these processes (by comparison with evolutionary computation), so that the underlying theory has seen limited development. For more complex problems, where multiple and dynamic objectives are involved, there is potential for substantial improvement in the search protocols. Simulation through the methods of evolutionary computation is one potential way to gain the necessary insights. The complex fitness functions and huge populations involved in combinatorial chemistry render detailed simulation infeasible. However detailed simulation is not needed, so long as simulations are sufficiently similar to yield qualitative insights. In this paper, we investigate whether one class of problems - those involving short-chain evolution, where stereochemical effects do not dominate - are likely to have sufficiently similar fitness landscapes to a simple problem, string matching, for useful inferences to be made. In the outcome, it appears that the differences between more detailed simulations and string matching are not sufficient to significantly alter the behaviour of evolutionary algorithms, so that string matching could be used as a realistic surrogate. This is valuable, because string matching can be implemented in GPUs, offering speed-ups to the level where populations of 10ˆ7, or even 10ˆ8, might be feasible, thus reducing the population gap between chemical and computer evolution.

Biometric Recognition Algorithm (SSGA) and an Estimation of Distribution Algorithm (EDA) for multi-biometric feature selection and weighting. Our results show that when fusing face and periocular

modalities, SSGA-based feature weighting produces higher average recognition accuracies, while EDA-based feature selection performs better at reducing the number of features needed for recognition.

on Gate Operations and negative couplings between qubits, to overcome the effects of relative phases due to qubit precessions, both during idle times and gate operations. The scheme uses decoherence-free subspaces, and we show how to realize gate operations on these encoded qubits. The main advantage of our scheme is that most gate operations are realized by only varying a single control parameter, which greatly reduces the circuit complexity. Moreover, the scheme is robust against phase errors occurring as a result of finite rise and fall times due to non-ideal pulses.

DNA Computers DNA computing in vitro to learn the recently-proposed hypernetwork model of cognitive memory. The molecular learning process is designed to make it possible to perform wet-lab experiments using DNA molecules and bio-lab tools. We present the bio-experimental protocols for selection, amplification and mutation operators for evolving hypernetworks. We analyze the convergence properties of the molecular evolutionary algorithms on simulated DNA computers. The performance of the algorithms is demonstrated on the task of simulating the cognitive process of learning a language model from a drama corpus to identify the style of an unknown drama. We also discuss other applications of the molecular evolutionary algorithms. In addition to their feasibility in DNA computing, which opens a new horizon of in vitro evolutionary computing, the molecular evolutionary algorithm provides unique properties that are distinguished from conventional evolutionary algorithms and makes a new addition to the arsenal of tools in evolutionary computation.

Optimization Numerical optimization. dynamics of Multiobjective Evolutionary Algorithms (MOEAs) towards the Pareto Front (PF). By varying mutation and crossover parameters, several scenarios of exploration and exploitation are considered, in which each of them is analysed in order to assess the role of diversity levels on the evolution of high quality sets of non-dominated solutions, in terms of the Hypervolume indicator. For this task, the application of the NSGA2 algorithm for approximating the PF in five ZDT benchmark problems is considered. The results not only indicate that there are significant statistical correlations between several diversity metrics and the observed maximum Hypervolume levels on the evolved populations, but also suggest that there are predictable temporal patterns of correlation when the evolutionary process is portrayed generation wise.

Optimization Heuristics Multi-objective evolutionary algorithms optimization has recently received an increasing attention by the research community. Motivated by this trend, we experimentally study the impact that the integration of preference models into evolutionary multi-objective search algorithms has on performance. In this article, we consider three preference models, ranging from rather simple to more complex ones; these are (i) reference point, (ii) guided dominance, and (iii) P ROMETHEE II. As a benchmark problem we consider multi-objective traveling salesman problem instances of various sizes and with a varying number of objectives.

measures of multi-objective optimization. Based on this, we construct a component oriented classification for dynamic multi-objective optimization problems. For each category we provide synthetic examples that depict in a more explicit way the afferent defined model. We do this either by positioning existing synthetic benchmarks with respect to the proposed classification or through new problem formulations. In addition, an online dynamic MNK-landscape formulation is introduced together with a new comparative metric for the online dynamic multi-objective context.

Resource Investment Project Scheduling Multi-objective evolutionary algorithms as project scheduling problems. Unlike conventional deterministic project scheduling problems, such problems involve uncertainty and the execution of the plan will definitely be perturbed by many factors. In other words, the circumstances under which the plan will be executed are changing and stochastic. In this paper, we first use scenarios to represent the stochastic elements in the problem; these are: perturbation strength and perturbation occurrence time. We define and explain the Stochastic Resource Investment Project Scheduling (SRIPS) problem. A multi-objective optimization model of SRIPS is proposed where three optimization objectives are considered simultaneously: makespan, cost, and robustness. A multi-objective genetic algorithm is employed to solve the problem. Finally, we generate two test problems with 30 and 60 non-dummy activities to validate the performance of the proposed approach and analyze the sensitivity of the results to different parameter settings.

Matching Synthesis which requires theoretical and experimental knowledge about the synthesis engine. Commonly, performers need to deal with synthesizer interfaces and a process of trial and error for creating musical sounds similar to a target sound. This drawback can be overcome by adjusting automatically the synthesizer parameters using optimization algorithms. In this paper a

hybrid particle swarm optimization (PSO) algorithm is proposed to solve the frequency modulation (FM) matching synthesis problem. The proposed algorithm takes advantage of a shuffle process for exchanging information between particles and applies the selective passive congregation and the opposition-based learning approaches to preserve swarm diversity. Both approaches for injecting diversity are based on simple operators, preserving the easy implementation philosophy of the particle swarm optimization. The proposed hybrid particle swarm optimization algorithm was validated for a three-nested FM synthesizer, which represents a 6-dimensional multimodal optimization problem with strong epistasis. Simulation results revealed that the proposed algorithm presented promising results in terms of quality of solutions.

Optimization applications, Genetic algorithms mathematical relationships (empirical or otherwise) in an engineering design problem using the Pareto-optimal front is referred to as innovization. Past studies on the subject have limited themselves to a single front. In this paper we introduce the higher- level innovization task through an application of a manufacturing process simulation for the Friction Stir Welding (FSW) process where commonalities among two different Pareto-optimal fronts are analyzed. Multiple design rules are simultaneously deciphered from each front separately and compared. Important design aspects of the FSW problem are revealed in the process. The overall study aims at showing how some design principles can considerably ease the task of optimizing future enhancements to the design.

applications efficiency. To realize such an optimization, its distribution network requires solving several tens to hundreds (max. 1500-2000) cities Traveling Salesman Problems (TSP) within interactive response time (around 3 seconds) with expert-level accuracy (below 3% level of error rate). Moreover, as for the algorithms, understandability and flexibility are necessary because field experts and field engineers can understand and adjust it to satisfy the field conditions. To meet these requirements, a Backtrack and Restart Genetic Algorithm (Br-GA) is proposed. This method combines Backtracking and GA having simple heuristics such as 2-opt and NI (Nearest Insertion) so that, in case of stagflation, GA can restarts with the state of populations going back to the state in the generation before stagflation. Including these heuristics, field experts and field engineers can easily understand the way and use it. Using the tool applying their method, they can easily create/modify the solutions or conditions interactively depending on their field needs. Experimental results proved that the method meets the above-mentioned delivery scheduling requirements more than other methods from the viewpoint of optimality as well as simplicity.